ACCELERATING THE DEVELOPMENT OF SUSTAINABLE WATER MARKETS IN THE U.S.

In water matters, the United States in both profligate and caring, rapacious and thrifty, and, when Americans turn their mind to it, of awesome capability.
Marq De Villiers

The key future challenge will be starting to manage water as an economic commodity and getting more efficient systems for the allocation and use of water, while simultaneously insuring that it is available to all.
Steve Maxwell

No problem can be solved from the same level of consciousness that created it.
Albert Einstein

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INTRODUCTION

This report provides a comprehensive "map" of the sustainable water landscape in the United States and a set of recommendations for future investments that could accelerate the development of sustainable water markets/systems and maximize the economic impacts of pursing greater water sustainability. It employs a market-analysis and market-development approach to examine the buying and selling of products, services, and rights in the water value chain among a complex mix of private, public, and quasi-public water users and providers. It sorts through the many issues and proposed solutions in each of the segments of the water market to pinpoint "hot spots"—where solutions meet opportunity—that are ripe for investment. And it assesses the condition of the *practice field* of sustainable water management, a nation-spanning community of practice that develops, implements, and shares knowledge, tools, and institutional capacities.

Deliverables

This report, supported by a grant from the Rockefeller Foundation, combines this narrative document and many background documents, available on a project Web site, http://water.in4c.net, which summarize the research upon which our recommendations are based. The Web site contains:

- PDF of narrative report.
- Summary descriptions of eight Water User Groups and twelve Water Service Provider segments.
- Summaries of "issues and solutions" in the research literature for each Service Provider Segment.
- Research Index with links to more than 170 publications scanned as part of developing the report.
- Details on the Frameworks used in the report.

Frameworks for Understanding

The report and map are built out of six frameworks that sort the information gathered through an extensive scan of the water literature, interviews with 32 practitioners, experts, and funders, and attendance at four relevant conferences.

- **Sustainability Characteristics.** Five key characteristics of sustainable water that can be linked to various issues.
- **Water Value Chain.** More than a dozen steps in the current water value chain, from extraction and desalination to wastewater treatment.
- **Water User Groups.** Eight distinct water-user groups that rely on public supply, self-supply, or a mix of both
- **Water Service Providers.** Twelve types of water service providers, including water and wastewater utilities, irrigation organizations, bottlers, watershed entities, engineers, and equipment suppliers.
- **Sustainability Solutions.** Five categories of proposed sustainable-water solutions found in the research literature or interviewing: public policy, technology, business model, provider management, or learning processes.
- **Practice Fields.** The stages of development of emerging practice fields, such as sustainable water.

(Each framework is introduced in more detail in the report. More details are available at the project Web site.)

CONTENTS

	Executive Summary	4
I.	Setting the Stage: Water As A Market	9
II.	Findings: Key Changes in Water Markets/Systems in U.S.	12
III.	Findings: Solutions Driving Development of Sustainable Water Markets/Systems	17
IV.	Investing to Accelerate Development of Sustainable Water Markets/Systems	31
V.	Next Steps	39
VI.	Maximizing Economic Impact of Sustainable Water Market/System Development	41
	List of Interviewees and Conferences Attended	46
	End Notes	

EXECUTIVE SUMMARY

Water is a roughly $130 billion-a-year market in the U.S., the world's largest national market. About two-thirds of this market is in the public sector, segmented into eight distinct groups of users served by 12 types of providers—with literally tens of thousands of governing and managing entities. For most of the nation's history, consumption of water increased steadily with population and economic growth, with the supply of water either naturally abundant or engineered, usually with government subsidies. But, as many analysts note, these long-standing patterns and their seeming certainties are changing.

What may have been a mostly sustainable water system through the first century of the nation's life—before the explosion of population, industry, energy-usage, and irrigated agriculture—has become much less so. It is not as efficient, resilient, regenerative, clean and safe, or equitable as it should be if it is to maximize its contribution to our quality of life. The water system and markets that emerged in response to prolonged increasing demand won't endure.

Our research—poring over 170 reports, interviewing 32 experts, attending four conferences—found that two types of changes are destabilizing traditional water markets and systems and spawning development of sustainable water markets and systems.

- ***Underlying dynamics of the water market—demand and supply—are shifting.*** On the demand side, current overall use of water in the U.S. is significantly below the 1980 level, when use began to decline, even though the population and economy have increased in size. The value of water is rising, due to competition over water and value-added services to assure water quality or environmental protection. As a result, more water is becoming subject to market forces and this is increasing cost pressure on water users, especially for sectors whose products compete for customers. Rising prices increase incentives for water conservation and shorten the "payback curve" on implementing innovations.

- ***New drivers of change—the economy, climate change, and energy—are growing in importance.*** Most water is used to drive the U.S. economy; only about 8.4 percent of freshwater is used by households. Without sufficient water supply, farms fail, factories slow, and electricity generation suffers. In the next few decades the predicted effects of climate change and the already severely reduced "water budgets" of some regions could result in water shortages that hobble economic activity more frequently and at much larger scale than before. "The fight for water between growing urban areas, agriculture, energy, and various forms of industrialization could shape the geopolitical landscape for decades to come," predicted Summit Global Management's 2012 investment review. "Climate change will constrain North America's already over-allocated water resources," concluded an intergovernmental panel several years ago, "thereby increasing competition among agricultural, municipal, industrial, and ecological uses." At the same time, even as it produces electricity, the dated water systems infrastructure is driving significant maintenance costs and greenhouse gas production.

As powerful forces come to bear on business-as-usual in the U.S. water market, they call into question many of the existing methods used for managing our water "budget" and assessing risks. But big changes in the context within which U.S. water systems operate are also stimulating new ideas, experiments, and the articulation of a vision about what to try to achieve. Boiling down the many definitions of "sustainable water" leaves five essential outcomes: a "sustainable water" system and market would be efficient, resilient, regenerative, clean, safe, and equitable. Although the U.S. is in the early stage of developing markets and systems that can perform this way, our research found four types of promising early-stage developments that are advancing sustainable water efforts around the nation.

- ***A transformation of the basic design principles for water "operating systems" is underway.*** The U.S. water system/market is an ensemble of processes, tools, business models,

and organizations designed and implemented on the basis of a fairly consistent set of principles (understandings, assumptions, beliefs, and customs). The principles, organized largely around an Engineering approach, are at the root of the U.S. water system's current problems because they address realities that are fading away, but do not effectively address the new, more complex and uncertain realities that are taking hold. An alternative paradigm, still in the making, embraces four new basic principles that either displace or combine with the traditional model: the Ecology, Performance Management, Market, and Adaptation Principles. This water-sustainability framework is driving the emergence of new practices.

- ***Measurable performance standards for sustainable water are slowly emerging.*** Performance data about water is lacking, and this impedes the development of standardized and scalable innovative practices, public policies, and water markets. Here and there, various types of standards, some rudimentary, some precise, are in the making and seeping into use. For example, some water utilities are working on performance standards. Water-intensive corporations are implementing water audits and footprint analysis.

- ***A "practice field" of sustainable water management is emerging and generating a growing number of intriguing innovations***. A field is a critical mass of people and organizations working in a variety of ways on a common problem. They develop knowledge, individual and organizational capacities, and systems for professional development, standards, and best practices. They support experimentation and the cross-pollination of thinking and practice, and create the "ecology" out of which many innovations emerge and reach scale. Fields evolve.

  The sustainable-water field is in a very early developmental stage—with lots of conceptual talk and writing, a growing number of experiments with particular solutions, and some networking among practitioners. A wide range of experimentation is occurring: green infrastructure; water-transfer markets; integrated watershed planning; dam removal; and much more. But most experimentation has not yet yielded the "proof of concept" that makes clear what results the innovation can produce and at what cost; it's being done by innovators and some early-adopters, but is not ready to penetrate the mainstream.

