The Water Report™
Water Rights, Water Quality & Water Solutions in the West

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WATER SECTOR INNOVATIONS

RISING TIDE: ENABLING INNOVATIVE WATER TECHNOLOGIES

A REPORT FROM THE WATER ENVIRONMENT FEDERATION TECHNICAL EXHIBITION & CONFERENCE

by Grace Richardson
Oak Ridge Institute for Science and Education (ORISE) Research Fellow

INTRODUCTION

In the early 20th century, America's nascent water sector faced new challenges in water management and sanitation. As urban centers grew and populations swelled in the arid West, new technologies helped meet the changing needs and demands of water infrastructure. The beginning of the 1900s marked the adoption of sand filtration units that provided the first large-scale modern treatment of municipal sewage. Secondary treatment, such as activated sludge, saw widespread use by the 1940s. Together, these technologies represented seminal leaps forward in the protection and improvement of waterways and public health worldwide.

Shifting water demands in the western United States, coupled with a cooperative sociopolitical climate, led to major engineering feats in the water sector throughout the 20th century. The construction of large public works, including the Los Angeles Aqueduct system and the Hoover and Glen Canyon Dams, reshaped the water landscape in a way that not only satisfied, but further encouraged, increased development in the West.

Although ever-increasing water demand has been a mainstay for many utility managers, the water sector now faces new, uniquely 21st-century, challenges. As farming practices have become more industrialized, agricultural impacts on water systems have similarly increased. Despite ongoing efforts to manage nutrient pollution in the Chesapeake Bay, the nation's largest estuary, and "dead zones" in the Gulf of Mexico, overarching solutions have yet to materialize.

The specter of climate change presents perhaps the biggest challenge facing the water sector for the coming decades. It threatens to stretch the capabilities of existing water systems in new and unexpected ways. Prolonged periods of drought have occurred in recent years in the central and western US. Those living in regions that benefited from the creation of Lakes Mead and Powell as water resources now endure dwindling water reserves and severe restrictions on water use. Several small municipal water utilities have even seen their surface water supplies vanish entirely during some seasons, forcing managers to take emergency action and begin considering radical new long-term solutions to water management.

The challenges posed by climate change go beyond the changing nature of water availability and extend to increased occurrences of extreme weather events that will further stress municipal systems. Water utilities need to replace aging infrastructure. Moreover, they need to be constructed and operated in a manner that will enable them to withstand the effects of extreme weather events.

Water Tech Innovations

Marketplace Opportunities

Technological Advancements

Key Themes

Though the current and anticipated challenges might be seen as pointing to a future lacking a sustainable water sector, the threats are not insurmountable. Just as the landmark innovations of the last century helped advance the safety and rapid expansion of water services, so too can new technologies and management strategies address the 21st-century problems we face.

The water industry is primed for — and already in need of — sector-wide re-evaluation and implementation of best operating practices and equipment. But how can innovative technologies and approaches find their way into the marketplace? Where are the best opportunities to bring new, inventive solutions? In April 2014, the US Environmental Protection Agency (EPA) Office of Water issued its sector-specific report, *Water Technology Innovation Blueprint* (EPA 820-R-14-006), which sought to help answer these questions (*see* epa.gov/innovation/watertech). The *Blueprint* presents ten market areas in the water sector that could benefit from innovative technologies and approaches, and discusses how new technologies might positively impact each area.

Taken together, the ten distinct market opportunities make a business case for needing innovation in the water sector. After receiving positive response from the *Blueprint's* release, EPA extended its collaboration with the Water Environment Federation (WEF), the hosts of the annual Technical Exhibition and Conference (WEFTEC). WEF shares an interest in the specific market areas and their commercial viability. To capitalize on the *Blueprint's* visibility, WEF hosted a series of open discussion sessions at the latest WEFTEC, held in September 2014. The series set out to help the water community as a whole identify the best ways to spur technological advancement and innovation in the ten market areas. WEF brought the conversation to WEFTEC to engage directly with the stakeholders who design and adopt water technologies.

The series of sessions at WEFTEC consisted of ten half-hour-long discussion periods focusing on each of the market opportunities presented in EPA's *Blueprint*. Facilitators guided participants through three key themes for each particular water subsector: 1) past successes; 2) barriers to innovation; and 3) keys to encouraging sustainability. WEF recruited water industry experts to facilitate each market opportunity session. All told, the open discussions solicited feedback from over 200 members of the water sector, including: operators; consulting engineers; representatives from non-profit groups; and government officials. Conversations included: collaborative deconstruction of sector-specific problems; direct exchanges among practitioners; and facilitator-induced dialogue. Each of the ten sessions held valuable, forward-looking insights on developing the path to water sustainability.

CONSERVING & RECOVERING ENERGY

During this discussion, participants noted that technologies are already available and have been implemented in various areas throughout the country. For example, a private industry representative explained that the metropolitan areas of Minneapolis and St. Paul, Minnesota, have been generating energy from the latent energy in sewage sludge. Moreover, there are multiple research efforts in which energy conservation and co-digestion are being investigated.

However, the common industry view holds that the marketplace has little room to use this innovation because of the high risk to operators. In addition, there is little incentive to offset this high risk. The public also has a negative perception of using gases derived from human wastewater, which presents a barrier to some applications of energy capture and use.

Citing a separate example, a US Department of Energy (DOE) representative noted that New York, Wisconsin, and California are currently taking on new and exciting projects with water and energy. Municipal representatives countered, however, that it is hard to find people willing to take risks for implementing "unproven" technologies, suggesting that innovation may be encouraged if EPA or DOE could somehow help share the risk with permittees. These changes could include: reducing the stringency

EPA's Water Technology Innovation Blueprint outlines 10 market opportunities:

Conserving and Recovering Energy
Recovering Nutrients
Conserving and Eventually Reusing Water
Improving Access to Safe Drinking Water
Reducing Water Impacts from Domestic Energy Production
Improving Performance of Small Drinking Water Systems
Reducing Costs and Improving Monitoring Techniques for Water Monitoring
Improving Resilience of Water Infrastructure to the Impacts of Climate Change
Improving and Greening of Water Infrastructure
Improving Water Quality of Our Oceans, Estuaries, and Watersheds

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Water Tech Innovations

Risk Sharing

of wastewater effluent limits, lowering the compliance risk, and creating a "State Revolving Risk Management Fund."

The risk-averse culture is complemented by a commensurate lack of drivers for change in the water sector. A utility representative from Texas related that because the price of natural gas is so low, power companies are unwilling to buy back electricity generated by municipalities from recovered biogas. Additionally, a private industry representative pointed out that the federal Clean Water Act succeeded in spurring innovation and interest because it originally made funds available.

Participants' suggestions — including spreading awareness, sharing risk, and providing economic incentive — suggest that EPA has many opportunities help promote energy conservation and recovery.

Cost Efficiency

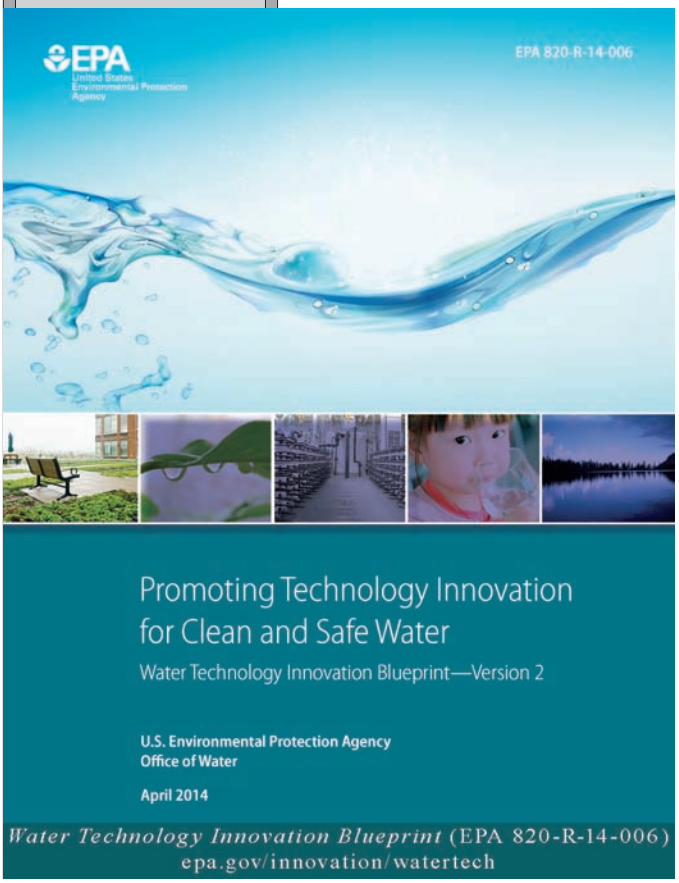
RECOVERING NUTRIENTS

Many of the comments made regarding nutrient recovery innovations echoed similar, previous concerns. Participants again expressed that while some innovative technologies exist, the industry still lacks motivational drivers to accelerate implementation. Representatives from EPA, private industry, and academia all pointed to the fact that nutrient recovery is not currently cost-effective for every utility.

In the specific case of recovering phosphorus during wastewater treatment, cost-effectiveness could be improved by imposing phosphorus limits in discharge permits. Some phosphorus removal technologies also remove small amounts of nitrogen. For example, one individual noted that Ostara technology removes about one part nitrogen to four parts phosphorus. However, most nitrogen-specific technologies, like ammonia stripping, are not economically feasible. Treating biosolids offers one potential avenue to remove and recover nitrogen, but regulations governing the transportation of wastewater treatment byproducts inhibit widespread implementation. Overall, participants generally indicated that recovering nitrogen still requires more technological development to improve its cost-effectiveness before wide-scale deployment could be considered.

Agricultural BMPs

Current projects demonstrate that better collaboration among industry players could improve the cost-effectiveness model. For instance, the National Association of Clean Water Agencies (NACWA) is working to get wastewater treatment plants to coordinate directly with agricultural entities for resource recovery. Collaborative efforts have led to new efforts that incentivize agricultural **b**est **m**anagement **p**ractices (BMPs) in Wisconsin and the Chesapeake Bay watershed.



CONSERVING & EVENTUALLY REUSING WATER

Climate change concerns are leading many organizations to become more proactive in maintaining water supply reliability. Municipalities are increasingly implementing practices that offer greater water use efficiency and long-term sustainability. Yet, much of this session's discussion focused on the need to help reshape the negative public perception of reclaimed water use. To garner adequate support for the next tier of advanced water reuse technologies, the water community will need to make progress in erasing the stigma associated with water reuse. Cultural resistance remains due to the perceived risks and "yuck" factor. Yet, this widespread resistance seemingly ignores the reality that many communities already have de facto water reuse with surface water intakes downstream of outflows.

Some participants stressed the importance of reframing water reuse as a collection of diverse needs that require using the "right water" for the "right use." In other words, not all water need be treated to the highest standard. Although a drinking water standard would fit for some contexts, the same might not be necessary for irrigation or industrial uses.

For the purposes of EPA's Blueprint, the term "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.

Water Tech Innovations

Water Reuse

Produced Water Reuse

Information Sharing

Communication Channels

Public Perceptions

Effluent Incentives

Third Party Barriers (No Injury)

During the discussion, representatives from both government and private industry advocated additional publicity for reuse projects being developed in the US and internationally. Israel and Singapore were mentioned as particularly advanced in implementing water reuse technologies. Representatives from private industry and EPA noted that technologies currently exist to provide treatment for varying levels of water reuse, including: irrigation; industrial use; greywater applications; and indirect and direct potable reuse. Areas of the country experiencing severe drought could represent an opening for testing and further refinement of water conservation and reuse technologies.

To start this initiative, several participants described a need for additional efforts to educate the general public (especially young individuals), regulatory agencies, utilities, and industries about the current state of the science and market. Additionally, representatives from the oil and gas industry expressed the need for a regulatory framework to address water reuse. Each year, the oil and gas industry generates about 870 billion gallons of produced water and fracking flowback wastewater in the United States and nearly three trillion gallons globally. Reusing this water for oil and gas operations and other beneficial purposes can reduce reliance on limited fresh water sources. However, there are no current domestic regulatory drivers to promote significant reuse. If progress can be made in this area, there is significant potential for produced water to improve water use efficiency by satisfying demand for a variety of purposes — not only for municipal and industrial uses, but also for agriculture activities.

IMPROVING ACCESS TO SAFE DRINKING WATER

As with many of the sessions, the discussion on safe drinking water systems was largely shaped by the professional background of the water experts in attendance. Consequently, many participants focused on the challenges and needs for safe drinking water systems in developing countries. Commenters stressed that developers of small drinking water systems would do well by sharing information on past successes. This information dissemination is particularly important for identifying the best methods for education and promotion of drinking water systems in developing countries.

Better education and conveyance of clean water's economic benefits will help reduce skepticism and facilitate community buy-in. This is especially critical in developing countries, where numerous stakeholders play a role. The creation of these communication channels also serves the project after it has broken ground. By establishing an ongoing feedback mechanism before a project begins, the process can respond more flexibly and make successful course corrections if problems arise. Additionally, because many of these projects are replicated at the local level, deliberately tracking mistakes can improve the outcomes for future undertakings.

Public perception in industrialized nations also hinders safe drinking water supplies, as it is a major driver for political inertia. This is especially true with regard to water reuse and biosolids management. Multiple representatives advocated for reframing regulations, as there are some restricted activities that are legally prohibited but otherwise serve the intent of the law and public good. For example, one county designed a water reuse project that supplied recycled water for irrigation on a golf course. The municipality wanted to use the water line for fire hydrants located between the water facility and golf course, but the project was scrapped because regulations would have deemed all hydrant use as an illegal discharge of effluent water.

REDUCING WATER IMPACTS FROM DOMESTIC ENERGY PRODUCTION

Different aspects of the permitting process were echoed across numerous discussion sessions. In the case of domestic energy production, participants suggested that incentives relating to wastewater effluent limitations could help drive the adoption of new technology in the sector. Currently, there is a lack of compliance schedules and consequences for non-compliance. Compliance schedules with extended time horizons for implementation may be especially helpful for developing and implementing newer technologies, provided that clear steps or guidance are given to establish when goals must be met.

DOE is conducting research into treating and reusing water from energy production processes. However, the widespread feasibility of this type of technology is location-specific. A power-production facility's ability to use reclaimed water from other external sources and generate water depends on the other parties involved in the transaction. For example, competing water rights issues are a significant barrier for water reuse at energy production facilities in most western states, since downstream water users have the right to maintain the flow conditions in a stream that existed when they first began using their water rights. The effluent from such facilities has been relied upon by downstream users for their own use and is already accounted for as part of the flow of the stream. On the other hand, the facility owners' position is that they are entitled to stop "wasting water" and thus may reuse or reclaim their effluent for additional use at any

Water Tech Innovations

Knowledge Dissemination

point before it is released back to the stream. The physical remoteness of the facilities can also limit access to these reused water sources by others.

Some participants noted that there has been a decrease in the frequency of EPA publications about treatment technologies. However, they countered that many ideas for reuse are already in circulation. For example, most water in the energy sector is used in the cooling process. Utilities can already feasibly capture the evaporative water generated by cooling and redirect it toward other applications, but this practice is not widespread. Continuing to help disseminate knowledge about the best reuse practices and new technologies is critical for implementation. A program that coordinates research efforts and results — sharing from real-world testing — could help facilitate implementation of best practices.

IMPROVING SMALL DRINKING WATER SYSTEMS PERFORMANCE

Regulatory Flexibility

Improved technologies for small drinking water systems exist already, but the consensus among operators is that the regulatory environment is too inflexible for easy adoption. Some single-person operators suggested that regulatory constraints are too complex and burdensome for managers who perform multiple roles in their communities. Mangers of small drinking water system are often tasked with managing additional services completely unrelated to water. Circumstances demand that they make the major technical decisions about water systems, despite not being expertly familiar with the regulatory intricacies. Managers' responsibilities may be further hampered by their working relationship with local governing authorities.