- ***Some visionary leaders are finding ways to broker cross-sector alignment and political will for large-scale innovation and investment in developing sustainable water systems.*** Across the U.S. there are visionary leaders with the skill and persistence to broker coalitions—across water provider segments, multiple levels of government, and among economic, environmental, and community interests—to get important sustainable water experiments off the ground. The work is never easy or risk-free. And vision, smarts, and courage are not all that's needed. Long-term political stability is a huge factor in whether or not a place-based system can make transformative progress. Ultimately, a stable political culture that supports sustainability—not just a bold leader—has to be in place.

Given findings: that the system's market dynamics are shifting, that big new drivers of change in water systems (the economy and climate change) are growing in power, and that a new system-level paradigm is emerging and being tested in a growing number of practice-based experiments, it made sense to look for "leverage points" in the water system that might accelerate *system-level transformation*. This led to identifying five system-level "hot spot" or leverage points for philanthropic investment to accelerate sustainable water system/market progress:

1. Development of the emerging **practice field** of sustainable water management.
2. Development of sustainable water **measurement and performance standards** for U.S. water providers

3. Development of innovations that leverage **financing, insurance, and other markets** to drive water providers to adopt sustainable water practices.
4. Development of innovations for transformation of **"urban water" systems**.
5. Support for **visionary leading practitioners** who are building civic and political will and implementing transformative innovations for sustainable water systems.

Recommendations for Accelerating Development of U.S. Sustainable Water Systems and Markets

(1) ***Build a coalition of funders who support development of a long-term (5-10 year) strategic plan for building the sustainable water field.*** Accelerating the development of sustainable water systems in the U.S. depends importantly on field building. As shifts in water market conditions increase the need and opportunities for sustainable water, the capacity of the nascent sustainable-water field is not yet strong enough to supply proven, reliable innovations and implement them in complex, often resistant, contexts. The field needs to move as quickly as possible beyond early-stage conceptualization and experimentation. By demonstrating that applied solutions work—"proof of concept," in innovation terms—the field can build clarity about and confidence in new paradigm principles and operating systems. This will accelerate adoption and the reaching of critical mass. A major field-building planning effort would be undertaken in collaboration with key players and relevant organizations. It would identify overarching definitions/frameworks, existing competencies/capacities, capacity gaps to be filled, network-weaving opportunities, potential high-impact activities, and potential resources for field building. Even more ambitiously, it could design an initial shared innovation-development agenda for the field. Accelerating the development of the sustainable water field will take years because of the complexity and scale of the endeavor. But this is precisely why philanthropy has a unique opportunity and role to play.

(2) ***Support, enhance, and help to align/coordinate promising efforts to develop sustainable-water measurement and performance standards for water providers in the U.S.*** Performance measurement and standards would guide water management and investment decisions, as well as water-user behaviors. These are "threshold practices"; if they are not in place it is difficult to develop best practices and fully understand what, if any, impacts they have. What's needed is a comprehensive collaboration among the many innovators of performance measurement and standards for various water provider segments; alignment around which innovations have been proven to work, and around a development agenda and strategies for reaching scale across water systems and markets.

(3) ***Support, enhance, and help to align/coordinate promising efforts to leverage financing, insurance, and other markets to drive water providers to adopt sustainable water practices.*** Markets are one of the most powerful ways to scale up innovation. It's clear, for instance, that water systems will need an enormous amount of capital to pay for new or repaired infrastructure, as well as many of the sustainable-water innovations, such as green infrastructure and new technologies. Most of the funding will have to be borrowed from capital markets. This is an opportunity to drive change into water systems. A similar risk-awareness dynamic is at work in the insurance market. But market leveraging requires expertise, creativity, and endurance—and the impact can be very high. What's needed is a weaving/amassing of substantial financial and technical resources to support a portfolio of the most promising market-driven approaches under development. Think of this as a combination of an early-stage "venture capital" fund and an applied-research network for market-driven solutions for sustainable water systems.

(4) ***Focus resources on innovations that transform "urban water" systems.*** Metropolitan areas have enormous potential leverage over the future of sustainable water markets/systems in America. They have the people and the economy. About 20 percent of all water withdrawn in the U.S. is "municipal water," but the tentacles of urban control over water spread into the countryside for hundreds, even thousands, of miles. As mammoth producers of stormwater and wastewater and pollution in waterways, they have king-sized water infrastructure problems. As mass consumers of most of the nation's food and energy,

metropolitan areas send compelling demand-signals to agriculture and energy-production systems about quantity, quality, and price. And, as they realize widely predicted population gains, their potential political clout in state legislatures and the U.S. Congress will likely grow. Metropolitan water systems can be the brokers of large-scale, long-term rearrangements of water allocation. This is particularly important in the West, where growing cities have "junior" claims on water, usually behind agriculture. Metropolitan water systems may muster their communities' consumer-market buying power to influence the water behavior of economic sectors, such as agriculture, energy, and manufacturing, and relevant state and federal government policies. In addition, metropolitan water systems are potentially huge players in the financial and insurance markets. Finally, in metropolitan areas, water issues are also closely linked to economic and social issues. Water is integrally linked to other sustainability issues that have risen to the top of urban agenda, such as revamping land use/urban form to promote density, reducing energy consumption, and fostering "locational equity" among neighborhoods and metro communities.

What's needed is development of an investment portfolio and a set of long-term urban-water "innovation laboratories," like the Charles River Watershed Association has stitched together, which supports two types of big opportunities in urban water: key management practices for transforming water operating systems, including integrated watershed planning, sustainable utility performance standards, resilience planning, and targeted "ready to scale" and "ready to prove" innovations.

(5) ***Support and develop visionary leading practitioners who are building civic and political will and implementing transformative innovations for sustainable water systems.*** Leadership in the sustainable-water field has two dimensions: leaders who are advancing sustainability in specific places, showing what can be done, and leaders who are building the field itself, typically by creating field-spanning organizations. A field-building agenda for leadership development should include support for both leaders in "high pain" water-stressed places, brokers who are innovating in a disciplined way at scale, and leaders ready and able to provide the field with "next stage" efforts including networking among pioneers and advocates, convergence around common method and tools, and integration of systematic innovations.

To move forward on these five recommendations, we propose two next steps:

- ***Development of a small "sustainable water funders network" that links foundations interested in building and pursuing a shared and strategic approach to field building.*** A starting point could be the circulation of this report and other key documents to selected funders, who would then together develop an initial outline of the elements: a table of contents, for a strategic plan and commission further strategic planning work. Further planning would require additional research about existing field capacities, and could be tied to the work of a handful of innovation teams as described below.

- ***Creation of "innovation teams" to work on each of four leverage points: measurement and performance standards, market-based innovations, urban water innovations, and leadership support/development.*** Funding for those teams would support a six-month development process so they can map in detail what is already happening at the leverage point and identify the "edge of innovation" where increased funding could accelerate transformation. Each team would present findings about specific high-potential innovation projects. These teams would be a temporary planning structure.

Maximizing Economic Impacts of Investments in Sustainable Water

In light of the trends in water markets/systems and what can be gleaned from the literature about national and metropolitan water economies and the occupational structure of water systems, the development of sustainable water systems/markets in the U.S. offers several important ways that philanthropic investors can advance their interest in economic opportunity for low-income people.

- ***Most important, a transition to sustainable water systems is crucial to the future economic viability of metropolitan areas, where most low-income Americans live.*** Disruptions in the supply of water to the very large water-using economy—due to drought, extreme weather events, failure to comply with pollution regulations, and other factors—can reduce economic activity through loss of wages, sales and employment. For example, just days after Hurricane Sandy struck, economists estimated up to $50 billion in economic losses. Investing in the development of resilient, adaptive water systems in metropolitan areas is the best insurance against this magnitude of loss.

- ***Investments in both grey and green infrastructure can generate economic activity that directly provides jobs for low-income people, as well as improves conditions in low-income neighborhoods.*** These investments depend mostly on decisions made in metropolitan areas by government owned or controlled water and wastewater utilities, and on the financial markets that fund their infrastructure/capital expenditures. The potential in this niche has been studied in some metropolitan areas, and is being realized in some areas' implementation of large-scale green infrastructure initiatives.

- ***Growth in private business activity in sustainable water will most likely center on technology development and sustainable water-system management.*** Increasingly this will be driven in metropolitan areas through research-and-commercialization clusters of collaborating businesses, governments, universities, and non-governmental organizations (NGOs). Although regional industry clusters are not a new phenomenon, water-related clusters are.

- ***The ongoing rise in water and wastewater pricing will disproportionately increase pressure on low-income household budgets***. This raises concerns about equity and ability to pay when it comes to financing some parts of the transition to sustainable water systems/markets. Large-scale adoption of water-conservation practices might help mitigate some of this growing financial burden. In addition, some communities are experimenting with differential pricing schemes that reduce the burden of cost increases on low-income households.

These opportunities for economic impact intersect in challenging ways with both the development of the sustainable water field and with existing practices in the workforce and economic development fields. They require a focus on metropolitan water systems, where there must be more "penetration" of key innovations in sustainable-water planning, management, and financing. And they require linkage of water-providing businesses with the workforce and economic development fields, neither of which has historically been very engaged with the water sector.

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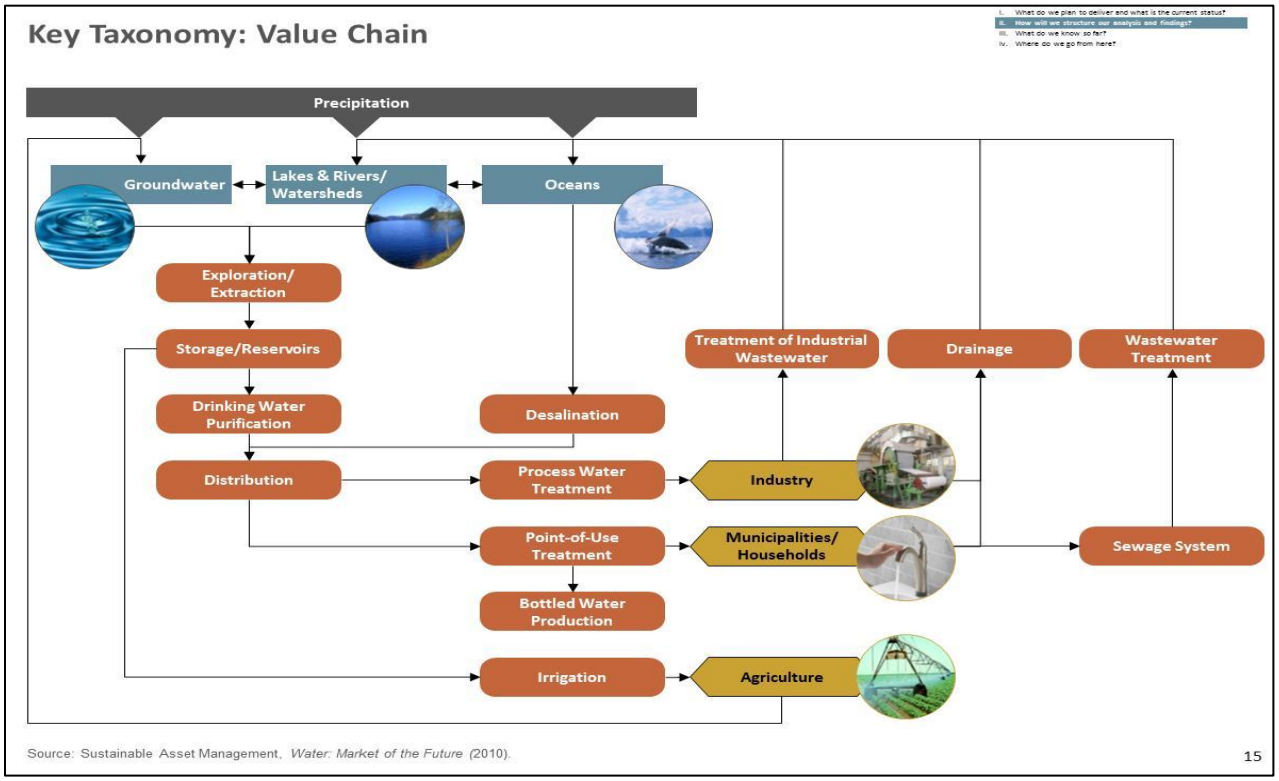
I. SETTING THE STAGE: WATER AS A MARKET

Very little literature dealing with U.S. water treats it as a market. Sometimes it is thought of as an entire industry, but, as Steve Maxwell, an astute analyst pointed out, "there is, strictly speaking, no such thing. There is instead a sprawling conglomeration of many, fundamentally quite different businesses that all have something to do with the delivery of clean water."[1] It's some particular aspect of this "sprawl" that is most often studied and written about: a user group such as agriculture or households; a water service provider such as wastewater utilities or bottled-water manufacturers; an issue such as stormwater management or ecosystem protection; a set of solutions such as water conservation programs, membrane technology, or federal policies; or some combination of these aspects. This excessive fragmentation in the reality of and research about water means that, to assemble an overall picture of U.S. water and identify potential "leverage points" for investment by philanthropy or other sources, you need an overarching organizing principle for gathering and analyzing information. We have used markets as that organizing principle.

What we mean by a "water market" is this: the collection of economic activities involving transactions—buying and selling—of products, services, and rights related to the water value chain. This buying and selling includes private, public, and quasi-public dealings within a complex mix of user groups, water service providers, and submarkets—each with their own economic dynamics and actors. In this analysis, water has a cost and a price, even when it is cheap, subsidized, or seemingly "free."

Our starting point in conducting a market analysis was to identify elements of the freshwater value chain and the multiple activities that entities perform to deliver valuable water products or services. The water value chain is not fixed in time; it has changed significantly in the past century and, as will be discussed, it is changing more.



Our second analytic step was to identify the large groupings of water users, such as agriculture, industry, thermoelectric power, and households—and understand how much water they use and at which point in the value chain. We also examined their market size and usage patterns. These groups differentiate by whether they tap public water supply or are self-supplied. Summaries of this information for each of eight user groups can be found at the project Web site, http://water.in4c.net.

The next analytic step was to identify the major segments of water service providers, such as water utilities and stormwater management—and understand their market size, customers, products, and value propositions. We also identified leading entities in the segment. These summaries are also available at http://water.in4c.net.

Water User Groups
Agriculture
Aquaculture Self-Supplied
Household Public Supply
Household Self-Supplied
Industry Self-Supplied
Mining Self-Supplied
Other Public Supply
Thermoelectric Power Self-Supplied

Another analytic step was to recognize important contextual issues in the water market, such as variations in regional hydrological cycles, state regulation of water, and legal doctrines concerning water rights. Finally, we identified the issues facing each type of service provider and the drivers of change in the market, such as population growth, climate change, and aging infrastructure. And we developed a framework for categorizing the various solutions—innovative practices, policies, and tools—that have been proposed or are being enacted.

Water Service Provider Segments
Bottled Water Manufacturers
Dam Management
Desalination Facilities
Engineers and Consultants
Equipment Manufacturers
Irrigation Supply and Equipment
Residential Water Treatment Suppliers
Stormwater Management
Thermoelectric Power, Industrial, and Mining Wastewater
Wastewater Utilities
Water Utilities
Watershed Organizations

Solution Category	Sub-Category
Public Policy	Revised Water Laws
	Revised Government Regulations
	Redesigned Government Incentives
	Increased Policy Advocacy
Learning	Sustainability Campaigns
	Public Education
Technology	Development of New Technologies
	Expanded Use of Existing Technologies
Business Model	Development of Performance-Based Provider Financial Models
	Ecosystem Services

	Alternative Financing Methods
Provider Management	New Sustainability Performance Standards Integrated & Collaborative Planning Improved Operational Practices Upgraded Professional Development

A summary of the "solution sets" is available at http://water.in4c.net.