Small System Disincentives

Another barrier to innovation is that cash- and resource-strapped small systems have little incentive to risk their tenuous position with innovative systems or equipment. Separating out utility funding to minimize the co-mingling of municipal funds can better protect the financial viability for small systems.

Mentorship

One creative approach that garnered support was the suggestion of a partnership program, whereby a large operator in a given region could help take smaller-sized utilities under their wing. This "mentorship" or advisory role could help foster collaboration and assist small operators who struggle with resources and/or technical expertise.

Agency Assistance

Participants adamantly supported better education and training to assist small communities and their operators. Regulators themselves could provide the needed assistance, which would help reverse the sometimes adversarial relationship between the two parties. Introducing innovative technologies in this context could accelerate buy-in by reducing the apprehensions of smaller system operators. WEF's Leaders Innovation Forum for Technology (LIFT) program, which helps connect practitioners to technologies, is a leader in that respect (*see* website at: www.werf.org/lift). With enough buy-in, meaningful change can take place. For instance, a participant mentioned recent legislation in Iowa that encourages small systems, especially in rural areas, to integrate wastewater, drinking water, and stormwater systems.

WATER MONITORING: REDUCING COSTS & IMPROVING TECHNIQUES

Communication Gap

The water monitoring sector also suffers from a communication gap between the end-users and the manufacturers of the sector's technology, especially with regard to very specific technological gaps. For example, there is a significant need for in-ground septic system performance monitoring and alarm systems. Water quality monitoring for headwater (small flow) streams is also lacking. Participants suggested that part of this information gap is masked by the large number of organizations that engage in water monitoring. Improved sharing of water quality sampling data between organizations could help highlight the need for further development of water monitoring technologies.

Technology Affordability

Although refinements for very particular applications can still be improved, participants stressed that the fundamental water sampling and analysis technologies already exist. The principal barrier is the cost of applying them over a wider geographic area. In the case of non-point sources of contamination, such as septic systems, the cost challenge is compounded by the need to monitor at millions of local, often remote, point sources. During the discussion, an EPA representative mentioned a new EPA challenge, starting this winter, to address the issue of affordable nutrient (nitrogen and phosphorus compounds) sensors (*see* www.act-us.info/nutrients-challenge). Additionally, the US Department of Agriculture is focusing some efforts on monitoring nitrogen and phosphorus in soils by supporting the creation of affordable sensors for the agriculture sector. Private efforts are also underway. For instance, private money has enabled Tulane University to initiate a $1 million Grand Challenge Prize competition to award "the team or individual that achieves our goal of creating a significant and workable solution to hypoxia" (i.e., aquatic "dead zones" arising from nutrient overload). *See* Tulane website: http://tulane.edu/tulaneprize/). These sorts of aspirational — and motivational — challenges offer encouraging signs in the development of other affordable technologies.

Water Tech Innovations

"Best Practices" Codification

Inaction Costs

Effective Guidance

Infrastructure Planning

Long-Term Performance

Holistic Management

Market Entry

IMPROVING WATER SECTOR RESILIENCY: ADDRESSING CLIMATE CHANGE

Discussion of the term "resiliency" took center stage in the climate change resiliency session. Although sustainability and resiliency are both widely used terms that encourage forward-looking investments, participants contended that the end goals of "resiliency" might be best served by adhering to a specific definition.

Participants acknowledged that the lack of codified "best practices" is a key gap with regard to water infrastructure being able to withstand the impacts of a changing climate. The lack of local specificity of climate projections plays a role in why there is little actionable guidance for water managers. Acknowledging this missing element, while also stressing the range of potential changes in climate, could help counteract public resistance. Some suggestions from the discussion were focused on strengthening the public understanding of the costs of inaction. Communities might also bolster their preparation by reframing how emergencies are addressed — by moving from a "response" to a "preparation" state of mind.

Due to the range of climate change projections, participants generally agreed that utility managers should identify a range of outcomes and attempt to quantify the cost of inaction when formulating their climate action plans. Improving communication challenges between climate data generators and water industry practitioners would smooth this process, especially with regard to meteorological information and water technology performance. Real-time data are already abundant, but decision-makers lack the forward-looking tools that enable them to analyze and interpret the data for the coming decades. A collection of key case studies would be an effective guidance tool to help practitioners identify risks, quantify costs, and adopt the most suitable technologies. Several participants noted that the Water Environment Research Federation (WERF), in conjunction with WEF, offers one such centralized clearinghouse of case studies (*see* www.werf.org/search).

The climate change discussion also touched on existing technologies that would unquestionably help ease climate impacts regardless of the projection scenarios. For example, the decentralization of water facilities and the widespread use of rain gardens are more resilient options for municipal infrastructure. These approaches allow for sustainable water infrastructure planning to be simultaneously integrated with other capital projects that might have faster turnover than water utilities (e.g., roads, sidewalks, building development). Collaboration among facilities may also help to improve the cost-efficiency and reduce the challenge of funding for climate change preparedness.

IMPROVING & "GREENING" WATER INFRASTRUCTURE

Closely paralleling climate change issues addressed in the resiliency session, the discussion of green technology in the water sector focused on similar uncertainties about the future. The implementation of **b**est **m**anagement **p**ractices (BMPs) for green water technologies is hindered by the uncertainty of their long-term performance and true benefits and costs, including their ongoing maintenance. To date, performing maintenance for an increasing number of BMPs already presents a significant challenge for the application of **g**reen **i**nfrastructure (GI) techniques. A corresponding challenge for ensuring proper operation and maintenance is the lack of enforcement of these BMPs at multiple levels (local, state, federal).

Although the feasibility of water technology is often case-specific, the applicability of GI practices is especially sensitive to local and regional influences. Geology, climate, existing institutional infrastructure, and space constraints all factor into the consideration of green technologies. Yet, participants generally agreed that most areas could see useful applications of GI in some manner so long as they had a dedicated local champion leading the charge. Increased education of students, citizens, and homeowners on the benefits of GI provides the supplementary demand from the end beneficiaries of the technology.

The all-encompassing nature of GI speaks to its versatile appeal. It is a truly holistic management technique that ties together various facets of a community and the environment — surface water quality, water supply and reuse potential, aesthetics, and air quality benefits, to name a few. By invoking the breadth of benefits from GI, a local GI champion can strengthen public support by linking to popular services, such as a reliable potable water supply and bolstered flood control.

OCEANS, ESTUARIES & WATERSHEDS: IMPROVING WATER QUALITY

Focusing on a few case studies in the southern US, this discussion session highlighted the importance of providing small-scale technology developers with opportunities to test and potentially fund their ideas. Manufacturers at the meeting, including self-made entrepreneurs, stressed the difficulty of bringing their products to market — especially for technologies designed to address watershed-sized problems. They

Water Tech Innovations

Deployment Delay

Watershed Perspective

Existing Innovative Technology

Risk Aversion

Longer Planning Horizons

Non-Compliance Risk

Regulatory Variance

Communication & Collaboration

frequently cited their inability to meet customer demands for comprehensive test results under a variety of scenarios. This considerable, costly, barrier to market entry often prevents consideration of potentially beneficial technology.

The long road from technology design to eventual testing and deployment means the time horizon for these watershed-scale technologies may take many years. Participants contended that this delay between development and implementation remains a significant deterrent for innovation. To accelerate progress and encourage more technologies making it to market, there must be support for the demonstration of new product performance in real-world settings (e.g., organized challenges, grant-funded research).

From a macroscopic view, participants also advocated refocusing the problem-solving approach used for watershed-based issues, such as nutrient pollution in the Gulf. Solutions for regional crises demand a shift from a more local estuary perspective to a whole watershed perspective. This larger view can encourage collaboration among industries by expanding the whole pool of interested stakeholders. This alone could reduce the need for government funding and encourage private partnerships. For example, a market-based nutrient trading program in Virginia has encouraged economic investments and reduced phosphorus pollution to local waterways, helping to steer the Chesapeake Bay toward specific water quality goals.

RECAPPING THE MESSAGES

Concluding the series of WEFTEC sessions, WEF hosted a final, lengthier capstone session that sought to integrate all ten discussions into a broader, "one water" context and gain actionable insights based on the common themes from throughout the conference. Even before the capstone session, certain issues recurred as predominant points of concern in the water community. The participants in the capstone session made several observations.

First, *innovative technologies already exist for much of the water sector*. WEFTEC itself is a testament to this availability of diverse technological solutions. Yet, time and again, participants stressed the notion that many technologies just simply do not get deployed. Discussion demonstrated that bringing the water sector into the 21st century is decidedly not a research issue.

Next, *risk aversion is a serious deterrent to deploying the innovative technologies that do exist*. Utility managers face a host of competing constraints — permits, budgets, and manpower — all of which factor into finding the most expedient and reliable solution. In the computer sector, the famous mantra states that "nobody ever got fired for buying IBM." Participants contended that the water sector has a comparable view, which results in an industry reluctant to explore the potential use of innovative technologies.

Finally, *decision-makers must look at longer, more integrated time horizons.* Modern-day hindsight demonstrates the importance of using the triple bottom line framework (economic, social, and environmental impacts) for gauging the success of potential undertakings. This theory also applies to the viability of water sector projects. Water infrastructure stands at the juncture of these three spheres — and has a mutually dependent relationship with each. The water sector cannot thrive without adopting a balanced approach to the decision-making process.

Armed with this feedback, the capstone session solicited input from participants as to how the water sector could next proceed toward water sustainability. Participants presented a myriad of strategies for overcoming risk aversion within the water sector. Many initial reactions pointed to regulatory barriers. Indeed, participants from industry explained that managers are reluctant to introduce any chance for error because the risk of non-compliance is so great. For example, by easing the impacts of non-compliance, EPA could see a corresponding adoption of newer and more advanced technologies. Other participants contended that, beyond just relaxing the impacts of non-compliance, the risk itself could be shared between enforcers and the regulated entities. Potentially, these agreements could be tailored individually to encourage specific technologies. They could also be tailored to include other sources of pollution being discharged into utilities. Yet, wholesale change to the regulatory environment need not even be required for the water sector to be less apprehensive. One participant suggested that the permitting process varies significantly by region in the United States, with rules being applied differently in different areas. Streamlining and harmonizing the application of the law would suffice to provide a measure of assurance to the regulated community.

Better communication is another strategy to help reduce industry risk and enact widespread changes across the sector. Participants stressed the need for collaborative, non-adversarial relationships between the industry and their regulators. Part of this relationship involves having clear and consistent messaging for compliance, but participants also stressed that regulatory agencies should communicate better amongst themselves and within themselves. In other words, regional staffers of federal agencies should be on the same page with colleagues in other parts of the country. When asked how EPA and other agencies could best play their role in the marketplace, speakers from the private and non-profit sectors emphasized EPA's

Water Tech Innovations

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potential role as a source of technically sound information. Federal agencies could leverage their industry expertise to provide vital assistance — especially to small systems with limited staff and funds — by clearly organizing technical resources and making them available free of charge.

Finally, participants emphasized the importance of broadcasting success stories. In addition to simply celebrating the outcomes seen by these ambitious utilities, a collection of success stories acts as guidance, or perhaps even a model, for other aspiring organizations. WERF's new LIFT program, with its focus on pilot projects and deployment, represents a key mechanism to generating buy-in from operators who expect ground-truthed data. *See* WERF website at: www.werf.org/lift.

MOVING FORWARD — WATER SECTOR INNOVATION

As evidenced from the discussion sessions, the challenges faced by the water community belie the excitement and keen interest shown by the attendees at the *Blueprint* sessions. Discussion participants noted the opportunity to capitalize on this momentum to promote continued technological advancement in the water sector. That growth depends on setting attainable goals, employing strategic actions, and measuring successes accurately.

To that end, there exists a great opportunity for federal agencies, non-governmental organizations, and industry representatives to continue this conversation with community stakeholders. Specifically, the EPA can help to foster buy-in from implementers and hone a more consistent voice at all levels of the Agency. Additionally, over the coming months, EPA could continue to work with its non-profit and industry partners to support sector-specific workgroups in deploying innovative technologies.

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EPA's Water Technology Innovation Blueprint is available from: epa.gov/innovation/watertech)
Additional information regarding the WEF conference can be found at: http://weftec.org/

MEASURING WATER RESOURCE RESILIENCE

by J. Scott Thomas, Stetson Engineers, Inc. & David A. Kerner, The Tauri Group, LLC

INTRODUCTION

America's water resources and associated infrastructure are coming under increasing pressure. Growing population, especially in arid climes, stresses local water resources and impacts our ability to deliver water from afar. Levee systems, vitally important for controlling floods and partitioning fresh water from saline water, are not being maintained. Aging dams and reservoirs are silting in, and the captured sediment no longer flows to river deltas to build land needed to protect coastal regions and valued wetlands from storm surge and seawater intrusion. Water managers face a plethora of these and other daunting challenges.

The American Society of Civil Engineers (ASCE) examines the state of the nation's infrastructure every four years, and the most recent overall grade was a dismal D+ (*see* Table 1). This assessment isn't new — that grade has remained essentially unchanged for decades.

Water Resource Resilience

Water Management Challenges

Infrastructure Needs

Table 1. ASCE Water Resource Infrastructure Grades for 2013

Infrastructure Category	Grade[1]
Ports	C
Dams	D
Drinking Water	D
Wastewater	D
Inland Waterways	D-
Levees	D-

[1] Grades are on an A-F scale (ASCE, 2013)

Water Resource Resilience

Renewing and maintaining water infrastructure has become a significant challenge for public agencies. The ASCE Report Card estimates that the investment required to repair all infrastructure is $3.6 trillion by 2020, with water-related investments a significant portion of this total. Faced with the monumental scale of this effort, what criteria should public officials employ to plan and prioritize these projects? We argue that a resilience perspective is crucial for determining the most expedient investment priorities. The National Academy of Sciences (NAS) agrees, and recently issued a challenge for policy makers:

New Path Needed

> As a nation we have two choices. We can maintain the status quo and move along as we have for decades — addressing important, immediate issues…Or, we can embark on a new path — one that also recognizes and rewards the values of resilience to the individual, household, community, and nation. Such a path requires a commitment to a new vision that includes shared responsibility for resilience and one that puts resilience in the forefront of many of our public policies that have both direct and indirect effects on enhancing resilience.
>
> The nation needs to build the capacity to become resilient, and we need to do this now. (NAS, 2012).

Managerial Priorities

Water managers are interested in enhancing their programs' resilience. However, the "tyranny of the urgent" all too often dominates decision-making. Attention and resources are directed toward providing good services, satisfying customers, and complying with regulations — often at the expense of preparing for potential disruptions to operations. Managers know they need to prepare — indeed, these concerns can cause them sleepless nights — but it is hard to find the time and resources to do so. It is also often unclear for which threat to prepare. Generally, managers end up controlling risk by instituting internal controls, purchasing insurance, and establishing safety plans. They make operations more efficient. They hope these activities make their systems resilient. But for most organizations this range of efforts falls short of addressing overall system resilience. Managers need tools for specifically assessing system resilience, determining points of vulnerability, and leveraging investment to build resilience into their systems.

This article introduces a suite of resilience attributes that can be used to develop metrics for comparing project alternatives and tracking progress towards resilience in water resource programs. We make a number of recommendations with reference to the current federal efforts to update guidance concerning federal agency water resources investments.

RESILIENCE

System Viability

Resilience is a concept that has evolved based on decades of research in engineering, ecology, and other sciences, and it is also a trending buzzword hard to miss in discussions as diverse as: ecosystem restoration; disaster response and hazard mitigation; climate change adaptation; energy security; cyber security; and community preparedness. Developing and maintaining resilience within water resource programs is particularly crucial to ongoing water system viability. To be successful we must translate resilience theory to practice.

Resilience definitions vary. Engineers and business leaders often think of resilience as the amount of disturbance a system can resist or the speed with which it returns to equilibrium (Holling, 1973). This approach implicitly assumes an equilibrium point and some degree of stasis in the system — an approach not necessarily descriptive of large open systems.

Defining Resilience

Over four decades of research, ecologists and others focusing on natural systems and social systems have developed a "social-ecological systems" definition for resilience: The amount of disturbance that a system can absorb without changing structure, feedbacks, function, and overall identity (Holling, 1973; Walker et al. 2004 and 2006). This definition recognizes that these systems adapt, survive, and thrive despite a wide range of stresses and disruptions within very dynamic circumstances. No open system can seek resilience by remaining static.

FEDERAL GUIDELINES FOR WATER PROJECTS

Federal Guidance Update

In March of 2013 the Obama Administration's Council on Environmental Quality (CEQ) issued an update to the guidance that had governed how Federal agencies evaluate proposed water resource development projects since 1983 (*Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (US Water Resources Council, 1983)). The new document — *Principles and Requirements for Federal Investments in Water Resources* (CEQ, 2013; website below) — provides direction for evaluating and selecting major water projects, including projects related to: navigation; storm resilience; wetland restoration; and flood prevention. The update states that it is intended to help "accelerate project approvals, reduce costs, and support water infrastructure projects with the greatest economic and community benefits."

Water Resource Resilience

"PR&G"

In December of 2014 the administration issued *Interagency Guidelines for Federal Investments in Water Resources* (CEQ, 2014), which updates interagency guidance to ensure consistency and compatibility across the affected federal agencies.

In practice, these updated documents are now used in combination and referred to as the Principles, Requirements, and Guidelines or "PR&G." The updates are designed to allow agencies to better consider the full range of long-term economic benefits of protecting communities against future storm damage, promoting recreational opportunities that fuel local business, and "supporting other locally driven priorities" (CEQ, 2013). Federal agencies falling under the PR&G include: the Army Corps of Engineers; Environmental Protection Agency; Department of Agriculture; Department of the Interior; National Oceanic and Atmospheric Administration; Tennessee Valley Authority; Federal Emergency Management Agency; and Office of Management and Budget.

Projects Criteria

The PR&G emphasize that water resources projects should maximize economic development, avoid the unwise use of floodplains, and protect and restore natural ecosystems (CEQ, 2013; Michelsen, 2014). The PR&G establish criteria for evaluating new water projects, asking the question: Do the benefits of a proposed project match or exceed the costs of the project? The PR&G also require agencies to promote resilient ecosystems while supporting sustainable economic growth.

Implementation Procedures

The next step in the administrative process is for the affected agencies to develop Agency Specific Procedures for implementation. This establishment of new agency implementation procedures poses a tremendous opportunity for incorporating resilience thinking into these decisions. One option is for agencies to use a set of resilience metrics to provide a structure and comprehensive basis for justifying investment decisions when assessing risk, uncertainty, and tradeoffs. The efficacy of such an approach will depend on meaningful resiliency measurement and evaluation.

Questions pertinent to be addressed in this article include:

- Do the PR&G incorporate system resilience?
- How should the affected agencies define and measure resilience?

Resilience Metrics

The PR&G frame a comprehensive, systems-based approach and introduce the concept of resilience. However, they do not follow through with specifics for how resilience should fit into project and program evaluation. The PR&G do not fully describe what constitutes a resilient project or program, nor do they incorporate resilience considerations into the framework for evaluating water resource investments. The Interagency Guidelines state that "systems-level models are needed to accurately describe the interactions of ecosystem components under stress and predict their response. No standard methods or models for measuring ecosystem resilience currently exist" (CEQ, 2014). This gap in the policy and in the state of the science contributes to uncertainty and leaves room for conflicting interpretations as agencies develop their implementation procedures. To alleviate these weaknesses, we propose that the set of resilience attributes described in this article (and more fully in Kerner and Thomas, 2014) be used for enhancing agency understanding of what constitutes system resilience and for developing resilience metrics for increasing accountability within water resource planning.

WATER RESOURCE RESILIENCE ATTRIBUTES

System Vulnerability

Continuing to assume that adequate water (and requisite energy) supplies will be readily available — either through technological innovation or discovery of new sources — appears unrealistic. Recognizing this uncertainty, many water agencies have optimized their water portfolios to rely predominantly on the most efficient mode of water production and delivery available. However, changes to water supplies over time, or in sudden, low-frequency/high-consequence events, can upset these carefully optimized systems. To combat such vulnerability, agencies are increasingly acknowledging the limits to even the most sophisticated technologies and aggressive extraction strategies. They have begun to adopt a resilience approach that recognizes the risk mitigation value of diversification, including a tolerance for suboptimal processes.

Honing Resiliency Definition

The PR&G define resilience simply and inclusively as "the capacity of an ecosystem or community to respond to changes, including climate change." This generality can be interpreted very broadly, enabling agencies to develop and interpret policies as they deem best fit their needs. Such flexibility is valued by the agencies, but a loose definition does not provide a good basis for measuring and assessing progress in implementing government initiatives. If resilience is all things to all people, then by what standard can it be measured? How can water managers know if system resiliency is sufficient or is falling short?

We recommend that the federal agencies, as well as State and local water agencies, adopt a "social-ecological systems perspective" on resilience. As discussed below, this perspective directly addresses how to retain the capacity for mission success, is inclusive of the other definitions (to an extent), and enables rigorous measurement — thereby supporting better decision-making and providing a basis for adaptive management.

Water Resource Resilience

Practical Language

Attribute Categories

Leadership & Initiative

Resilience Attributes

What attributes of a system reflect whether a water system will be able to continue to function and retain its identity in the face of existential challenges? We considered attributes for all types of systems, including natural and manmade, physical and institutional, small and large, simple and complex (Kerner and Thomas, 2014). Building on others' efforts (e.g., Holling, 1973; Lovins, 1982; Walker et al., 2006), we have delineated and defined these common resilience attributes.

With an eye toward practicality, we describe these resilience attributes in the language of managers and stakeholders. The terms address easily-assessed water system attributes without requiring extensive knowledge of new theory, and they promote the ready consideration of the broadest range of factors that could affect water system resilience. To meet typical stakeholder needs, we focus on system traits that can be construed from commonly available information. The terms form a baseline for resilience analysis, providing a snapshot of a water system's resilience posture that can be retaken on a regular basis as part of an adaptive management strategy to maintain and enhance system resilience.

Resilience attributes are sorted into three categories:

Stability: attributes that relate to an inherent ability to *withstand* the stresses

Adaptive capacity: attributes that address a water system's ability to *respond* to stresses

Readiness: attributes that might enable or impede that response

In other words, managers need to know if their water system: can survive a challenge as things currently stand (Stability); has the ability and options to respond if necessary (Adaptive Capacity); and understand if there are factors that help or hinder that response (Readiness). Broader definitions for these categories are now discussed:

Stability

Stability denotes the degree to which a water system can continue to function if inputs, controls, or conditions are disrupted. It is a reflection of: how minor a perturbation is capable of rendering the water system inoperable or degraded; the types of perturbation to which the system is especially vulnerable; and whether the system can "ignore" certain stresses; and the degree to which the system can be altered by surprise.

Adaptive Capacity

Adaptive capacity is the ability of a water system to reorganize and reconfigure as needed to cope with disturbances without losing functional capacity and system identity. It reflects an array of response options and the ability to learn, adapt, and create new strategies to ensure continued functionality.

Readiness

Readiness addresses how quickly a water system can respond to changing conditions. It is affected by the physical, organizational, social, psychological, or other barriers, internal or external, that might impede timely response. Readiness is a measure of responsiveness. Its converse is entanglement, a measure of the forces impeding responsiveness.

The resilience attributes do not arise from the categories, but the categories instead arise from a convenient grouping of the attributes. Each of the attributes in fact features some degree of all three categories. Within each of these three categories, there are specific system attributes to consider (Table 2). These resilience attributes are defined in Table 3 (next page).

Table 2. Resilience Attributes

Stability	Adaptive Capacity	Readiness
Single Points of Failure	Response Diversity	Situational Awareness
Controllable Degradation	Collaborative Capacity	Simplicity/Understandability
Resistance	Connectivity	Preparedness
Balance	Abundance/Reserves	False Subsidies
Dispersion	Learning Capacity	Autonomy
Leadership and Initiative		

Complementing the resilience attributes, strong leadership and initiative are important factors for achieving resilience. Leadership and initiative transcend the other categories and are foundational to the development and maintenance of resilience.

Taken together, the attributes are intended to provide the necessary but sufficient terms to fully describe the resilience posture of any water system. While there is significant overlap between the attributes, each term has been found adequately unique to stand as a separate trait. Note that certain attributes will play a more prominent role than others for any given situation, but the entirety of the list is intended to provide a firm foundation for assessing and managing resilience. Moreover, changes that foster improvements in some areas of resilience may reduce it in others, with trade-offs being necessary.

Water Resource Resilience

Table 3. Definitions of Resilience Attributes	
Stability Category	
Single Points of Failure	Singular features or aspects of the system, the absence or failure of which will cause the entire system to fail.
Pathways for Controlled Reductions in Function	Whether the functionality of a system, operation, or capability can be reduced in a manner that avoids the overwhelming effects of an unconstrained failure.
Resistance	The insensitivity of the system to stresses of a given size, duration, or character.
Balance	The degree to which a system is not skewed toward one strength at the expense of others.
Dispersion	The degree to which the system is distributed over space and time.
Adaptive Capacity Category	
Response Diversity	The variety and disparity of steps, measures, and functions by which an operation can carry out a task or achieve a mission.
Collaborative Capacity	The capacity to act through coordinated engagement.
Connectivity	How readily resources and information can be exchanged to ensure continued functionality.
Abundance/Reserves	The on-hand resource stores (capital) upon which a system can rely when responding to stress.
Learning Capacity	The ability to acquire, through training, experience, or observation, the knowledge, skills, and capabilities needed to ensure system functionality.
Readiness Category	
Situational Awareness	How well system, component, and functional capabilities are monitored. How readily emerging stresses or failures can be detected.
Simplicity/Understandability	How well system functions and capabilities can be understood.
Preparedness	The level of preparation in plans, procedures, personnel, and equipment for responding to system perturbations.
False Subsidies	Whether inputs, outputs, or internal processes receive incentives disproportionate or unrelated to their value.
Autonomy	A system manager's authority to select and employ alternate actions, configurations, and components in response to stress.
Enabling Traits	
Leadership and Initiative	The ability to motivate, mobilize, and provide direction in response to disruptions, as well as the ability to assume responsibility and act.

RESILIENCE ATTRIBUTES AND TARGETING QUERIES

FOCUSSING ON THE NEED FOR METRICS

Metrics Tailoring

This section provides full descriptions of the resilience attributes, each presented with several associated "targeting queries" (Army REF, 2013; Kerner and Thomas, 2014) to further assist in understanding the intention of each attribute, and to support use of metrics derived from the resilience attributes. The resilience attributes can be used widely and across water systems. Effective metrics should be tailored to the specific system being managed. These select targeting queries provide a means to bridge that gap and facilitate metric delineation. (*See* Kerner and Thomas (2014) for a more detailed discussion of the targeting queries). Following each attribute description and select targeting queries, examples are offered that depict tangible factors of potential interest in a resilience assessment of a water system, project, or program.

Stability Category

Stability

Generally, stability refers to the inherent ability of a water system, as currently structured and functioning, to remain unaffected or minimally affected by disruptive forces (Walker et al., 2004). More specific stability attributes are now discussed.

Water Resource Resilience

Failure Points

SINGLE POINTS OF FAILURE

Single Points of Failure addresses those singular features or aspects of the water system, the absence or failure of which will cause the entire system to fail (*see* Lovins, 1982).

Single Points of Failure can include physical, human (manpower, skills, leadership, cultural, psychological, political, organizational, legal, regulatory), and other factors. They develop when a water system is overly reliant on certain resources or capabilities that, if lost, can threaten functionality. Systems may fail catastrophically. More commonly, however, specific stresses will challenge critical weaknesses in a system. Even seemingly robust systems have single points of failure, but the circumstances for their emergence may be relatively rare.

Select targeting queries:

- On what physical and human factors does the water system depend?
- Do single points of failure emerge only after a certain period of time? How well known are the time delays?
- Do single points of failure emerge without warning, or are there forewarnings or other indicators? How well known are the warning signs?

Example: The Water Agency purchases imported water from a single wholesale agency. The conveyance system and agency agreements are established to support only that single source of imported water.

Functionality Reductions

PATHWAYS FOR CONTROLLED REDUCTIONS IN FUNCTION

This attribute addresses whether the functionality of the water system can be reduced in a manner that avoids the overwhelming effects of an unconstrained failure (as derived from Lovins' (1982) concept of stability).

A water system might not be able to retain its full function beyond a certain duration or degree of external stress, but it can "fail gracefully" if it can maintain sufficient functionality long enough to engage compensatory measures or mitigation responses. Uncontrollable collapse may be mitigated by the development of Redundancy, Response Diversity (specifically substitutability), and Preparedness, and by enhancing Situational Awareness.

Select targeting queries:

- Are there methods for controlling a reduction in system function? Can problems be isolated and contained?
- Can a managed reduction in functions and services be initiated before the onset of an unconstrained failure?

Example: When faced with temporary process disruptions in its treatment plants, the Water Agency is able to draw from reservoir storage to maintain sufficient output to meet customer demand.

Resisting Stress

RESISTANCE

This attribute addresses the insensitivity of the water system to stresses of a given size, duration, or character. Water systems possess varying degrees of Resistance to different stressors. Some systems are unaffected by stressors that may disrupt other systems.

Select targeting queries:

- Does the water system have a history of being relatively unaffected by certain types of stresses?
- Can the system endure certain challenges for a known period or with a minimum of additional resources?
- Are there specific conditions under which the system is resistant to challenges and others under which it is more vulnerable?

Example: Because the Water Agency draws a majority of its water from a local groundwater source, it is able to withstand droughts and conveyance disruptions that may affect its imported water supplies, compared to neighboring water agencies lacking the local groundwater resources.

Balancing Strengths

BALANCE

This attribute addresses the degree to which a water system is not skewed toward one strength at the expense of others (Kerner and Thomas, 2014). *See* also Biggs et al., 2012. A water system is in Balance when its inputs, controls, processes, and outputs do not weaken the system over time or build vulnerability to certain types of stress. A system retains Balance when it does not sacrifice certain strengths in favor of optimizing others. "False Subsidies" (see below) can skew a system out of Balance. Situational Awareness and Preparedness may be able to bring a system into Balance if sufficient reserves are available.

Select targeting queries:

- Is the water system skewed to a particular strength?
- How well does the system handle a wide variety of services and challenges?
- Is the system subsidized to favor certain services over others?

Service Portfolio

Example: The Water Agency provides a number of services: it sells potable water; collects, treats, and disposes of wastewater; produces and sells recycled water; and is increasing its capability to generate electricity to power its operations. This Balance within its portfolio of services provides multiple sources of revenue as well as multiple sources of water for various uses.

Water Resource Resilience

Dispersion (Space/Time)

DISPERSION

This attribute addresses the degree to which the components of the water system are distributed over space and time (*see* Lovins, 1982). Dispersion provides separation from systemic stressors. As a system evolves over time, dispersion may build resilience by fostering: independent development of processes and capabilities; disparate strategies for responding to stress; and novel responses to external influences. Dispersion can be employed as part of a strategy to control the degradation of a system. It also supports development of Autonomy. Dispersion is loosely, and inversely, related to Connectivity.

Select targeting queries:

- What form does the system dispersion take (e.g., separation due to distance, time, physical barriers, technical barriers, administrative or other organizational division, etc.)?
- Is the separation sufficient to prevent the spread of systemic stresses?
- Does the distribution drain resources or slow responses to challenges?

Example: The Water Agency has multiple treatment plants. Its labor force is also drawn from several towns. Road closures or other emergencies in one location do not prevent staff from other locations reaching the plants. The Water Agency also spreads business among several financial and underwriting institutions.