From this constellation of market information we identified what seemed to be significant "leverage points" for accelerating the transition to a sustainable water market in the U.S. At that point, two additional concepts became important: operating systems and fields of practice. It became apparent that despite the fragmentation of the water market, the operating systems of most providers share a number of characteristics or underlying principles: a water-system paradigm with a long history. It also became apparent that a large amount of innovation is already underway to fundamentally transform this paradigm so that a new water system can emerge and achieve sustainability outcomes.

Glossary of Essential Terms

- Water *use/withdrawal* and *consumption*. Withdrawal refers to water taken from a local source or transported from a distant source. Consumption refers to water that is unavailable for reuse in the natural basin from which it was extracted, due to evaporation, incorporation into plant biomass, contamination, or other factors.
- *Grey*, *black*, *waste* water. Grey water refers to untreated water generated from household uses, like bathing and washing clothes. Black water is more heavily contaminated from toilets. Wastewater usually is grey and black water combined into a single stream. Wastewater is typically treated and then returned to nature.
- *Direct recycled or reused* water. Wastewater that is treated for potable or non-potable reuse and provided directly to users, without being returned to natural systems. Potable use meets drinking water standards; non-potable use is treated to various levels depending on the end use. Reused water is usually grey water for landscaping, irrigation, toilet flushing, or recharging aquifers.
- *Fit for Use* water and *Water Match*. Fit for use means water tailored to suit product and process demands and quality standards; i.e., not always potable water. Water match refers to the process of matching uses for grey or black waste water.

Looking at sustainable water through the lens of markets allowed us to apply a common analysis that transcends but doesn't disregard the fragmentation of U.S. water systems—separation into unique places, ecosystems, and regions, differing legal regimes, and the organizational and public policy silos of water providers and users. A market lens emphasizes the economic value and allocation of water, but this doesn't necessarily imply privatization of water assets and services or ignoring the environmental/biological value of water. Using the lens of practice fields allowed us to transcend the also fragmented funding of water system improvements by aligning the many challenges and innovations into a common repertoire of innovations—practices, policies, technologies, processes, and systems—within a "new paradigm" framework.

II. FINDINGS: KEY CHANGES IN U.S. WATER MARKETS

As news headlines and cautionary reports attest regularly, water providers and users are driven to change by necessity: water scarcity, compliance with government regulations, flooding, and anticipation of the drastic effects of climate change. What all of this adds up to is less noted: the chronic and worsening failures of U.S. water markets and management systems developed in layers and phases for several hundred years—a peculiar blend of law, engineering, regulation, science, technology, businesses, and public institutional structures extending from surface water and groundwater to ecosystems and oceans, and now to the globe's climate.

If a century ago you had mapped the nation's water system you wouldn't have seen most of the huge engineering projects—55-million acres of irrigated land, nearly 1-million miles of drinking-water pipes, plus dams, sewers, canals, and reservoirs—that now dominate the waterscape. You wouldn't have seen the large-scale public municipal water utilities that now serve most of the nation's households; the nationwide electricity generation-and-distribution system that uses a large portion of the nation's water; the national water pollution standards that affect practically every water provider; or a $10.6-billion-a-year consumer market for bottled water.

Today water is a roughly $130 billion-a-year market in the U.S., the world's largest national market, about two-thirds of it in the public sector,[2] segmented into eight distinct groups of users served by 12 types of service providers, with tens of thousands of governing and managing entities.[3] For most of the nation's history, consumption of water increased steadily with population and economic growth, with the supply of water either naturally abundant or engineered, usually with government subsidies. But, as many analysts note, these long-standing patterns and their seeming certainties are changing. Peter Gleick, president of the Pacific Institute, wrote recently that "It has become increasingly difficult to find new water supplies that are economically, politically, and environmentally acceptable."[4] Steve Maxwell, author of *The Future of Water*, summarized the big change: "We've moved from an era of water development to an era of water allocation. Whether it's desalination, long-distance water transfers, or new dams and reservoirs, there's a high cost to new or alternative water supply."

What may have been a mostly sustainable water system through the first century of the nation's life—before the explosion of population, industry, energy-usage, and irrigated agriculture—has become much less so. Today's water systems are not as efficient, resilient, regenerative, clean, safe, or equitable as its sustainability requires. The water systems and markets that emerged in response to the prolonged burst in demand won't endure. "The traditional, linear 'take, make, waste' approach to managing water is increasingly proving unsustainable," said Glen Daigger, president of the International Water Association and vice president of water-engineering firm CH2M Hill.[5]

Our research found two types of changes that are destabilizing traditional water markets and systems, and spawning development of sustainable water markets and systems.

1. **Underlying dynamics of the water market—demand and supply—are shifting in ways that increase the power of market forces.**
2. **New drivers of change—the economy, climate change, and energy consumption—are growing in importance.**

1. Underlying dynamics of the water market—demand and supply—are shifting in ways that increase the power of market forces.

Four large, discernible trends are changing the U.S. water market:

- Overall water use is declining.
- New market niches are developing.

- The price of water is rising.
- The economic value of water is increasing.

On the demand side, current overall use of water in the U.S. is significantly below the 1980's level, when use began to decline, even though the population and economy have since increased in size. Overall reduction has been driven by a range of forces: increased costs due to government pollution regulation; government efficiency standards for toilets, urinals, clothes washers, and other products; technologies and processes that increase efficiency; the peaking of expansion in irrigated agriculture and energy cooling systems.[6] Corporations are beginning to manage their "water footprint." Some water utilities are giving away low-flush toilets and teaching their users to conserve water. Many farmers are installing efficient sprinklers and drip systems. Agriculture, industry, and energy have reduced their overall water withdrawal. At the same time, overall household water use, which is about 8.4 percent of all U.S. freshwater use,[1] has increased in total. However, *per capita* household use in 2005 was slightly less than a decade earlier.[7]

On the supply side, value creation is changing. New types of value creation are emerging. These include installing green infrastructure; monetizing environmental services; protecting in-stream flows; providing bottled water or residential water treatment, monitoring, and testing equipment/services to consumers; creating market exchanges for water rights and water-pollution credits; injecting water into coastal aquifers to prevent saltwater incursion; mining wastewater for minerals and nutrients; using micro-filters, membranes, and nano-technologies to clean water; developing regional water-technology business clusters. And there is growing value at the "back end" of the value chain as reused or reclaimed wastewater use increases. "For many inland and coastal regions facing water scarcity, water reuse will become an increasingly attractive source of new supply, especially for irrigation, heating, cooling, and other non-direct potable uses," concluded a Goldman Sachs water market analysis, and this will drive investment in technologies for wastewater treatment.[8]

The price of water is rising. "Nation's Water Costs Rushing Higher," reported *USA Today* on September 28, 2012, based on its survey of residential water rates in 100 cities, added that "a resource long taken for granted will continue to become more costly."[9] "Water is still too cheap to spend much time worrying about it," reported Steve Maxwell, but, he added, prices will continue to rise. One reason is spending on water infrastructure: the U.S. Environmental Protection Agency estimated that during the next 20 years more than $600 billion should be spent on drinking water transmission and storage and wastewater infrastructure, while Goldman Sachs, in a research report, pegged the backlog of infrastructure replacement/upgrade to be as high as $1 trillion.[10] Maxwell predicted rapid increases in the cost of water services: collecting, cleaning, and distributing water.[11] Strengthened regulation for water safety and increased requirements to prevent degradation

The Price of Water Conservation

A 2007 Pioneer Institute white paper reported that in the U.S. "water management"—and conservation in particular—"has typically been approached as an engineering problem, rather than an economic one." But, it argued, price increases (economic solution) are a more effective water-conservation tool than "non-price demand management" (engineered solutions) such as requiring the adoption of low-flow fixtures and other technologies or restrictions on lawn watering and other uses. Among the information cited:

- A 10 percent increase in water price can be expected to diminish demand among urban residents by 3-4 percent, a "price elasticity" similar to that of electricity and gasoline demand.
- Price-based approaches to conservation are more cost-effective than non-price approaches. Higher prices allow households to respond as they choose, instead of adopting a specified technology or practice.
- Utilities that implement price increases to reduce demand will experience increases in total revenues, while those that use non-price demand management programs will experience increases in total costs and decreases in revenues if water demand drops.