Adaptive Capacity Category

Coping with Disturbance

Adaptive Capacity is the ability of a water system to reorganize and reconfigure as needed to cope with disturbances. Adaptive Capacity in ecological systems is related to diversity and heterogeneity of biophysical parameters, whereas in social systems it is "the existence of institutions and networks that learn and store knowledge and experience, create flexibility in problem solving and balance power among interest groups" (Resilience Alliance, 2013).

Response Options

RESPONSE DIVERSITY

Response Diversity addresses the variety and disparity of steps, measures, and functions by which a water system can deliver a service (as derived from Holling, 1973; Lovins, 1982; Walker and Salt, 2006; Walker et al., 2006; Kerner and Thomas, 2012 and 2014; *see also* Biggs, et al., 2013; Anderies et al., 2013). Response Diversity refers to the number of different options, and the breadth of and comprehensiveness across that difference, available to achieve a mission or task. It involves all aspects of a water system: human-built and natural; subsystems and components; manpower; and skill sets. Variety enables managers to select operational modes and capabilities that are either unaffected by perturbations or are able to spread the force of the disturbance over multiple system facets — allowing the system to continue to function as intended. Response Diversity includes "substitutability" — i.e., how readily different functional capabilities or sources of supply can be employed to achieve a mission, function, or task.

Select targeting queries:

- How easily can a task or function be accomplished in different ways or with different resources? How readily can this be done under stressed conditions?
- To what degree can substitute or redundant capabilities, components, subsystems, controls, resources, skill sets, or features be combined, modified, or directly employed?
- What burdens are placed on the water system to maintain redundancies? Does the presence of redundancies foster complacency?

Example: The Water Agency employs state of the art technologies for most of its treatment plants, but also maintains some older processes that can provide backup in case new equipment fails and replacement parts are not readily available. Additionally, while its predominant source of energy is the electric grid, it also maintains natural gas-powered generators to keep operations going during power outages.

Coordinated Engagement

COLLABORATIVE CAPACITY

This attribute addresses the capacity to act through coordinated engagement (as derived from Walker and Salt, 2006; Walker et al., 2006; Thomas and Kerner, 2010; Biggs et al., 2013; Stokols et al. 2013. Described in Kerner and Thomas, 2014). Collaborative Capacity refers to the potential of a water system and its component parts to work in a cooperative manner to achieve a desired function or capability. It involves the ability to engage linkages — including: relationships; authorities or permissions; understanding of roles; and communication in a timely and flexible manner — to ensure system functionality. Collaborative capacity enables a water system to provide services that would be too burdensome for the system or any component part to maintain on its own. Collaboration may be voluntary or compulsory (via regulation).

Select targeting queries:

- Do managers and stakeholders know others within the system with whom they can act, and how to make that coordination happen effectively?
- Can linkages be established and utilized in a sufficiently timely manner?

Linkages Use

Example: The Water Agency has good relationships with its commodity suppliers, who are willing to adjust their supply rates to meet Agency needs if a surge or drop in production is needed.

Water Resource Resilience

Response Flexibility

Isolating Threats

CONNECTIVITY

This attribute addresses how readily resources and information can be exchanged to ensure continued functionality (*see* Biggs, et al., 2013; Kerner and Thomas, 2014). Connectivity includes sharing at larger and smaller scales, i.e., with water systems of which an agency is a part hierarchically as well as with its own subsystems and adjacent systems. Connectivity confers resilience by providing response flexibility and situational awareness. It allows managers and stakeholders to proactively alter their readiness posture in anticipation of looming challenges, or to rapidly exploit information and resources in response to surprises. While connectivity may help avoid water system failure by allowing stresses to be spread over several systems, it may also hasten an even larger collapse as the demands of one failing system can overwhelm others from which it draws support. As such, it may be desirable to have connective links that can be decoupled when desired, thereby isolating threatening disturbances and preventing larger failures. Connectivity involves feedback loops that send signals about how system activities affect connected systems and subsystems. Loose feedback loops reduce resilience by slowing system response to disturbances or masking system affects upon subsystems or adjacent systems.

Select targeting queries:

- Where, when, and how are information and/or resources exchanged?
- Are the pathways and links for that exchange known? How well are they maintained?
- Can connectivity pathways and links be severed when necessary to prevent the spread of problems?

Example: As a member of the regional water authority and state association of water agencies, the Water Agency maintains an active information sharing culture. Regarding its system of water conveyance and delivery lines, the Water Agency has options for rerouting and decoupling to provide service while working around maintenance or repair issues.

Resource Stores

ABUNDANCE/RESERVES

This attribute addresses on-hand resource stores upon which the water system can rely when responding to stress (per Kerner and Thomas, 2014; *see also* Resilience Alliance, 2010; Stokols et al., 2013). Abundance/Reserves is the excess capacity with which a water system, in response to a stressor, is able to surge delivery of resources above normal requirements by engaging compensatory measures or mitigation responses, thereby sustaining functionality.

Select targeting queries:

- What resources does the water system maintain for immediate engagement when stressed?
- Are the system's reserves monitored and their limits known?
- Is the system made vulnerable or less stable when it employs its reserves?

Example: The Water Agency's just-in-time inventory practices for water treatment supplies leave it vulnerable to supply chain disruptions and abrupt price escalation of key materials.

Acquiring Knowledge

LEARNING CAPACITY

This attribute addresses the ability to acquire, through training, experience, or observation, the knowledge, skills, or capabilities needed to ensure system functionality (Kerner and Thomas, 2014. *See also* Resilience Alliance, 2010; Folke et al., 2010; Anderies et al., 2013). Learning Capacity may be a trait of individuals as well as organizations. It involves the ability to combine or obtain different types of knowledge to support system readiness and responses to disturbance.

Select targeting queries:

- Is there a culture of learning within the water system?
- Is there an active lessons-learned program in place?
- Have personnel received expected training?

Example: The Water Agency does not pay to keep its employees' skills current, and only minimal on-the-job-training occurs due to little interaction between staff. As a result, the Agency has difficulty engaging current employees in new practices, attracting the highest quality recruits, and employing new technologies that would enhance services.

Responsiveness

Readiness Category

Readiness is a measure of responsiveness; its converse is entanglement, a measure of the forces impeding responsiveness. While readiness is affected by physical traits, it is even more prominently driven by institutional factors. It manifests spatially and temporally. Factors of readiness may have arisen as a water system evolved. Altering those factors may quickly challenge functionality.

Understanding & Monitoring

SITUATIONAL AWARENESS

This attribute addresses how well the water system functional capabilities are understood and monitored (*see* Kerner and Thomas, 2012 and 2014; Anderies et al., 2013) and how readily emerging stresses or failures can be detected and acted upon to minimize adverse effects. Situational awareness includes an understanding of the system's potential tipping points and possible means to avoid passing them. This includes an awareness of how system components present opportunities or vulnerabilities in the face of challenges. It is a measure of the ability to recognize critical dependencies. Situational Awareness relies on the availability of accurate, useful, and timely information, including sufficiently frequent updates.

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Select targeting queries:
- How comprehensive is the information about the water system and environment within which it functions? Conversely, how well known are the information gaps?
- How current and understandable is the information provided?
- How well are personnel trained in knowledge of the overall system; in the use of system monitoring technology; and how to capitalize on advantages designed into the system?

Example: Via the regional water authority, the Water Agency monitors federal and state legislatures and regulatory agencies to stay abreast of changes that will affect compliance programs.

System Understanding

SIMPLICITY/UNDERSTANDABILITY

This attribute addresses how well system capabilities can be understood (as derived from Lovins' (1982) concept of Accessibility). Simplicity effects the degree to which system functions are readily understood. This does not mean that a system must be simple to be understood, but it refers instead to how well it is comprehended by people acting within the system. Simplicity can be enhanced by features that support understanding, such as technology (sensors and visual aids that readily explain status), techniques (daily observations), and strategies (the culling of the excess and superfluous).

Select targeting queries:
- How is system understanding achieved and maintained?
- How is system understanding shared or transferred? How readily can a new manager or a stakeholder understand the system?

Example: Due to recent changes in key management, new Water Agency corporate personnel do not yet fully understand their underlying financial arrangements. Similarly, with the retirement of long-term plant employees, leadership does not fully comprehend operational capabilities and constraints. However, the Water Agency has good records, and the plants have standing operating procedures and manuals that can be used to rectify this shortcoming.

Response Planning

PREPAREDNESS

Preparedness refers to the existence of plans and procedures by which the water system can respond to perturbations and stressors. It addresses whether contingencies have been considered and thought through, including expected disturbances but also, and perhaps more importantly, disturbances for which little consideration would normally be given but for which the system is particularly vulnerable. Preparedness may involve formal plans that are tested, regularly exercised, and kept current, as well as informal plans that are developed on an impromptu basis.

Select targeting queries:
- Do response plans and procedures exist? Are they formal or informal?
- How accessible are plans and procedures? Are they well maintained and tied to training and exercises?
- Are personnel well prepared and aware of threats?
- Is equipment well maintained?

Example: Because the Water Agency has suffered during previous material and manpower shortages, it has developed contingency plans in case those problems re-emerge. It has not updated or practiced those procedures, however.

Skewed Supports

FALSE SUBSIDIES

False Subsidies refer to whether the water system receives external support that exceeds, or is unrelated to, the services it provides. These skewing incentives may come in many forms, including: financial; material; organizational; legal; social; and cultural. They may be formal or informal, sought or imposed. False Subsidies influence a system to function in a manner different than it normally would. The unwanted effects of subsidies may emerge unintentionally and even undetectably as a system evolves.

Select targeting queries:
- Are any false subsidies observed?
- How readily can detrimental subsidies be discontinued, either temporarily or permanently?
- Who controls the false subsidies, and how engaged is that controlling entity in the function or purpose of the water system?

Example: The cost of imported water has been kept artificially low due to federal subsidies. The Water Agency has structured its water production capability around these low costs. If national sentiment about the environmental hazards of long-distance water transfers were to influence government officials to end the subsidies, the Water Agency may face drastic increases in the cost, or potentially outright loss, of imported water. Absent the false subsidy, the Water Agency would have sought to develop a different, less vulnerable water supply portfolio.

Choice Controls

AUTONOMY

Autonomy refers to the degree to which a water system controls its own destiny. It depends on the authority of water system personnel and stakeholders to select and employ alternate actions, configurations, and components in response to stress. Autonomy enables choice in the timing, order, and priority of actions deemed appropriate for a given circumstance to avoid systemic failure. It allows personnel

Water Resource Resilience

Structuring Autonomy

and stakeholders to select or establish the relationships necessary to function, and to loosen, tighten, or otherwise change the nature of those linkages as necessary. It also allows them to make modifications and trade-offs that ensure continued system functionality. Water system personnel who require permission in how and when to act may encounter costly delays and receive instructions from those not close enough to fully understand the nature of the problem.

Select targeting queries:

- Can autonomy be exercised on a situational basis, e.g., in proportion to the stressor, for specific stresses or system features, or on a time-limited basis?
- Are personnel trained to handle autonomous decision-making?
- Does the right or authorization to act autonomously include the ability to negotiate and coordinate with other parties?

Example: The Water Agency's management approach is rigid and hierarchical, so employees must receive permission before making even simple changes in how they accomplish their work. When production or maintenance problems emerge, much time is wasted awaiting authorization to make necessary fixes.

ENABLING RESILIENCE

Leadership Need

Strong leadership is necessary to motivate, mobilize, and provide direction in response to disruptions. Strong leadership is underscored by initiative to assume responsibility and act. These enabling traits transcend the categories depicted above and are foundational to the development and maintenance of all resilience attributes.

Water system managers, personnel, and stakeholders exercise leadership and initiative to respond to changing conditions. They select from possible responses and create new options in reaction to shocks and disturbances. Strong leadership entails accountability. Leadership tempers initiative, using judgment and patience to determine when to effectively engage a problem. Leadership and initiative involve knowing how to leverage actions to greatest effect and how to moderate any actions so as to achieve the most desirable outcomes (Ostrom, 2005 and 2009; Olson et al., 2006; Walker and Salt, 2012; Kerner and Thomas, 2014).

Leadership Support

Select targeting queries:

- Do the leaders possess the authority to affect changes and negotiate with governmental agencies and other stakeholders?
- Do the leaders have enough history within the system to be knowledgeable about system conditions, vulnerabilities, and threats?
- Do system rules present incentives or obstacles to initiative in the face of system challenges?

Example: The Water Agency's leadership is very hierarchical, with the General Manager having authority over all operations. However, the GM is new and inexperienced regarding Agency operations, regional setting, and external stakeholders.

RESILIENCE BENEFITS

Compatible Metrics

Using a common approach for characterizing the resilience of different water systems will help federal and state water agency managers to aggregate resilience assessment results and chart progress toward goals over time and among disparate areas of assessment. If the underlying metrics for resilience are incompatible, this is difficult to do in any meaningful way.

Additional Benefits

Additional benefits include the following:

- Filling the current gap in the PR&G regarding measurement of system resilience for evaluating benefits and costs of federal water project investments.
- Supporting informed decision-making, providing a common basis for comparing and understanding resilience across water systems.
- Supporting identification of potential problems and tipping points, instead of learning from failures or from systems on the edge of failure.
- Providing additional insights about the effect of policies and practices on system function in the face of unforeseen challenges.
- Providing a basis to assess and compare trends over time. It also supports the evaluation of investment and intervention options (Thomas, 2009; Thomas and Mouat, 2011).
- Providing an additional line of evidence for making investment decisions by water resource and regulatory agencies, managers of federal installations, states and municipalities, and water utilities.
- Providing ties to strategic planning objectives and milestones. Generating quality metrics is typically the most challenging part of the strategic planning process. Using these resilience attributes and targeting queries to develop system-specific metrics can greatly improve strategic plans while incorporating resilience principles.
- Supporting adaptive management. The resilience attributes lend themselves to assessing system thresholds and sensitivities within adaptive management programs.

Water Resource Resilience

Applying Resilience

Categorical Applications

Assessment Process

Supply Disruption

RESILIENCE APPLICATIONS

Resilience methods are intended for application at multiple scales within water systems. This scalability supports the development of organizational resilience strategies, policies, programs, and training. For example, water agency managers may focus on building water resilience by increasing redundant sources of supply for critical applications (involving the resilience attribute of Response Diversity) and addressing how to deal with delivery interruptions — both short term and long term — within their emergency response plans (Preparedness and Pathways for Controlled Reductions in Function).

Resilience may be increased immediately by developing additional interconnections and alert systems (Connectivity and Situational Awareness). Managers may focus efforts to build resilience by conducting drills and exercises to test for Single Points of Failure, critical dependences, and the ability to substitute power types for key systems, e.g., testing regular and extended use of back-up power for water treatment and conveyance (Response Diversity).

Legislators and federal and state water agency managers may assess water policies with an eye toward realigning or eliminating incentives that provide funding support but work against making recipients more resilient (False Subsidies).

Potential applications of the resilience attributes to water resources management, and suggestions for how they might be employed, are delineated in Table 4.

Table 4. Examples of Applications for Resilience Attributes and Metrics

Category	Application
Federal and State Water Agencies	• Set resilience goals and establish resilience metrics while administering the PR&G for federal water projects. • Perform assessment of critical infrastructure's resilience to climate change in response to the 2013 Executive Order on Climate Change Adaptation and Resilience. • Develop uniform analytical metrics and assessment methodology for Federal agencies' response to Presidential Policy Directive-21 regarding Critical Infrastructure Security and Resilience. • Assess water resource resilience in the face of climate change, including changing relationships in the water-energy-food nexus. • Use resilience metrics to assess the quality of Integrated Regional Water Management Plans, Groundwater Management Plans, and similar plans.
Municipal Water Agencies	• Incorporate resilience metrics into Integrated Regional Water Management Plans, Capital Improvement Plans, and similar required plans. • Assess resilience of municipalities' water resources and critical infrastructure to climate change and prolonged drought. • Develop resilience-based funding rationale for grant applications.
Watershed Management	• Incorporate resilience metrics into watershed management plans and water quality improvement initiatives.
Communities	• Assess the disaster preparedness of a community and tailor emergency response exercises toward the weakest sectors. • Incorporate resilience metrics into community preparedness and emergency response plans for flooding and drought. • Evaluate the resilience of water-reliant, rural agro-economies and develop the funding rationale for capacity building and development.

CONCLUSION

Development of the resilience attributes described herein has been a synthesis of systems engineering and ecological resilience theory. The resilience attributes were developed to characterize human-managed systems, where shifting baselines can greatly alter system dynamics. These attributes have been refined through a dozen iterations and are the subject of a longer, more detailed, open access journal article by your authors: *Resilience Attributes of Social-Ecological Systems: Framing Metrics for Management* (access information below). The collection of resilience attributes focuses on the key factors affecting the resilience of most systems. Moreover, certain variables will play a more prominent role than others for any given situation, but the entirety of the list is intended to provide a firm foundation for beginning the resilience assessment process.

Competition for water is rendering resources ever tighter, leaving water systems and stakeholders increasingly vulnerable to even small supply perturbations. The first response of many water agencies is to go after the "low hanging fruit" of water efficiency and conservation measures, and that is a sensible approach. But while these measures are necessary and generally help to build resilience, they are not

Water Resource Resilience

Tight Definition

Standard Measurement

Threat Recognition

enough. Efficiency myopia may drive performance, profit, or savings over the short term, but eventually the low-probability, high-consequence events — earthquake-damaged infrastructure, sabotage, or extreme drought, for example — will threaten stability. Continuing to rely upon the least costly supplies without systematically exploring and preparing to use alternatives would leave managers and stakeholders with few choices when the supply gradually (or suddenly) runs out.

Establishment of the Agency Specific Procedures for implementing the new PR&G provides an opportunity for pursuing resilience by exploring and preserving options, seeking diversity in water and energy sources, and monitoring supplies and demand parameters at multiple scales. Critical to achieving water resilience, however, is the ability to quantify and control. A tight definition for water resilience is needed to focus federal cost-benefit assessments, and a common set of resilience metrics should be adopted to standardize measurement. Water managers, whether federal agency personnel or local water district staff, can incorporate resilience metrics to make their plans and programs more robust to disruption. Since metrics are best developed with the specifics of the system being managed in mind, we developed for each resilience attribute the generalized "targeting queries" presented above, which can aid managers in tailoring metrics for their systems.

We advance this proposed suite of resilience attributes to aid resource managers and planners in recognizing threats and vulnerabilities. The resilience attributes provide a basis for developing resilience metrics that support existing resource management plans and programs and bring a new perspective for prioritizing objectives, planning resource allocation, and defending investment decisions. Use of the attributes and metrics can provide an image of the resilience posture of a system. Deeper analysis is necessary to understand more complex phenomena such as "panarchy," "precariousness," and other resilience concepts, and that can be attained using the system-level models discussed in the Interagency Requirements, as noted above. Absent that deeper analysis, however, agencies can use the resilience metrics and follow an adaptive management approach to learn about system behavior and system resilience over time.

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Interagency Guidelines for Federal Investments in Water Resources available at: www.whitehouse.gov/sites/default/files/docs/prg_interagency_guidelines_12_2014.pdf

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Water Resource Resilience

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IN-PIPE HYDROPOWER

PORTLAND'S IN-PIPE HYDROPOWER SYSTEM SECURES 20-YEAR POWER PURCHASE AGREEMENT

by Jennifer Allen Newton, Bluehouse Consulting Group

In-Pipe Hydropower

Renewable Energy

Gravity Flow

In-Pipe Technology

Continuous Monitoring

Private Funding

20-Year Buyout Option

INTRODUCTION

The Portland Water Bureau (PWB) and Lucid Energy in Portland, Oregon have turned a major city water pipeline into a generator of renewable energy for Portland General Electric customers. The Conduit 3 Hydroelectric Project incorporates a 200kW in-pipe (or in-conduit) hydropower system that uses the gravity-fed flow of water inside a PWB pipeline to spin four 42-inch turbines. The Portland system, which was installed with no out-of-pocket costs to the City or the Portland Water Bureau, has the distinction of being the first project in the US to secure a 20-year Power Purchase Agreement for renewable energy produced by in-pipe hydropower in a municipal water pipeline. The Portland Water Bureau will share in the revenues produced by the sale of electricity from the system, which will help them become more sustainable and reduce the cost of delivering water.

IN-PIPE HYDROPOWER

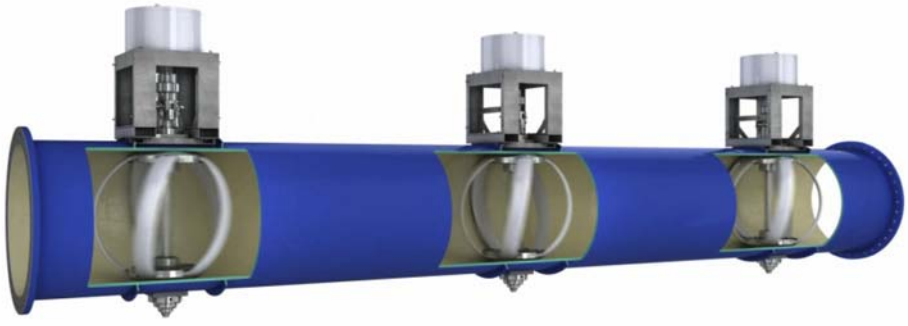
The in-pipe hydropower technology, known as the LucidPipe™ Power System, (*see* previous in-depth article in *TWR* #112) is installed in a section of large-diameter, gravity-fed water pipeline just upstream of a pressure reducing valve. LucidPipe uses a unique, spherical, in-pipe turbine that spins as water passes through it, producing clean, reliable, low-cost electricity with no impact on the environment or water delivery. The system helps water agencies improve their operations through smart monitoring and baseload energy production while providing a new potential source of revenue that can be used to offset energy costs and fund infrastructure improvements.

The system in Portland is expected to generate an average of 1,100 megawatt hours of energy per year, enough electricity to power up to 150 homes. In addition to sharing in the revenues from the energy produced by the LucidPipe system, PWB is also able to take advantage of the system's smart water infrastructure — providing continuous monitoring of system status — to improve efficiency and water operations. Conduit 3 began generating electricity in December 2014 and will be fully commissioned and generating at full capacity by March 2015.

NO OUT-OF-POCKET COSTS

The project was done at no cost to the City of Portland or to the Portland Water Bureau (PWB). Similar to the way large solar and wind projects are financed, the project was funded entirely through private investment — in this case from Lucid Energy and Harbourton Alternative Energy. Electricity generated by the project will be sold to Portland General Electric (PGE) through a 20-year Power Purchase Agreement (PPA) and the project will generate approximately $2 million worth of renewable energy capacity over the PPA period. As the project investor, Harbourton will share the revenue with the City of Portland and PWB to reduce the cost of water operations. After 20 years, PWB will have the right to purchase the system and own all the energy it produces. Since pipelines have useful lives in excess of 50 years, this is an excellent opportunity for the investor and the City. Producing in-pipe hydropower provides a way for PWB to use their own infrastructure to contribute to generating electricity for the community in a clean, low-cost, and renewable way and it will help the City of Portland meet its Climate Action Plan goals.

Cutaway of LucidPipe In-Conduit Generation System showing internal hydrofoils and external generators



PROJECT SPECIFICS

Portland provided an ideal location and opportunity for in-pipe hydropower generation. The LucidPipe installation in Portland was completed in conjunction with planned PWB construction. Installing the system as part of an existing PWB project helped keep costs down and minimizes disruption to operations. Engineering and construction of the project was subcontracted to local companies as much as possible.

In-Pipe Hydropower

Pressure Reducing Valve

Cost Reductions

"Smart" Monitoring

Precedent Set

Additional Opportunities

"The Water Bureau welcomed the opportunity to explore the innovative use of a Portland pipe delivering water to create hydroelectric power as well," said PWB Administrator David Shaff. "Water and energy are closely linked. The Lucid pipe system provides a way for the Water Bureau to contribute to generating electricity for our community in a clean, low-cost and renewable way."

With the addition of the new Powell Butte reservoir, PWB needed to install a new **p**ressure **r**educing **v**alve (PRV) to remove some pressure from the gravity-fed pipeline to ensure water is delivered to customers at the appropriate pressure. The construction of a new horseshoe-shaped segment of pipeline beneath 147th Street at Powell Boulevard for the PRV provided an ideal location and opportunity for installation of the LucidPipe system. Because LucidPipe extracts some pressure from the pipeline, the system was placed just upstream from the PRV. In addition to providing energy, this placement of the 4-turbine LucidPipe system, which extracts approximately 20 psi (pound per square inch) of pressure from the pipeline, reduces the workload of the PRV and helps extend its life.

SYSTEM BENEFITS & APPLICATIONS

The Portland LucidPipe system serves as a model for cities and water bureaus looking for ways to become more energy efficient and reduce costs. Energy is often the number one cost concern for water utilities. The Portland installation, which is the second LucidPipe installation in the US (the first was at Riverside Public Utilities in Riverside, California, where energy is used by the utility), has received considerable interest from municipalities and water utilities around the world, as they face ever-increasing energy costs and the impending need to repair and replace aging, and often leaking, water infrastructure.

In addition to providing clean, low-cost electricity, LucidPipe also includes smart monitoring technology that helps water agencies better manage their operations through real-time, continuous monitoring of system status, water pressure and water quality (e.g. turbidity, conductivity, pH, chlorine). Smaller-diameter turbines can also be used within water distribution lines to power smart monitoring technology alone, providing reliable power without the need for grid connection, batteries, or vandalism-prone above-ground solar stations.

The LucidPipe system is also suitable for use by industrial and agricultural users and can be incorporated into large-diameter, gravity-fed transmission and effluent pipelines.

CONCLUSION

The pioneering 20-year PPA for Portland has set a new precedent in the water industry by highlighting a new source of capital plus operational efficiencies that can be realized through the incorporation of in-pipe hydropower in municipal water pipelines.

"Water agencies are looking for ways to be more energy efficient, energy utilities are seeking more renewable sources of energy and investors are seeking opportunities in smart water and energy infrastructure," said Gregg Semler, President and CEO of Lucid Energy, Inc. "The industry is looking to Portland as an example of how all of these entities can partner to take advantage of in-pipe hydropower to generate investment returns and reduce the cost of delivering clean, safe drinking water."

Lucid Energy is currently exploring additional in-pipe hydropower development opportunities with other cities and water agencies around the country. Private funding is available for these projects, which, like Portland's system, can be completed with no out-of-pocket costs to the water agency.

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Previous *TWR* article: More comprehensive article concerning the Portland Water Bureau's in-conduit hydropower project appeared in *The Water Report* #112, which is available in PDF format upon request to: TheWaterReport@yahoo.com

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Yellowstone Compact

YELLOWSTONE RIVER COMPACT DECISION

SPECIAL MASTER RULING IN *MONTANA V. WYOMING*: LIABILITY, WITH LIMITED DAMAGES

by David Moon, Editor

Special Master's Report

INTRODUCTION

In late December, Special Master Barton H. ("Buzz") Thompson, Jr. — appointed by the US Supreme Court (Supreme Court) to hear Montana's allegations that Wyoming violated the Yellowstone River Compact — issued his *Second Interim Report of the Special Master (Liability Issues)* to the Supreme Court. *Montana v. Wyoming and North Dakota,* Case No. 137, Original (Dec. 29, 2014). Running 231 pages, the *Report* goes into great detail regarding the interstate dispute over the waters of the Tongue River, which begins in Wyoming and flows north into Montana before merging with the Yellowstone River.

Compact Flaws

BACKGROUND

The Yellowstone River Compact (Compact) controls the allocation of water among Montana, Wyoming, and North Dakota of post-1950 water rights from the Yellowstone River system, including the Tongue River and its tributaries. Pub. L. No. 82-231, 65 Stat. 663 (1951) (Compact). The Compact was ratified by the three states in 1951 and the US Congress consented to it that same year. The Special Master, though, noted in the *Report*, "[U]nfortunately, the Compact is not exemplary legal writing. The Compact does not explicitly address many key issues, perhaps because they were not anticipated. The Compact also is sometimes vague and ambiguous. As a result, Montana and Wyoming have argued over the meaning of various provisions of the Compact since its ratification." *Id*. at 14.

Liability Issues

Montana alleged that Wyoming violated the Compact by diverting and storing water from the Tongue River for uses arising *after* January 1, 1950, at times when pre-1950 water rights in Montana went unmet due to Wyoming's upstream use. Essentially, Montana has the burden to prove that it did not receive sufficient water to enjoy its pre-1950 water rights due to Wyoming allowing post-1950 storage or use of water upstream. Montana also has to prove that it provided adequate notice to Wyoming that it was receiving insufficient water for its pre-1950 rights. *Id*. at 35. Following earlier proceedings in this case, the two states agreed to bifurcate the action into two phases, a liability phase and a remedies phase. The *Report* addresses the liability phase, "examining whether Wyoming violated the Compact and, if so, the size of any violation… ." *Id*. at 3.

Efficiency Improvements Allowed

The case began in early 2007, with Montana alleging Compact violations within the Tongue and Powder River basins by Wyoming most years since the Compact was ratified in 1950. In 2011, the Supreme Court issued an important decision denying Montana's claim that Wyoming breached the Compact by consuming more than its share of the Tongue and Powder Rivers. *Montana v. Wyoming et al.*, Case No. 137, Orig.; 2011 WL 1631038 (5/2/11). In that ruling, the Supreme Court decided that the Compact does allow water users to switch from flood irrigation to sprinkler irrigation, so long as no additional acreage is irrigated. The Supreme Court concluded that "…the best evidence we have shows that the doctrine of appropriation in Wyoming and Montana allows appropriators to improve the efficiency of their irrigation systems, even to the detriment of downstream appropriators." *Id*. at 19. For additional information on that decision, including discussion regarding "return flow" and the "no injury rule," *see* Water Briefs, *TWR* #87 (May 15, 2011).

SPECIAL MASTER'S RULING

Wyoming Violations

The Special Master ruled that Wyoming did violate the Compact and improperly used water in Wyoming, thereby injuring Montana. Liability, however, was limited to the amount of water from Wyoming's post-1950 uses and storage *after* notification by Montana "that it needed additional water for its pre-1950 rights under Article V(A) of the Compact" in the years 2004 and 2006. *Report* at 220. With adjustments for "transit losses" from the point of diversion or storage and the Stateline, plus a deduction for "return flows" that would have been available to Montana during the irrigation season (from use of water from the Padlock Ranch reservoirs), the Special Master recommended that Wyoming's liability be limited to 1300 **a**cre-**f**eet (AF) for 2004 and 56 AF in 2006. Wyoming's Attorney General (AG), Peter K. Michael, has noted that the total replacement value of this water for both years is approximately $14,000 (Press Release, 12/29/14). The Special Master, while discussing future proceedings and the magnitude of the case, said that although the "current phase of the case did not concern the question of damages" those damages "might be as low as five figures." *Id*. at 228.

Limited Liability

Yellowstone Compact

Wyoming Views

Montana Views

Injury Determinations

"Interstate Call"

Notification Required

Notice Ruling

Groundwater Covered

Conjunctive Use

State Responses

Each state viewed the Special Master's recommendations quite differently. Montana focused on the finding of Compact violation. Wyoming focused on the limitation of damages found to have occurred.

Wyoming AG Michael, in the December 29th press release, stated that "in nearly every important respect, the Special Master sided with Wyoming." The press release went on to quote Wyoming State Engineer, Patrick Tyrrell: "While the Supreme Court did not agree with our interpretation of the Compact, we are glad to see that our estimates were correct and that these decisions have had almost no impact on Wyoming or its water users. With a few minor adjustments in our regulatory response to Montana in future years, Wyoming should have no difficulty meeting its obligations under the Compact."