The rare water suppliers concerned with equity and distributional goals can offer rebates tied to household incomes.

[1] Data about total water use includes fresh and saline water.
Our data on household use percentage considers freshwater only.

of water ecosystems will also boost costs. Heightened competition for scarce water, a growing dynamic in some regions, is driving prices upward for agriculture, industry, and energy as population growth increases demand for food, electricity, and products. Sometimes cost pressure leads water users and providers to change their behaviors. For instance, agricultural demand for irrigated water is lower today than three decades ago, due in part to irrigation efficiencies and the higher energy costs of transporting and supplying water.[12]

Higher risks also mean higher costs. Capital markets are factoring in the risks water systems face, making financing costs for new infrastructure an additional potential driver of cost and price increases, especially for water systems that rely on the bond market for capital. A 2010 Ceres report argued there are "hidden risks" for bond investors—weak conservation measures, underpricing of water, and incomplete analysis by credit-rating agencies when it comes to assessing a utility's risk of water availability.[13]

The economic value of water is rising, due to competition over water and value-added services to assure water quality or environmental protection. Even drinking water, long the subsidized product of water utilities that have local monopolies, is finding a market price in the form of bottled water. "Water has historically been consumed as if it were a permanently abundant commodity," the Goldman Sachs report noted. "There is increased recognition that water cannot be the same low-cost utility everywhere for everyone."[14] As a result, more water is becoming subject to market forces and this is increasing cost pressure on water users, especially for sectors with competing products. Rising prices increase incentives for water conservation and shorten the "payback curve," which is the time it will take for an investment in a new practice to bear financial fruit.

"A market price and a marketplace for water services are coming into existence," concluded business journalist Steven Solomon in his study of water's history as a driver of wealth creation, *Water: The Epic Struggle for Wealth, Power and Civilization.*[15]

2. New drivers of change—the economy, climate change, and energy consumption—are growing in importance.

Over the longer run, three relatively new factors will increase the demand for water sustainability.

The economy needs sustainable water. Nearly every American has access to sufficiently clean and affordable water for drinking and household use. Although the system is flawed, this is a blessing of living in a water-rich nation that invested heavily in its water supply-and-delivery system, and seriously regulated pollution of waterways. But the vast majority of America's water is not used directly by its 300 million citizens. It is used to grow food, fiber, and livestock and to produce manufactured goods and energy. [16] **In other words, most water is used to drive the U.S. economy.** Without sufficient water supply, farms fail, urban growth slows, and electricity generation suffers. This is not a hypothetical scenario; it's already happening. The Federal Emergency Management Agency estimates that the average annual cost of drought in the U.S., partly due to crop loss, is $6-8 billion.[17] Depletion of the Ogallala Aquifer has left irrigation dependent parts of Texas without local water supplies.[18] Atlanta's water shortages have put economic growth at risk: "Water permits will be harder to obtain for new construction, and that could potentially limit the Atlanta metro area's long-term growth," said Atlanta Federal Reserve Bank research economist Chris Cunningham.[19] In California and Georgia, where energy demand is growing, the lack of water supply has led to an inability to site new electricity generating plants. In 2008, an Alabama nuclear plant closed temporarily due to drought.[20] Not surprisingly, there's talk among water experts about the likelihood that water availability will affect the location of businesses. "There is a growing discipline in evaluating water resources as part of locational decisions for industry," said Jim Renner, Principal Senior Geologist at Golder Associates, Ltd., an international water-engineering firm.

The economy's vast thirst leads to water overuse in some places, draining natural water systems faster than they can be replenished, which damages the environment and reduces long-term water supply. It leads to continuing problems with maintaining water's quality for human consumption.[21] It leads, in water-scarce, highly populated places, to heated competition over water between urban areas and economic interests, especially agriculture. And there is "intensifying conflict between energy use and availability," according to a 2009 report for Ceres, which advises businesses and private investors. "With increasing frequency, choosing

one of these resources means undermining the other—the other, usually being water. For example… corn-based ethanol production in the U.S. has incrementally increased fuel supplies, but at the expense of significant water impacts."[22] Even more troubling is where the economy-water relationship is heading. In the next few decades the predicted effects of climate change and the already severely reduced "water budgets" of some regions could result in water shortages that hobble economic activity more frequently and at much larger scale than before. "When Lake Mead goes dry and the Hoover Dam stops generating electricity, *then* you'll have a water crisis. It's going to happen,"[2] said Mary Ann Dickinson, president & CEO of the Alliance for Water Efficiency. "The fight for water between growing urban areas, agriculture, energy, and various forms of industrialization could shape the geopolitical landscape for decades to come," predicted Summit Global Management's 2012 investment review.[23]

Increasingly, said Steve Maxwell, water will be treated as a "factor of production" in the economy, like energy, labor, and capital. An analysis of the link between economic production and water availability, initiated by Veolia Water, the world's largest water-services business, found that about 22 percent of the world's economic output (Gross Domestic Product) is "already at risk due to water stress"—and much of western U.S. is in the high-risk category. Veolia's conclusion in the "Growing Blue" report: "If we want to grow our economies and create jobs, we must develop the right water solutions now."[24] Another element in this equation is the enormous economic value of "virtual" water, water embedded in products, especially food, that is sold overseas by U.S. companies. "The water challenge is therefore closely tied to food provision and trade," noted the 2009 "Charting Our Water Future," a critical-issues analysis prepared by McKinsey & Company.[25] How might the global market in beef, for example, adapt to changing conditions and pricing of water? "Animal production uses a fair amount of water," said Michael Hamm, C.S. Mott Professor of Sustainable Agriculture at Michigan State University. "I've come to the conclusion that there's going be a decline in meat consumption in the U.S. The land base just won't support it and competition from the developing world will increase global demand on the meat supply. And there's also increasing competition for animal feed from the energy sector, for bio-fuel production." Might this complicated set of factors reduce U.S. agriculture's demand for water?

As the economic challenges become more evident, they will result in new opportunities for devising and enacting sustainable water solutions. The economic realities will result in increased focus on water-system issues and forge the civic and political will to embrace solutions. The increasing economic value of solutions will drive innovation in water supply, use, and management. And a growing urgency for solutions will bring economic interests into discussions and negotiations over water in a way that allows them and other stakeholders to agree on overarching goals and solutions for sustainability of natural-and built-water systems, rather than just advancing individual economic interests. "The financial and business worlds are also rapidly coming up the learning curve on the economic impact of water," the 2012 Summit investment review noted. "Companies that provide products or services tangential to the core water industry are looking at ways of becoming more involved. Industries whose existence depends on clean water supplies—sectors like semiconductor, food and beverage, and pharmaceutical—are increasingly realizing their true dependence on clean water and the business risks to which they may be exposed."[26]

Climate change is creating conditions and uncertainties that need new solutions. A great deal has been predicted about how climate change will affect the U.S. water system, and little of it is good news. Climate change is already generating changes in the globe's hydrological cycle: increasing/decreasing precipitation; increasing precipitation intensity and variability which increases risk of flooding and drought; reducing snow covers and spring melt-off; increasing water temperatures, which affects water pollution. Climate change is shifting the predictability, timing, and extent of natural rainfall patterns. A 2010 report for the Natural Resources Defense Council calculated that under a business-as-usual scenario, water supplies in 70 percent of U.S. counties "may be at risk to climate change"—meaning demand will outstrip supply—and about a third of all counties are likely to be at "high or extreme risk." In those regions, "the pressure on public officials and water users to

[2] Lake Mead, on the Colorado River southeast of Las Vegas, is the nation's largest reservoir.

creatively manage demand and supply—through greater efficiency and realignment among competing uses, and by water recycling and creation of new supplies through treatment—will be greatest."[27]

Some impacts will be nationwide, others regional. The 2009 Ceres report cataloged changes already affecting U.S. water: earlier snowmelt that causes earlier peak stream flow in the West and New England; decline in the proportion of precipitation falling as snow in the West; decline in the duration of the snow cover in most of the nation; decline in rainfall in the Central Rockies and southwest; increase in the frequency of heavy precipitation events in most of the country; decline in runoff and stream flow in the Colorado and Columbia River basins; reduction in ice cover of the Great Lakes; periods of drought in the West.[28] Meanwhile, sea level rise threatens freshwater supplies of coastal cities through, for instance, saltwater intrusion into freshwater aquifers.

As climate change impacts the water cycle, it also impacts the economy. Some governments are banning water-intensive products and services, noted the Pacific Institute: "Products and services that require large amounts of water to produce or to use may be phased out by law, lose market share to less water-intensive products, or may lead to reputational damages for the company."[29] The long-term scenario for the water-climate change nexus may be more complicated still. As governments and markets shift to renewable energy generation, Veolia's "Growing Blue" report asserted, the increased use of hydropower, which results in some water evaporation from reservoirs, and biomass, which requires some irrigation, will drive up water use to an extent that could outweigh potential water savings from efficiency gains.[30]

The bottom line according to one government panel's report: "Climate change will constrain North America's already over-allocated water resources," concluded an intergovernmental panel several years ago, "thereby increasing competition among agricultural, municipal, industrial, and ecological uses."[31]

The water-energy nexus drives water-system costs. U.S. water systems use an estimated 3-4 percent of the nation's energy to move and treat water and wastewater,[32] with the portion much higher in some places such as California. As energy costs climb, and as energy use is tied to greenhouse gas production and climate change, the water industry has started to look for ways to become more energy efficient. The water and energy sectors "have historically not worked much together," said Mary Ann Dickinson of the Alliance for Water Efficiency. "They've been separate silos." But the connection between energy and water is compelling, she said: "In simple terms, every drop of water saved, saves energy, and every kilowatt of electricity saved, saves water." And of course there is hydropower generation, which marries energy production and water use.

Energy costs are already driving change in water systems. "Electricity is our second largest cost after labor," noted Jeff Sterba, CEO of American Water Works, serving 15 million people in more than 30 states. "It takes energy to treat and deliver water. We've committed to reducing our carbon footprint by 16 percent by 2017. That mandate is fostering innovation and helping us reduce energy in our operations. As an example, we are testing a new technology that reduces energy use in wastewater treatment facilities by 30 to 50 percent." Because water is still so inexpensive, Sterba added, "the business case for sustainable water now centers on energy savings."[33]

III. FINDINGS ABOUT SOLUTIONS DRIVING DEVELOPMENT OF U.S. SUSTAINABLE WATER MARKETS

Powerful forces—shifting market dynamics, the realities of the water/economy nexus, and climate change—are coming to bear on business-as-usual in the U.S. water market. They call into question old knowledge and solutions, and generate uncertainty. "Even if we were able to repair and expand the current water infrastructure," said Robert Zimmerman, Executive Director of the Charles River Watershed Association, "the great probability is that within 10-20 years of completion, the 'fixes' would be rendered obsolete by climate change. They are simply not flexible enough."

Flexibility and risk management go hand-in-hand. Chuck Clarke, CEO of Cascade Water Alliance, serving municipalities just east of Seattle, said that new trends in water defy old-style management of water systems. For example, decades of increasing water use have given way, at least for the last 10-15 years in some parts of the U.S., to a decline in water demand. "Seattle has 400,000 more customers than it did a decade ago, but water demand has dropped 25 percent. The county is putting a $2 billion wastewater treatment plant on line, but they don't have anything to send to it right now." This and other trends have to be addressed in scenario planning and decision making, Clarke said. "Traditional risk managers in water are always thinking supply risk, supply risk. Now they should also be thinking demand risk, economic risk, ratepayer risk—but they haven't made that transition yet. I've said to my board of directors that, since there are all these risks, I need to provide you with the flexibility now so that you can make different decisions in 10, 15, or 20 years, so that a future board is not stuck with our decisions and with no flexibility. This isn't consistent with where water utilities have been. It's been, let me build a plant that gives you 100 years of water security. But in 10 to 20 years, you may say, I was pretty stupid for convincing you to do that."

Even with a new approach to risk management, it's a huge challenge to figure out what to do. As water journalist Chris Gasson explained: "Both NGOs and fund managers are pushing large corporations to measure and manage their water risks…A corporation might start by looking at the potential impact on production of a drought which causes a water outage, but quite soon it will realize that long before it reaches that kind of absolute water scarcity, it is likely to run into conflict with the local community over access to water… The corporate sector cannot effectively address the problem of water risk on its own. The public sector must also play its part."[34]

These and other big changes in the context within which U.S. water systems operate are stimulating new ideas, experiments, and the articulation of a vision for future decisions. Search for "sustainable water" and you'll turn up dozens of definitions and lists of characteristics—most aspirational and vague. We reduced these to five characteristics that come closest to describing the outcomes a sustainable water system would deliver.

Characteristics of Sustainable Water Systems/Markets	
Efficient	The market/system values water conservation and using the least amount of water possible for the desired use.
Resilient	The market/system can withstand variations in water availability and quality caused by aging of infrastructure, population growth, climate change, and other factors.
Regenerative	The market/system manages water use to maintain the natural system's "water budget" at its regenerative capacity.
Clean and Safe	The market/system delivers water that is safe for its intended use and meets government/scientific standards.
Equitable	The market/system provides all segments of the population with fair and equal access to water supply and services needed for health and life, while offering non-discriminatory opportunities to use water for economic gain.

These orienting generalizations are the sort of vision and values upon which sustainable-water movements and advocacy are being built, but they fall far short of providing performance metrics that reveal how well water markets and systems achieve desired outcomes. Neither surprise nor criticism, the U.S. is in an early stage when it comes to the development of sustainable water markets/systems.

Our research found four types of promising early-stage developments that are advancing sustainable water efforts around the nation.

1. **A transformation of the basic design principles for water "operating systems" is underway.**
2. **Measurable performance standards for sustainable water are slowly emerging.**
3. **A "practice field" of sustainable water is emerging and generating a growing number of intriguing innovations.**
4. **Some visionary leaders are finding ways to broker cross-sector alignment and political will for large-scale innovation and investment in developing sustainable water systems.**

1. A transformation of basic design principles for the water "operating system" is underway.

It may seem strange to refer to a U.S. water "operating system," given the remarkable fragmentation of water suppliers into tens of thousands of entities with no cohesive national water agenda, policy, or governance; the often conflicting demands of farmers, manufacturers, communities, and other users; the fundamental difference in water law in different parts of the country; and the regionalization of water availability and federal water infrastructure. But a system it is—an ensemble of processes, tools, business models, and organizations designed and implemented on the basis of a fairly consistent set of principles (understandings, assumptions, beliefs, and customs). The principles may be applied differently in places to account for differences in water supply and demand, but they form a coherent guiding whole. And they are the root of the U.S. water system's challenges because they address old realities, but do not effectively address the new, more complex and uncertain realities.

The traditional water paradigm, the set of principles that underlie practices, is often referred to as an "engineering" mentality or model. The Pacific Institute summarized this framework as a "hard path" that uses "centralized infrastructure and decision making using technology and institutions… to deliver water, mostly of potable quality, and sometimes to remove wastewater."[35] Shivaji Deshmukh, a young urban water-system manager in southern California, said the domination of engineers is fading: "Up until the 1980s, everything was run by engineers. They built the pipes, the aqueducts; they ran the water districts. What's changed now is that a lot more lawyers are involved. It's not about the construction anymore; it's about all the deals, all the laws, we have to enact to get water. Engineering is still needed, but you're seeing a shift."