Montana's AG Tim Fox, on the other hand, noted that "the United States Supreme Court agreed that Wyoming violated the Yellowstone River Compact to deprive Montana of the full enjoyment of its water rights in the Tongue River. The decision found Wyoming liable for depriving Montana of water in 2004 and 2006, years in which severe drought conditions significantly harmed Montana farmers and ranchers along the Tongue River." Montana AG Press Release (12/29/14).

The Special Master's finding that no liability exists unless Montana properly notifies Wyoming resulted in the Special Master's decision that "Wyoming's liability is relatively small." *Report* at 227. "Although Montana suffered shortages in multiple years, Montana has proven that it gave effective notice on specific dates only in 1981, 2004, and 2006. In 1981, there was no injury. In 2004 and 2006, Wyoming is liable for only 1,300 af and 56 af, respectively. Even if Wyoming were liable for all post-1950 storage and use in Wyoming in 2004 and 2006, not just storage and use that occurred after Montana's notice, Wyoming would be liable only for approximately 2,400 af in 2004 and 3,000 af in 2006." *Id*. at 227-228. Earlier, the Special Master explained that there was no injury in 1981 because during that year "…Montana complained only of shortages to the Tongue River Reservoir, which ultimately filled." *Id*. at 47.

Wyoming's December 29th press release directly addressed the Supreme Court's decision regarding the notice requirement or "interstate call." "Importantly, the Special Master also found that Montana has to make an affirmative call for water under the Compact before Wyoming has any obligation to act, and Wyoming cannot be liable for any use of water before a call is made."

Notification Requirement

The Special Master ruled that "…I conclude that Montana must notify Wyoming that it needs additional water for its pre-1950 appropriative rights, unless the states or the Compact Commission establish an alternative procedure. Absent notice, Wyoming is not liable under Article V(A) if it fails to reduce or eliminate post-1950 diversions or storage when Montana is short of water for its pre-1950 uses." *Report* at 47.

In laying out the groundwork for his conclusion regarding notice, the Special Master noted that: "Interstate compacts do not inherently require states to provide notice to each other when asserting their rights. States can be liable for failing to deliver water even when they are unaware of their compact obligation or disagree that they have an obligation." *Id*. at 47. "The Yellowstone River Compact, moreover, does not explicitly set out any specific procedure for enforcement of its provisions. No provision of the Compact explicitly requires one state to notify another state of its water needs." *Id*. at 48.

While acknowledging the lack of inherent requirement and Compact-specific procedures , the Special Master still found reasons for liability. "I nonetheless conclude that Article V(A) requires that Montana provide notice to Wyoming of any pre-1950 shortage, unless the Commission or the parties agree to an alternative procedure. Both the language of the Compact and the parties' historical practice support this conclusion. Wyoming therefore should not generally be liable for any post-1950 uses that occur prior to such notice. The notice requirement, however, should be applied flexibly, with an eye to its purposes rather than as an exercise in formalism. The notice need not follow any specific form so long as it adequately alerts Wyoming to Montana's shortage, and exceptions to the notice requirement may sometimes apply." *Id*. at 49.

Groundwater Use & Water Rights Protection

During the litigation, Montana also alleged that coalbed methane production in Wyoming was adversely affecting the flow of water in the Tongue River. The Special Master did find that the Yellowstone River Compact protects pre-1950 water rights from groundwater use, in addition to protection from surface diversions or storage. This finding was based on the broad language of Article V(A) that pre-1950 rights "shall continue to be enjoyed" as well as the Special Master's finding that other portions of the Compact "reflects an intent to cover all waters including groundwater." *Id*. at 202-203. The "…pumping of hydrologically connected groundwater in this case can prevent Montana from 'enjoying' its pre- 1950 rights." *Id*. at 202. The *Report* also pointed out that, "[T]hird, the law of prior appropriation, which Article V(A) explicitly adopts, has long recognized the need to integrate surface water with at least some forms of groundwater." *Id*. at 203. "Finally, the Compact's definition of 'diversion' in Article II(G) provides support for the Compact's intent to regulate at least some forms of interconnected groundwater." *Id*. at 204.

The *Report* includes a discussion of the "appropriate standard for determining when such [**c**oal**b**ed **m**ethane (CBM)] production violates Article V(A)" (*Id*. at 208-211) and an evaluation of the evidence and

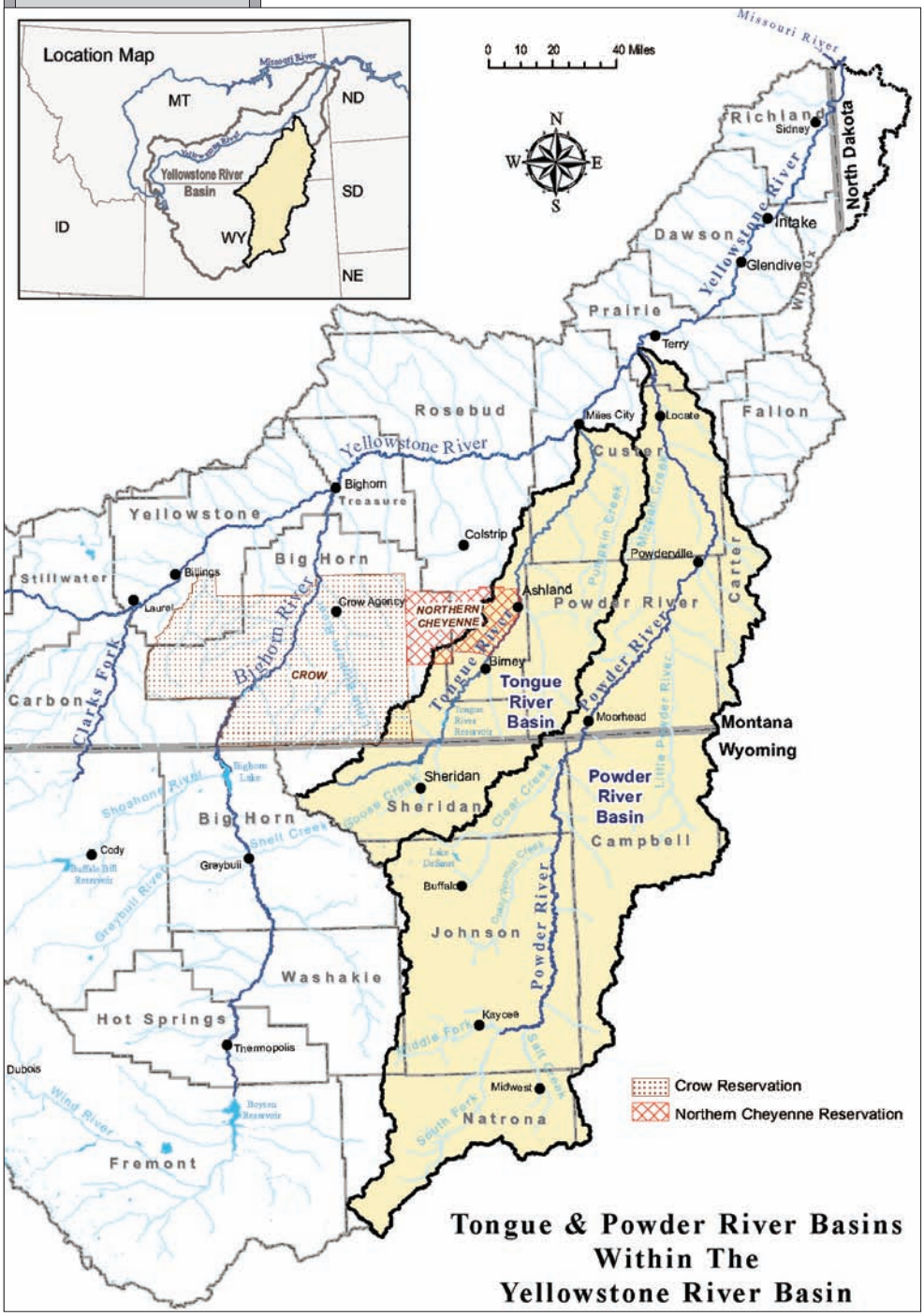
Yellowstone Compact

Future Relief

expert testimony concerning such water use (*Id*. at 211-219). Ultimately, the Special Master found that there was insufficient evidence that groundwater pumping associated with coalbed methane production caused any reduction in the flow of the Tongue River. "…I conclude that Montana has failed to prove that it was injured by CBM groundwater production in the years at issue." *Id*. at 219.

Prospective Relief

Due to the relatively small amount of water that Wyoming was found to have improperly used in the liability phase of the case, "…Wyoming argues that the quantum of injury is insufficient to justify further proceedings in the case." *Id*. at 228. In addition to the specific question of damages for those small amounts of water, however, Montana has sought injunctive relief to govern future activities by Wyoming. The Special Master discussed this issue on page 229 of the *Report*: "As for prospective relief, current Wyoming water officials testified at trial that they are now ready and willing to regulate post-1950 uses whenever Montana issues an appropriate call for more water under Article V(A). *See, e.g.,* 21 Tr. 4938:15-23 (Sue Lowry); 22 Tr. 5270:22-5271:5 (Patrick Tyrrell). While Wyoming has not rushed to help Montana in the past when Montana has needed water, Wyoming state officials have seemed genuine in their willingness to abide by the decisions of this Court." The Special Master eventually recommended that, "…if the [Supreme] Court agrees with the above recommendations and finds that Montana has been injured, the Court remand for the determination of damages and other appropriate relief. Given the narrowed focus of the case, proceedings can and should be short." *Id*. at 230.



CONCLUSION

The Supreme Court will most probably ask the parties to file any exceptions to the Special Master's *Report* and could set oral argument on those exceptions before making a final decision. The Supreme Court may adopt, in whole or in part, the Special Master's recommendations.

TWR highly recommends that interested readers take the time to review the *Report* in full due to its comprehensive and thoughtful look at many aspects of water law, particularly as it relates to Wyoming and Montana. This process in an "original" action before the Supreme Court — where the Supreme Court appoints a Special Master for recommendations — results in a situation that is far different than most court proceedings, where the decision-maker may have little or no experience with water law. There are several other aspects of water law, including "futile calls," storage rights, and tribal water rights that are not discussed in this short article — check out the *Report* for additional insight into those issues.

For Additional Information:
The Second Interim Report of the Special Master (Liability Issues) is available at:
https://media.dojmt.gov/wp-content/uploads/No.-137-Original-COMBINED-Proof-Stanford-University.pdf

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RECYCLED WATER OR BEER BREWING PROPOSAL

Clean Water Services (CWS), a wastewater treatment agency in Washington County, Oregon, is proposing to use high-purity recycled water on a limited scale to brew beer as a way of promoting their ability to produce very high quality water from wastewater. The Oregon Department of Environmental Quality (DEQ) has rules that govern the reuse of recycled water; however, there is a high threshold for approving potable (drinkable) reuses of wastewater. DEQ rules specifically prohibit potable reuses of recycled water unless the Oregon Health Authority approves the use, DEQ holds a public hearing to approve the use, and the Environmental Quality Commission approves the use.

A public hearing on the proposal has been scheduled for February 12 at 3 p.m. in Portland, with written comments due on February 20 (see weblink below for details). The proposed use allows recycled water to be used in the preparation of alcoholic beverages where processing includes bringing recycled water to a boil. The recycled water must first be treated to a very high quality, equalling or exceeding all regulated drinking water contaminant criteria (standards) as well as other criteria for non-regulated chemicals proposed by the National Water Research Institute for potable reuse water. The Oregon Health Authority has reviewed this proposed treatment process, and has approved this treatment process to achieve high quality water for the limited use of producing an alcoholic beverage.

In Oregon (as noted by DEQ), recycled water refers to any treated effluent from a domestic wastewater treatment system that, as a result of treatment, is suitable for another use, such as irrigation, business use, dust control and street sweeping. Recycled water must provide a resource value, protect public health, and protect the environment. At this time, recycled water use in Oregon is restricted to facilities that have a wastewater discharge permit for domestic waste that discharges to either surface water or to ground, and have an approved Recycled Water Use Plan as part of the permit.

Highly treated water means using one or more treatments to purify water. Clean Water Services has proposed and tested three different treatments for their proposal. These include ultra-filtration which involves filtering the water through a very small pore size; reverse osmosis or passing water through a membrane that does not allow large chemicals to pass through it; and enhanced oxidation, which uses ultra-violet light and an oxidizing chemical to break down impurities. This combination of treatments effectively breaks down or separates chemicals, viruses, and bacteria from the treated water.

For info: DEQ website: www.oregon.gov/deq/docs/022015drinkable.pdf

TRIBAL COMPACT MEMO MT
AG'S MEMO TO GOVERNOR

A proposed water rights Compact between the state of Montana and the Confederated Salish and Kootenai Tribes of the Flathead Reservation (CSKT) was rejected by Montana's Legislature in its 2013 session. *See* Weiner & Stermitz, *TWR* #114 (8/15/13). Since that time, the Montana Reserved Water Rights Compact Commission (Commission) released a report on the proposed Compact to address issues and questions that arose during the Legislative session. For additional details on that report and the Commission itself, *see* Water Briefs, *TWR* #119 (1/15/14). The proposed Compact is extremely controversial in Montana and marked the first time in the Commission's 35-year history that the Legislature declined to ratify a reserved water rights settlement presented to it by the Commission. *See also* Water Briefs, *TWR* #106 (12/15/12) for additional background information.

A revised compact proposal, to be presented to the 2015 Legislature, has once more brought forth opposition. Responding to a letter sent to Montana's Governor Steve Bullock by the Flathead County Commission (FCC) expressing opposition to the proposed water Compact, Bullock's legal counsel, Andrew Huff, sent the Governor a memorandum January 19, 2015 addressing FCC concerns. The memo was later forwarded to the FCC.

Huff concluded that he did "not believe that the County's opposition to the Compact is well-founded, for both legal and factual reasons." The memo goes on to respond to several specific points of opposition, as well as discussing five changes to the compact that FCC has requested. The memo provides a worthwhile overview of some of the issues as Montana's Legislature gets ready to once again take on the question of ratification of the compact.

For info: Memo available upon request to: TheWaterReport@yahoo.com

INSTREAM DONATION WA
WATER SUPPLY/TRUST PROGRAM

On January 8, the Washington Department of Ecology (Ecology) signed an agreement with the Cascade Water Alliance (CWA) that will protect flows for fish in the White River. CWA is making a permanent donation of 684,571 acre-feet of water (equivalent to a football field covered with water 130 miles deep) to the state's Trust Water Rights Program for the preservation of instream flows and to protect fish habitat in a stretch of the White River that flows through the Muckleshoot Tribal Reservation. The donation completes the agreement CWA made in 2010 to donate a portion of the water rights it acquired in the purchase of Lake Tapps from Puget Sound Energy (PSE).

CWA is the water purveyor for eight King County cities and two water and sewer districts. In addition to its permanent water donation, the alliance is donating another 154,751 acre-feet of water to the Temporary Trust water rights program until 2034. The donated water stays in the White River for the benefit of fish, wildlife, recreation and the natural environment.

Ecology has agreed not to approve or issue new water right permits for 20.7 miles of the Reservation Reach of the river, between Buckley and Sumner. Several salmon species use this stretch of the river for migration, spawning, rearing, and flood refuge. "For more than 90 years diversions from the White River at Buckley have largely de-watered the stretch of river that flows through our Reservation," said Muckleshoot Tribal Council Chair

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Virginia Cross. "The water donations restore and will permanently preserve river flows through the Reservation that allow recovery of healthy fish runs."