An alternative paradigm is still in the making, but can be described as embracing four new basic principles that either displace or combine with the traditional model: the Ecology, Performance Management, Market, and Adaptation Principles.

New Principle	Description
Ecology—Mimic Natural Systems	• Preserve and/or restore natural systems (rather than supplanting them with built systems) • Value environmental services • Treat waste as a resource • Adopt biological technologies • Plan and manage at the watershed—hydrological system—level • Use decentralized, interdependent, "web" models rather than centralized, command-and-control models
Performance Management—Use Data and Standards to Drive System Changes	• Focus on water productivity • Seek "whole system" outcomes (success measured by environmental, energy, economic, and social impacts • Conduct "one water" planning, management, and policies (watershed level) • Measure, monitor, and continuously improve performance • Match water quality to different water uses

	• Manage demand as well as supply • Adopt decentralized/small-scale/cost-effective "end user" systems • Use water more than once • Assess and manage risk • Engage the community/stakeholders
Market—Use Market Dynamics to Achieve Outcomes	• Use economic incentives to influence water consumption behavior • Adopt full life-cycle costing • Uncouple revenues from volume • Embrace competition among water providers • Use market pricing • Incentivizing private investment and public-private partnerships
Adaptation—Maximize System Resilience	• Build climate change into risk assessment • Invest in/maintain resilience and flexible capacity of systems • Adopt adaptive management

Each of these four new principles has implications for changing traditional water operating systems and markets—what outcomes are sought, how performance is measured and assessed. Each is giving rise to new practices that change ideas into reality.

2. Measurable performance standards for sustainable water are slowly emerging.

It's often noted that performance data about water is lacking, and this impedes the development of marketable innovative practices, adoptable public policies, and new water markets. "There is a real paucity of reliable market research and intelligence in the water business," reported Steve Maxwell.[36] "Very little data is available on the state of water systems or their sensitivities to declining water demand, volatile supplies, and variable costs of energy and other system inputs," noted a report on financing water infrastructure.[37] When it comes to how much freshwater is available in the U.S. on a renewable basis, explained Peter Gleick, "We have no precise estimate. Remarkably, comprehensive, long-term, and reliable data on total freshwater availability in the United States are not available."[38] In the U.S. west, much agricultural water is unmetered, with users paying a flat fee no matter how much water they consume. When the Center for Neighborhood Technology surveyed water utilities in the Great Lakes region, according to Harriet Festing, Director of CNT's Water Program, it discovered that "There is a real lack of transparent information in this market. Just to get the names of the water utilities and basic contact information was a huge job." Nor are there any generally accepted standards for the performance of water providers, such as municipal utilities.

Market data, enterprise-specific performance data, issue-specific data like leakage rates, and environmental data all fall short of what's needed to develop fully functional standards.

In 2010 Stanford University professors Thomas Mercer and Jon Christensen concluded that in California—the place widely regarded as the epicenter of America's water crisis, where households alone spend nearly $8 billion a year for water and wastewater services—the state of information about water "is woefully inadequate… nothing short of shocking." They noted that "calls for financial accountability and competing resource demands is at a fever pitch, the margin of error for water management in the West has narrowed, and the pressure is higher than ever to define and achieve desired outcomes." But, they continued, without performance measurement, "How do we know if we're managing our water resources sustainably? How do we know whether our water resource management strategies are effective? How do we know that we're allocating financial resources efficiently?"[39]

It's also remarked that measurement of a water system's "sustainability" comes with complexities when the sustainability of other systems is taken into account. "For any individual person in any specific place around the globe," observed Maxwell, "our carbon footprints, our water footprints, our agricultural footprints and food consumption are all tied together in different and complex ways."[40]

Investors in water system infrastructure may well start to ask penetrating questions about the risks of proposed municipal bonds, as a 2010 Ceres pointed out, and this could lead water utilities to measure, monitor, and publicly reveal new information about their performance. Among the performance standards that Ceres sees becoming a part of risk assessment are "water risk score," based on a standardized risk assessment of potential undersupply of water, and "water rate benchmark," based on comparison of water rates and potential for conservation.[41]

Here and there, various types of standards—some rudimentary, some precise—are in the making and seeping into use. Some water utilities, research institutions, and professional water associations are working on performance standards.[42] Water-intensive corporations are implementing water audits and footprint analysis. In addition:

- "Large urban water managers [in California] are deploying performance measurement and control systems that are nearly as sophisticated as those in private sector firms… They are awash in data—about operational performance and economic efficiency, water use efficiency, water quality, and supply constraints," according to a 2011 report on measuring water-system performance.[43] The Santa Clara Valley Water District "has gone beyond standard operational metrics and employs new techniques for performance measurement, including adoption of a balanced scorecard, as well as pursuing ISO 14001 and 9001 to demonstrate and execute their commitment to environmental stewardship."[44]
- The LEED Green Building Rating System contains standards for reduced water use, including use of alternative on-site sources of water (e.g., rainwater); no potable water use for landscaping; and reduced generation of wastewater (e.g., use of recycled greywater to flush toilets). "On average," according to the Pacific Institute, a LEED certified building uses 30% less water than a conventional building."[45]
- The 2012 Ceres/American Rivers report recommended development of "a performance rating system for water utilities," similar to the LEED model. "A utility sustainability rating system could transform the way utilities are designed, built and operated… As a voluntary, evolving rate system, utilities would have the opportunity to increase their rating as they mold to the standards."[46] It noted that the Institute for Sustainable Infrastructure has developed a framework for evaluating and rating the community, environmental, and economic benefits of infrastructure projects.
- The *Aqua Gauge*, developed by Ceres, the World Business Council for Sustainable Development, Irbaris, and the IRRC Institute, is a standardized tool to help companies manage water risk. It provides a qualitative assessment of water management, allowing benchmarking against leading best practices.
- In 2008 the State Water Resources Control Board in California began to use a performance measurement model that for the first time focused on outcomes using performance targets, and reported how well they had performed against the targets.[47] Some of this data is used by NGOs to report on specific water quality issues, such as Beach Report Cards.
- The 2030 Water Resources Group developed a rough framework for assessing the potential of implementing new water practices: difficulty in scaling; underdeveloped local supply chains; on-going management complexity; up-front transaction costs; and agency issues.[48]

Gradually, as water and energy become more costly, providers and users have more incentive to measure water-system performance. Water utilities are "monopolies with little incentive for benchmarking and communication between them," observed a 2012 Ceres/American Rivers report. "However, our aging water infrastructure, the potential impacts of climate change, a growth in new, more distributed technologies, and the current state of financial markets will change the way utilities are run, what systems they build and how they are financed."[49] Water quality/safety, as well as cost, will drive more measurement of performance, Maxwell argued: "As a more informed public demands better information about their drinking water, as more

comprehensive regulatory controls evolve, and as new contaminant effects are better understood, it seems certain that testing and monitoring requirements will only continue to expand."[50]

3. A "practice field" of sustainable water is emerging and generating a growing number of intriguing innovations.

Across the United States you can see countless efforts underway to reinvent the way freshwater is captured, stored, conveyed, consumed, treated, and returned (or not returned) to the natural water cycle. Scores of innovations are popping up throughout the water value chain and among the various user groups and water providers. In the table below we identify many of them in a repertoire of sustainability practices, aligning them with the transformative principles of the new paradigm.