The trust water donation is the culmination of a water rights package that has converted Lake Tapps in Pierce County into a future municipal water supply for 50 years or longer for Bellevue, Redmond, Kirkland, Issaquah, Tukwila and the water and sewer districts serving the Sammamish Plateau and Skyway. Ecology approved the transfer of water rights from PSE to Cascade and issued new municipal water rights to Cascade in 2010. PSE sold Lake Tapps to Cascade in 2009 after PSE no longer needed the lake as a reservoir for hydroelectric power operations. In its purchase of Lake Tapps as a future drinking water supply for nearly 400,000 residents and 22,000 businesses in eastern King County, Cascade agreed to preserve the lake for the benefit of surrounding homeowners, boaters, swimmers and anglers.
For info: Agreement and additional information at Ecology website: www.ecy.wa.gov/programs/wr/swro/lktappshome.html

COLORADO WATER PLAN CO

DRAFT RELEASED

On December 10, 2014, James Eklund, Director of the Colorado Water Conservation Board (CWCB) submitted the first draft of the Colorado Water Plan to Governor John Hickenloper. As noted by Eklund, the CWCB intends for Colorado's Water Plan to be a meaningful document that meets the following criteria: Fosters collaborative solutions to responsibly address the looming gap between supply and demand (fortify the Prior Appropriation Doctrine, not undermine it); Identifies and tests cost-effective alternatives to the permanent "buy & dry" of irrigated lands; Asserts that Colorado will protect its compact entitlements, act affirmatively to avoid compact curtailments where possible, and demonstrate effective state-based policy to prevent federal erosion of state and local water authority; Encourages strong cooperation by interested stakeholders to move regulatory and permitting efforts more quickly through the processes by front-loading state involvement; and Aligns state policies, resources, and funding to support Colorado's water values and actionable objectives.

According to Eklund, Colorado's Water Plan reflects agreement from water interests statewide on broad, near-term actions needed to secure Colorado's water future. These include continued efforts to conserve water; additional reuse and recycling of water; support for water supply projects where interests can agree on actions and approaches that protect the environment; create benefits for basins that provide water; and rely only on the wettest years to store more water. Colorado's Water Plan doesn't prescribe specific projects. Instead, it outlines how various interests across basins can attain locally driven, collaborative solutions, and how balanced approaches can garner the broad support needed to accelerate projects and shorten the federal regulatory process often associated with water-related actions.

To finalize Colorado's Water Plan, additional work with numerous stakeholders will continue throughout 2015, including input and guidance from the Governor's office. Submission for Colorado's Water Plan is planned for no later than December 10, 2015.
For info: Plan available at: http://coloradowaterplan.com/

EPA SETTLEMENT NV/NM

URANIUM CONTAMINATION: $5.15 BILLION

On January 23, the US Environmental Protection Agency (EPA) and the US Department of Justice (DOJ) announced that the settlement reached with Anadarko and Kerr-McGee is now final, allowing funds to be disbursed for cleanups. The settlement secures payments of $5.15 billion to resolve claims that the defendants fraudulently transferred assets in part to evade their liability for contamination at toxic sites around the country. Approximately $4.4 billion of that total will be used to clean the environment. This is the largest sum ever awarded in this type of a bankruptcy-related environmental settlement with the federal government.

An estimated $1.1 billion will be paid to a trust responsible for cleaning up a former chemical manufacturing site in Nevada that led to perchlorate contamination in Lake Mead. The site is located within the Black Mountain Industrial complex near Henderson, Nevada. Fifty to 100 pounds of perchlorate are still seeping into Lake Mead every day, and the funds will allow Nevada's Department of Environmental Protection to clean up the remaining underground sources of contamination. The Henderson site is the largest perchlorate groundwater plume in the US.

More than $985 million is expected to be paid to EPA to fund the cleanup of approximately 50 abandoned uranium mines in and around the Navajo Nation, where radioactive waste remains from cold-war era Kerr-McGee mining operations. The Navajo Nation is also expected to receive more than $43 million to address radioactive waste left at the former Kerr-McGee uranium mill in Shiprock, New Mexico. EPA is currently meeting with the Navajo Nation and the State of New Mexico to plan work to occur there later in 2015.

Kerr-McGee mined over 7 million tons of ore on or near the Navajo Nation from the late 1940s through the 1960s in the Lukachukai area, and from the 1950s to the 1980s in the Eastern and Ambrosia Lake areas. Kerr-McGee Corp. was founded in 1929 as an energy company involved with oil and gas exploration and production, and uranium mining. The company left abandoned uranium mine sites, including contaminated waste rock piles, in the Lukachukai Mountains of Arizona, the Eastern Agency of the Navajo Nation in New Mexico, and in the Ambrosia Lake/Grants Mining District of New Mexico.

In addition to the cleanups in Nevada and on the Navajo Nation, funds are also starting to flow to cleanups across the nation, including sites in Jacksonville, Florida, West Chicago, Illinois, Columbus, Mississippi, and Navassa, North Carolina.

On April 3, 2014, DOJ announced this settlement, which was then subject to a period of public comment and judicial approval. After considering comments from the public, the United States sought approval of the settlement, and on November 10, 2014, the district court approved the agreement as "fair

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and reasonable." The deadline for any appeals from the district court's decision passed on January 20, 2015, without any appeals having been taken.
For info: Margot Perez-Sullivan, EPA, 415/ 947-4149 or perezsullivan.margot@epa.gov

INSTREAM RULES WA

REPEAL DENIED/NEW RULE

Washington Department of Ecology (Ecology) Director Maia Bellon on January 15 issued a response denying a petition from realtor's groups seeking repeal of the Skagit Instream Flow Rule (Rule). Both the petition and Director Bellon's response (denial) are available on the Skagit River Basin-Water Management Rule webpage listed below. One group of landowners significantly impacted by the Rule are domestic users who would otherwise seek to establish permit-exempt groundwater uses without mitigation.

The Skagit River Basin Instream Resources Protection Program Rule (WAC 173-503) went into effect on April 14, 2001. It established instream flows throughout the basin to protect flow levels in streams. In 2006, Ecology found that limited reservations would not substantially harm fish populations and the rule was amended to establish finite "reservations" of surface and groundwater for future out-of-stream uses. The reservations provided uninterruptible (year-round) water supplies for new agricultural, residential, commercial/industrial and livestock uses, distributed among 25 subbasins.

The Swinomish Tribe challenged the establishment of the reservations in 2008 and appealed a Thurston County Superior Court finding in Ecology's favor in 2010. On October 3, 2013, the Washington Supreme Court ruled that Ecology cannot set aside reservations of water through adoption of water management rules where water was previously set aside to support stream flows for fish. As a result, the 2006 amendments to the rule were found to be invalid. *Swinomish Indian Tribal Community v. Dept. of Ecology*, 178 Wn.2d 571, 311 P.3d 6 (2013). *See* Moon, *TWR* #116 (10/15/13). Without water reservations, later water uses can be interrupted when dry spells impact the protected stream flows.

Meanwhile, in another part of the state, a new rule has been adopted by Ecology to preserve and protect water levels in the Spokane River for fish, recreationists and businesses for many years to come. Ecology adopted an "instream flow rule" for the river's main stem in Spokane County and a small portion of Stevens County. The rule allocates specific amounts of water to the river to protect fish habitat and other uses. The rule protects the Spokane River and balances the needs of all water users by setting a regulatory threshold to determine when there is water available for new uses.

With the rule in place, Ecology can make decisions on existing applications requesting to withdraw groundwater from the Spokane Valley Rathdrum Prairie Aquifer, which is in direct continuity with the river. Ecology's webpage also noted that it had acquired and placed into trust a senior water right with help from Washington Water Trust that will be used to support river flows and offset any new domestic well uses that could impact the river in the rule area.
For info: Ecology Rule webpage: www.ecy.wa.gov/programs/wr/instream-flows/skagitbasin.html ; Supreme Court 2013 decision at: www.courts.wa.gov/opinions/pdf/876720.pdf; Spokane River Rule at: www.ecy.wa.gov/programs/wr/rules/557-ov.html

RECREATIONAL CRITERIA US

WATER QUALITY STANDARDS

As a follow up to EPA's 2012 national recommended criteria for recreational water bodies, EPA has published an overview document and the first of three technical support documents that will help states develop alternative recreational water quality criteria. These documents take into account site-specific factors and incorporate the new and evolving science of microbial measurement. The document, Overview of Technical Support Materials: A Guide to the Site-Specific Alternative Criteria TSM Documents (December 2014), will help water quality managers evaluate their site information and choose the best technical approach for developing site-specific recreational water quality criteria. EPA plans to publish two more technical support documents in 2015.
For info: EPA website: http://water.epa.gov/scitech/swguidance/standards/criteria/health/recreation/index.cfm

FRACTURING DATA US

USGS ON TRENDS & DATA

Two new U.S. Geological Survey (USGS) publications that highlight hydraulic fracturing trends and data from 1947 to 2010 were released January 27. Hydraulic fracturing is the primary stimulation technique for oil and gas production in unconventional resource reservoirs. Comprehensive, published, and publicly available information regarding the extent, location, and character of hydraulic fracturing in the US is scarce. "These national-scale data and analyses will provide a basis for making comparisons of current-day hydraulic fracturing to historical applications," said USGS scientist and lead author Tanya Gallegos. "We now have an improved understanding of where the practice is occurring and how hydraulic fracturing characteristics have changed over time."

This national analysis of data on nearly 1 million hydraulically fractured wells and 1.8 million fracturing treatment records from 1947 through 2010 is used to identify hydraulic fracturing trends in drilling methods and use of proppants (sand or similar material suspended in water or other fluid to keep fissures open), treatment fluids, additives, and water in the US. These trends are compared to peer-reviewed literature in an effort to establish a common understanding of the differences in hydraulic fracturing and provide context for understanding the costs and benefits of increased oil and gas production.

The publications also examine how newer technology has affected the amount of water needed for the process and where hydraulic fracturing has occurred at different points in time. Although hydraulic fracturing is in widespread use across the US in most major oil and gas basins for the development of unconventional oil and gas resources, historically, Texas had the

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highest number of records of hydraulic fracturing treatments and associated wells documented in the datasets.

These datasets also illustrate the rapid expansion of water-intensive horizontal/directional drilling that has increased from 6% of new hydraulically fractured wells drilled in the US in 2000 to 42% of new wells in 2010. Increased horizontal drilling also coincided with the emergence of water-based "slick water" fracturing fluids. This is one example of how the most current hydraulic fracturing materials and methods are notably different from those used in previous decades and have contributed to the development of previously inaccessible unconventional oil and gas target areas, namely in shale and tight-sand reservoirs.

For info: USGS *Scientific Investigation Report* at: http://pubs.usgs.gov/sir/2014/5131/; companion Data Series at: http://pubs.usgs.gov/ds/0868/

FISH CONSUMPTION RULE WA

TOXICS STANDARDS PROPOSAL

On January 12, the Washington Department of Ecology (Ecology) announced proposed water quality standards for toxics, including rules that address fish consumption rates for the state. The proposal is tied to toxics-reduction legislation Governor Inslee is proposing to address toxics that enter the environment from unregulated everyday sources, such as consumer products. The proposed standards for toxics, formally called the human health criteria, say that waters need to be clean enough for people to eat the fish that swim in the waters. The standards are important because they drive pollution discharge limits for industries and other entities that discharge pollution and are required by the federal Clean Water Act. Ecology's January 12 press release noted that the proposed changes are in line with Governor Inslee's July 2014 policy directive that says updated water quality standards should protect people and the environment and not overburden local governments or industry.

In a parallel process, the US Environmental Protection Agency (EPA) started its own rule-making process in December 2014 to update Washington's standards should the state's process stall. EPA Regional Administrator Dennis McLerran wrote a letter to Ecology Director Maia Bellon dated December 18, 2014 (www.epa.gov/region10/pdf/water/wqs/wa_wqs_promulgation_letter_to_maia_bellon.pdf), which included the admonition that he continues to "strongly encourage the State to fully consider the issues that the EPA has raised during the State's rulemaking process, particularly regarding the need for the State to base its decision on sound science and the best available date, which provide evidence of fish consumption rates well above 6.5 grams per day in Washington, and to explain why a change in the State's long-standing cancer risk protection level is necessary and how it is consistent with its strategy for protecting higher fish consumers in Washington."

Governor Inslee's proposed budget includes funding for the initiative to strengthen existing programs to prevent releases of toxics, reduce the impacts of toxics, and develop safer chemicals for use. "Our regulations today often try to fix our pollution problems at the end of a wastewater discharge pipe," said Carol Kraege, Ecology's toxics coordinator. "Reducing the use of toxic chemicals on the front end, when products are created, is more effective, cheaper and reduces the burden on water dischargers."

According to Ecology, the updated water quality standards would ensure that no standard, except naturally occurring arsenic, becomes less protective. Seventy percent of the new standards would be more protective, with most from two to 20 times more protective. The remaining 30 percent of the standards would maintain the current protective standards and not backslide. Because arsenic occurs naturally at high levels in Washington, Ecology proposes the updated arsenic standard align with the federal drinking water standard. Ecology's cost-benefit analysis on the updated water quality standards indicates the new standards would create minimal costs to water dischargers. Although there would be approximately 55 new polluted water listings under the proposal, the new water pollution listings would not immediately result in new requirements for any existing water discharger.

Opposition to the proposed rules clearly hasn't gone away. The proposed rules include a new fish consumption rate of 175 grams/day. Opposition still exists due to the fact that the rules also include a change in the risk level used in the criteria calculations for carcinogens. For background information regarding fish consumption rates, *see* Water Briefs, *TWR* #128 (10/15/14). A Northwest Indian Fisheries Commission (NWIFC) article on February 3, 2015, began with the statement, "Gov. Jay Inslee wants to change the cancer risk rate used to set state water quality standards from one in one million to one in 100,000. That is unacceptable to the treaty Indian tribes in western Washington. We refuse to accept this tenfold increase in the risk of getting cancer from known cancer-causing toxins, and you should, too." NWIFC's view of the fish consumption rate and the cancer risk level was addressed later in the article: "Under his plan, Inslee would correctly increase the fish consumption rate from a ridiculously low 6.5 grams per day (about one bite) to 175 grams per day, the same protective rate as Oregon's. But he would effectively cancel out that improvement by decreasing our protection under the cancer risk rate." Article at NWIFC website: http://nwifc.org/2015/02/eating-fish-shouldnt-risky/.

For info: Sandy Howard, Ecology, 360/ 791-3177 or sandy.howard@ecy.wa.gov; Rule Making documents at: www.ecy.wa.gov/programs/wq/ruledev/wac173201A/1203docs.html; Overview of Key Decisions at: https://fortress.wa.gov/ecy/publications/publications/1410058.pdf

WATER RIGHTS PRIORITY CA

STATE AGENCY REPORT

The California Division of Water Rights has prepared a *Dry Year Program Report* (*Report*) with recommendations to improve the implementation of California's water rights priority system in future dry years pursuant to Resolution No. 2014-0031. Presentation of the report to the State Water Resources Control Board (Board) is tentatively scheduled for February 17, 2015 as an informational item at the Board Meeting. The report and additional information are available on

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the project webpage listed below.

The *Report* focuses on recommended improvements to implementation and enforcement of water rights during drought conditions. As part of this process, Board staff and stakeholders will consider: 1) the State Water Board's January 1978 "Dry Year Program" Report and its recommendations for enforcing the water rights priority system; 2) the 2014 curtailment and complaint process; 3) the quality of the data in the water rights database for post-1914 and pre-1914 appropriative water rights and riparian water rights (including as compared to the reported demand data in the 1978 Dry Year Program Report, statewide planning models and other available information); and 4) opportunities to expand and improve data and database capabilities to assist with the implementation of the water rights priority system in future dry years.
For info: *Report* at: www.waterboards.ca.gov/waterrights/water_issues/programs/drought/dryyear_report/

WATER FINANCING US

NEW EPA WATER FINANCE CENTER

In July 2014, President Obama launched the Build America Investment Initiative, calling on federal agencies to find new ways to increase investment in ports, roads, bridges, broadband networks, drinking water and sewer systems and other projects by facilitating partnerships between federal, state and local governments and private sector investors. As part of this effort, on January 16, the Obama Administration is announced a new Water Finance Center at the US Environmental Protection Agency (EPA). This effort is designed help local and state governments access federal loan and grant programs to get more projects off the ground.

To help address more than $600 billion in needs for drinking water and wastewater management over the next 20 years, the Center will work closely with municipal and state governments, utilities, and private sector partners to use federal grants to attract more private capital into projects and promote models of public private collaboration that can address the real needs of cities and towns to provide safe water, rebuild sewer systems, and keep streams and rivers clean.

The current level of infrastructure investment in the US is far too low and too many worthwhile projects go unfunded. The system of water pipes that bring drinking water to homes and businesses, for example, is rapidly aging. An estimated 237,600 water mains break every year. We also lose more than 46 billion gallons of water per day through leaking pipes — enough water to supply the 10 largest American cities for almost two weeks. The costs for maintenance are only increasing. Over the next fifteen years, utilities will have to spend three times as much on pipe replacement as the current system continues to decline.

EPA's Water Finance Center will:

- Stimulate private investment and make federal dollars go further. Around the country, towns, cities and states are exploring how to bring innovative financial tools such as public private partnerships to the water sector to get more projects off the ground. The new Center will help interested local and state governments bring private sector investment and expertise into water system construction and management. Among other roles, the Center will: bring together investors and project sponsors; highlight promising deals; provide peer-to-peer learning and workshops; and develop case studies and toolkits. The Center will work with states to maximize the benefits of more than $3 billion in annual federal water investments.
- Help attract investment to small communities. Many rural communities are served by small water utilities that lack the resources to explore financing alternatives, engage the private sector and attract investment. The new Water Center will work with on-the-ground partners to provide financial training and technical assistance to small communities and rural water systems.

The Administration is proposing the creation of an innovative new municipal bond, Qualified Public Infrastructure Bond (QPIB). Today, public private partnerships that combine public ownership with private sector management and operations expertise cannot take advantage of the benefits of municipal bonds. QPIBs will extend the benefits of municipal bonds to public private partnerships, like partnerships that involve long-term leasing and management contracts, lowering borrowing costs and attracting new capital.

A similar existing program, Private Activity Bond (PABs), has already been used to support financing of over $10 billion of roads, tunnels, and bridges. QPIBs will expand the scope of PABs to include financing for solid waste disposal, sewer, and water. Unlike PABs, the QPIB bond program will have no expiration date, no issuance caps, and interest on these bonds will not be subject to the alternative minimum tax. These modifications will increase QPIB's impact as a permanent lower cost financing tool to increase private participation in building our nation's public infrastructure. QPIBs would not be available for privately-owned facilities or privatizations of public facilities.

The Center will be releasing new products, including supplemental provisions for toll concession model contracts and a new guide on utilizing Federal-aid funding.
For info: http://water.epa.gov/infrastructure/waterfinancecenter.cfm

GREEN INFRASTRUCTURE US

EPA FINANCING & PLANNING GUIDANCE

In early February, EPA's National Estuary Program announced the release of guidance to assist municipalities in paying and planning for incorporating green infrastructure into their stormwater management plans.

Getting to Green: Paying for Green Infrastructure, Finance Options and Resources for Local Decision-Makers summarizes various funding sources that can be used to support stormwater management programs or finance individual projects. Each type of funding source is illustrated by several municipal programs and contains a list of additional resources. A comparative matrix is included which describes the advantages and disadvantages of the various funding sources.
For info: http://water.epa.gov/infrastructure/greeninfrastructure/index.cfm

CALENDAR

February 15-18 OR
Environmental Connection: World's Largest Soil & Water Event, Portland. Portland Convention Ctr. Presented by International Erosion Control Ass'n. For info: www.ieca.org/conference/annual/ec.asp

February 16 TX
Texas Leadership Roundtable on Water, Austin. Capitol Extension Auditorium. Legilative Briefing. For info: Jon Comola, 512/ 695-8806 or jrcomola@wrgh.org

February 17-18 NV
Indian Water Rights & Water Law Seminar, Las Vegas. Rivera Hotel. For info: www.falmouthinstitute.com/training/public/feb/NR002.html?utm_source=cc&utm_medium=email&utm_campaign=ccemailPUB1502

February 17-20 TX
AWWA/WEF The Utility Management Conference 2015, Austin. Hyatt Regency Austin. Presented by Water Environment Federation & American Water Works Ass'n. For info: www.wef.org/UtilityManagement2015/

February 19 CA
Endangered Species Regulation & Protection Course, Sacramento. Sutter Square Galleria, 2901 K Street. For info: UC Davis Extension, 530/ 757-8777 or https://extension.ucdavis.edu/section/endangered-species-regulation-and-protection

February 19 CA
Water 2015 - 14th Conference on Critical California Issues, Sacramento. Masonic Temple. Presented by Capitol Weekly & UC Center. For info: http://events.r20.constantcontact.com/register/event?oeidk=a07ea5gpzsza0ae8db2&llr=wx6upyeab

February 19-20 CA
Western Water Law Conference, San Diego. The Westin. For info: CLE Int'l, 800/ 873-7130 or www.cle.com

February 19-20 NM
Watershed CPR: Restoring Natural, Built & Human Environments - 2015 Land & Water Summit, Albuquerque. Sheraton Albuquerque Airport. Presented by Xeriscape Council of New Mexico. For info: http://xeriscapenm.com/

February 19-20 NV
Road Map 2015 - A Farmer's Guide to the Water Universe: Family Farm Alliance Annual Meeting, Las Vegas. Monte Carlo Resort. For info: www.familyfarmalliance.org

February 19-20 OR
Groundwater & Surface Water Interactions: Current & Evolving Technology & Tools Shortcourse, Portland. World Trade Center, 121 SW Salmon Street, 2WTC. For info: www.stevenswater.com/catalog/Two-Day-Shortcourse-Class-Ticket-P506.aspx

February 20-21 AZ
Living with Less Water - Experts Discussion, Tucson. Presented by Institute on Science for Global Policy. Registration Required. For info: http://wrrc.arizona.edu/node/13178

February 23 WEB
Moving Toward Sustainability - Water Utility Webinar, WEB. Presented by EPA. For info: https://attendee.gotowebinar.com/register/2550881603600161 29

February 25-26 DC
ACWA 2015 DC Conference: 114th Congress - New Directions Require New Strategies, Washington. The Liason Hotel. Presented by Ass'n of California Water Agencies. For info: www.acwa.com/events/dc-conference

February 26-27 CA
Planning & Environmental Law Course, Sacramento. Galleria, 2901 K Street. For info: UC Davis Extension, 530/ 757-8777 or https://extension.ucdavis.edu/

February 27 GA
14th Annual Georgia Water Law & Regulation Seminar, Atlanta. Georgia World Congress Center. For info: The Seminar Group, 800/ 574-4852, info@theseminargroup.net or www.theseminargroup.net

February 27 CO
Colorado Water Law Conference, Denver. Grand Hyatt. For info: CLE Int'l, 800/ 873-7130 or www.cle.com

February 27 OR
The Freshwater Trust 2015 Gala & Auction - 32nd Annual, Portland. Portland Art Museum. For info: www.thefreshwatertrust.org

February 27 WA
Winter Waters 2015 - Restoring the Upper Columbia River Event, Spokane. Patsy Clark Mansion. Presented by the Center for Environmental Law & Policy and the Sierra Club. For info: www.celp.org/events/winter-waters-2015-restoring-the-upper-columbia-river/

March 2-3 CA
Groundwater Law & Regulation Seminar, Sacramento. Tsakopoulos Library Galleria. For info: Law Seminars Int'l, 800/ 854-8009, registrar@lawseminars.com or www.lawseminars.com

March 3 GA
Key Environmental Issues in U.S. Environmental Protection Agency Region 4 Conference, Atlanta. State Bar of Georgia Conference Ctr. For info: http://shop.americanbar.org/ebus/ABAEventsCalendar/EventDetails.aspx?productId=135022897&sc_cid=NR15031-C1

March 4 CA
ACWA 2015 Legislative Symposium, Sacramento. Sacramento Convention Ctr. Presented by Ass'n of California Water Agencies. For info: www.acwa.com/events/acwa-2015-legislative-symposium

March 4 TX
Reduce & Reuse: Making Water Conservation Work for the Gulf Coast Region - 2015 Gulf Coast Water Conservation Symposium, Houston. United Way Community Resource Center, 50 Waugh Drive. Presented by Texas Water Foundation. For info: www.texaswater.org/2015/01/2015-gulf-coast-water-conservation-symposium/

March 5 AZ
UA Water Sustainability Program's Distingushed Speaker: Brian Richter, Tucson. UA Student Union, 1303 E. University Blvd. Presented by Water Resources Research Center & Water Sustainability Program. For info: wrrc@arizona.edu

March 5-6 NM
Law of the Rio Grande Conference, Santa Fe. La Fonda on the Plaza. For info: CLE Int'l, 800/ 873-7130 or www.cle.com

March 5-8 OR
Public Interest in Environmental Law Conference: Changing Currents, Eugene. University of Oregon. Presented by Environmental & Natural Resources Law Center. For info: http://pielc.org/about-us/

March 6 WA
Sixth Annual SCBA Indian Law Conference, Spokane. Gonzaga University School of Law (Barbieri Courtroom). Organized by the SCBA Indian LawSection. For info: www.spokanebar.org/calendar-all.html

March 10 CO
2015 Distinguished Lecture: Mike Connor, Deputy Secretary of the Interior, Boulder. University of Colorado School of Law, Wittemyer Courtroom. Presented by Getches-Wilkinson Center for Natural Resources, Energy and the Environment. For info: https://cuboulder.qualtrics.com/SE/?SID=SV_eWGUevh2ZEmNkwt&Q_JFE=0

March 11 WA
Managing Stormwater in Washington Conference, Tacoma. Presented by Northwest Environmental Business Council. For info: www.nebc.org/

March 11-13 TX
Design-Build for Water/Wastewater Conference, San Antonio. Henry B. Gonzalez Convention Center. For info: www.dbia.org/Conferences/water/Pages/default.aspx

March 11-13 West
Lower Colorado River Tour 2015, Colorado River. Presented by Water Education Foundation. For info: www.watereducation.org/tour/lower-colorado-river-tour-2015

March 12 OR
Metolius Water Quality Conference, Camp Sherman. Community Hall. Presented by Friends of the Metolius. For info: www.metoliusfriends.org/

March 12-13 DC
Natural Resources Damages Seminar, Washington. Thurman Arnold Bldg.. For info: Law Seminars Int'l, 800/ 854-8009, registrar@lawseminars.com or www.lawseminars.com

March 15-17 CA
WateReuse California Annual Conference, Los Angeles. Millenium Biltmore Hotel. For info: www.watereuse.org/

March 15-18 OR
American Water Works Association Sustainable Water Management Conference, Portland. Marriott Downtown Waterfront. For info: www.awwa.org/conferences-education/conferences/sustainable-water-management.aspx

March 16-18 TX
National Groundwater Ass'n 2015 Groundwater Summit, San Antonio. Grand Hyatt. For info: http://groundwatersummit.org/

March 18 CA
Water Gala '15: Imagine H2O's 6th Annual Celebration, San Francisco. The Palace Hotel. Celebrating the Winners of Imagine H2O's Water Infrastructure Challenge. For info: www.imagineh2o.org/watergala15

March 19 Greece
Frontiers in Environmental & Water Management Int'l Conference, Kavala. For info: http://fewm.eu/

March 19-20 TX
Estimating Rates of Groundwater Recharge Course, San Antonio. Grand Hyatt. Presented by Nat'l Groundwater Ass'n. For info: www.ngwa.org/Events-Education/shortcourses/Pages/125mar15.aspx

March 19-20 TX
Fundamentals of Groundwater Geochemistry Course, San Antonio. Grand Hyatt. Presented by Nat'l Groundwater Ass'n. For info: www.ngwa.org/Events-Education/shortcourses/Pages/235mar15.aspx

March 19-20 CA
California Water Policy Conference 24, Claremont. The Roberts Environmental Center at Claremont McKenna College. For info: www.cawaterpolicy.org/

March 19-20 CA
Planning & Environmental Law Course, Sacramento. Galleria, 2901 K Street. For info: UC Davis Extension, 530/ 757-8777 or https://extension.ucdavis.edu/

March 22-25 DC
Ass'n of Metropolitan Water Agencies 2015 Water Policy Conference, Washington. The Liason Hotel. For info: www.amwa.net/event/2015-water-policy-conference

March 25 CA
Water Education Foundation 32nd Annual Executive Briefing: The Value of Water: Building Momentum in 2015, Sacramento. Red Lion Inn. For info: www.watereducation.org/foundation-event/2015-executive-briefing

March 26-27 CA
Endangered Species Act Conference, San Diego. The Westin. For info: CLE Int'l, 800/ 873-7130 or www.cle.com

March 26-27 OK
2015 Student Water Conference, Stillwater. Oklahoma State University. Hosted by OSU. For info: Dr. Garey Fox, garey.fox@okstate.edu or http://studentwater.okstate.edu/content/swc

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CALENDAR

(continued from previous page)

March 26-28 CA
44th Spring Conference: ABA Superconference on Environmental Law, San Francisco. Palace Hotel. For info: http://shop.americanbar.org/ebus/ABAEventsCalendar/EventDetails.aspx?productId=131644078

March 27-29 AZ
Balance - Unbalance International Conference: Water, Climate, Place: Reimagining Environments Conference, Tempe. ASU Campus. Presented by Global Institute of Sustainability at ASU. For info: https://sustainability.asu.edu/events/rsvp/balance-unbalance

March 27 OR
Floodplain Development: Regulation Under FEMA & ESA Seminar, Portland. Hilton Executive Tower. For info: The Seminar Group, 800/ 574-4852, info@theseminargroup.net or www.theseminargroup.net

March 30-April 1 CA
2015 AWRA Spring Specialty Conference on Water for Urban Areas, Los Angeles. Airport Hilton. For info: AWRA, www.awra.org/meetings

April 2 WA
Reauthorization of the Columbia River Treaty in an Era of Climate Change, Water Scarcity & International Tensions Forum, Seattle. Seattle First Baptist Church. Presented by League of Women voters of Seattle-King County. For info: http://seattlelwv.org/node/2127

April 7-8 WA
Clean Water & Stormwater Seminar, Seattle. Renaissance Seattle Hotel. For info: Law Seminars Int'l, 800/ 854-8009, registrar@lawseminars.com or www.lawseminars.com

April 8 CO
Aspinall Lecture by F. Ross Peterson - Proving Powell's Prognostications Erroneous: The Colorado River Basin & the Manipulation of Water, Grand Junction. Colorado Mesa University. Presented by the Aspinall Foundation & Colorado Mesa University. For info: www.coloradomesa.edu/aspinall/lectureship.html

April 8-9 OK
2015 Oklahoma Clean Lakes & Watersheds Ass'n Conference: From Watersheds to Wetlands, Stillwater. Wes Watkins Conference Ctr. For info: http://water.okstate.edu/news-events/conferences/2015-oklahoma-clean-lakes-and-watersheds-association-conference

April 9-10 HI
Endangered Species Act Conference, Honolulu. YMCA. For info: The Seminar Group, 800/ 574-4852, info@theseminargroup.net or www.theseminargroup.net

April 9-10 TX
Texas Water Law Conference, San Antonio. La Cantera Hill Country Resort. For info: CLE Int'l, 800/ 873-7130 or www.cle.com

April 12-17 Rep. Of Korea
7th World Water Forum 2015, Daegu-Gyeongbuk. For info: http://eng.worldwaterforum7.org/main/

April 13-15 DC
Federal Water Issues Conference, Washington. Washington Court Hotel. Presented by National Water Resources Ass'n. For info: www.nwra.org/upcoming-conferences-workshops.html