Repertoire of Some Sustainable Water Innovations		
	Examples of Practice	**Description**
ECOLOGY	Green infrastructure (many practices)	Use of soil and vegetation (gardens, trees, wetlands, etc.) to capture and clean stormwater. (See sidebar)
	Dam/canal removal, river/wetland restoration	Dismantling dams, canals and other engineered flows; restoring natural river/wetland flows
	Zero waste/recycling	Eliminating wastewater release back to natural systems through treatment and recycling/reuse systems
MANAGEMENT	Integrated planning	Collaborative, "one water" planning and management among water service providers within a watershed or region of watersheds, across different functions such as water, wastewater, and stormwater, and across different water sources. An additional integration is with land-use planning. California, for instance, has initiated regional water management planning, with funding provided by the state.[51]
	Community-based monitoring	Use of community-based organizations, in addition to government regulatory and water-user/provider self-monitoring, to track the quality of water systems. (See sidebar)
	Corporate water use auditing/foot printing	Development of company water budgets, throughout the supply chain, with measurement, performance targets, and continuous improvement processes.
	Energy efficiency	Reduce energy use in treatment and other water processing. Example: Seven Tennessee water and wastewater utilities, partnering with the EPA Region, 3 universities, the Tennessee Valley Authority, and Schneider Electric, assessed energy use at each of their wastewater plants and developed action plans with potential average energy reductions of 17.8 percent on average and combined savings of more than 7 million kilowatt hours per year.[52]
	"Sustainable utility" performance standards	Setting sustainability standards and practices for water utilities. (See sidebar)
	Low-impact development; other links to land use planning/rules	An array of practices, many of them from the "smart growth" field, which tie urban development patterns to water demand. As the EPA reported, "the most common characteristics of new conventional growth—large lots, low density, and dispersed development—all increase the cost of delivering water."[53] Tucson requires proposed commercial development to get 50 percent of its water on site (rain collection). Denver may require that proposed developments include a zero-water footprint and greener infrastructure.
	Water reuse/recycling	Treating used water and recycling it for targeted use (see "fit-for-use"

		water) or to groundwater for further filtering. (See sidebar)
	Consumer demand management	Using any of a number of tools—real-time information, pricing incentives, and/or free or low-cost efficiency equipment—to promote reduced demand/conservation by customers. Example: Kansas City recently distributed 6,000 "eco kits" (low-flow showerheads, aerators, and toilet water-use reducing kit), which customers can install to save water. Each kit cost $9, with predicted saving of 1,666 gallons per household annually
	Fit-for-use water	Use of differentiated water quality (i.e., treated to different standards) for different water uses, thereby reducing the amount of potable water delivered by water providers. Includes recycled water for various purposes. (See sidebar)
MARKETS	Wastewater mining	Removing material—minerals, nutrients—from wastewater and then selling them. Some wastewater facilities sell nutrients to nearby farmers. The Metropolitan Sewer District of Greater Cincinnati is working with university researchers on the feasibility of converting fats, oils, and grease into biodiesel fuel—a potential yield of 20,000 gallons of fuel per year.[54]
	Markets for water rights	Establishing trading markets for the voluntary buying and selling of water rights.
	Markets for water-pollution credits	Establishing "cap and trade" markets for the buying and selling of water runoff/pollution rights. The "cap" is a regulation that puts a limit on the amount of total runoff/pollution that may occur and requires land owners to make improvements to meet the standard. The "trade" allows owners to exceed their requirement and sell the excess to other owners who do not meet the requirement. (See Charles River Watershed sidebar).
	Insurance market-driven incentives for investment in flood and pollution prevention	Uses the incentive of cost savings on insurance to promote investment in practices that prevent the damage that would be insured. Results in differentiated (and lower) insurance rates for property owners and reduced losses for insurance companies. (See "wetrofitting" sidebar)
	Seasonal block rates	Price of water increases for each unit used during dry months. Used in Seattle, Los Angeles, and Salt Lake City.
	Decoupled costs/rates	Municipal water utilities typically recoup fixed costs based on volume of water sold. The more they sell, the greater the net revenue—a disincentive for promoting conservation. Decoupling water utility fixed costs from sales allows utilities to pursue conservation and efficiency. This has to be done utility by utility.
	Full cost-of-service accounting	Allows for "new pricing signals that can better reflect the true costs of water and/or facilitate application of market mechanisms for driving conservation and innovation."[55]
	Water technology accelerators/business clusters	Linking of private sector R&D and commercialization capacity, university and government research labs, and private/public supply chains within a region, to develop and market new water technologies. (See sidebar)
ADAP	Risk/vulnerability assessment	Undertakes new modeling of future scenarios in water supply and demand, taking into account factors such as predicted climate change and relatively new trends in the water market - such as reduced demand. A 2010 report on future risks concluded: "As the effects of

T A T I O N		climate change alter familiar [weather] patterns… trend projections and fixed water management regimes based on the historical record will become increasingly ineffective… Implement risk-based approaches that anticipate the range of potential change and employ flexible and adaptive management strategies that allow decision makers to integrate new knowledge and respond to disruptions or risks as they materialize over time."[56]

Below we also highlight some of the innovations in more detailed sidebars:

- A mini-scan of the current state of leading Green Infrastructure practices across the U.S.
- A mini-scan of the current state of development of a "sustainable water utility" performance and certification system.
- A description of an urban water "innovation laboratory," the Charles River Watershed in Massachusetts.
- A description of a "wetrofitting" concept and pilot in Chicago seeking to leverage market forces.
- A mini-scan of the growing and changing practice of recycling water, including Frito Lay's closed-loop system for water reuse and southern California's recycling practices.
- Highlights of some regional efforts to develop water technology accelerators/business clusters.
- A description of a community-based water and environmental monitoring program pioneered in northern Michigan by a mining company and a regional conservation NGO.

Highlighted Sustainable-Water Innovations

Green Infrastructure: State of the Practice

Green infrastructure (GI) is a new cluster of practices—green roofs, trees, rain gardens, vegetated swales, pocket wetlands, infiltration planters, vegetated median strips, reforestation, and protection and enhancement of riparian buffers and floodplains—that more and more cities/metropolitan regions are using to solve large-scale stormwater pollution of local waters and precipitation-related overflows from sewer systems. Sometimes these can be done at lower cost than building traditional "hard" infrastructure. "The effectiveness of these approaches," the U.S. Water Alliance said in a statement of principles in support of GI solutions, "can be supplemented with other decentralized storage and infiltration approaches, such as the use of permeable pavement and rain barrels and cisterns to capture and re-use rainfall for watering plants or flushing toilets."[57] Essentially, stormwater is directed to areas where soil and vegetation, instead of or along with, pipes, pumps, storage tunnels, etc., can capture and clean it. This can diminish flows into stormwater and sewer systems, which reduces discharges that can pollute local waters.

At the October 2012 U.S. Water Alliance conference, five communities—Greater Cleveland; Tucson/Pima County; Philadelphia; Kansas City; and Syracuse/Onondaga County—described their recent GI efforts, all initiated under pressure from federal clean-water regulations. Notably, GI projects are generating other environmental and economic benefits, including: enhanced water supplies, cleaner air, reduced urban temperatures, increased energy efficiencies, and improved streetscapes and neighborhood aesthetics, particularly in low-income areas. "Green Infrastructure seems to work everywhere," said Nancy Stoner, EPA Assistant Administrator for Water. "We can't meet the demand for technical assistance."

But GI as a water-management practice is in the early stage of proving itself. "A lot of this is 'feel' at this point," said Ron Coker, Program Manager for Kansas City's Overflow Control Program. "There's great promise and opportunity for Green Infrastructure, but there are real and significant barriers," noted Ben Grumbles, President of the U.S. Water Alliance. "There are technical barriers. We don't know everything we need to know; there has to be a lot of trial and experimenting… Then decision makers will be able to pick

and choose the right shade of green, depending on the region, the culture, the climate, the soil, and what the public wants." On the legal front, Grumbles continued, "there's no denying it: there are risks. We need mechanisms so that the environmental community will feel there's accountability. The lawyers, as well as the engineers, need assurances." Other big issues include a "more robust" life-cycle cost analysis of GI, especially long-term maintenance costs, and how to finance large-scale GI projects. This is critical in cities suffering from economic decline and population loss.

The Center for Neighborhood Technology (CNT), in partnership with American Rivers and the Great Lakes and St. Lawrence Cities Initiative, is piloting an effort to create a "Green Infrastructure Portfolio Standard" for the level of GI a community will put into place, much like the Renewable Energy Portfolio Standard that many states have adopted. CNT's pilot in Milwaukee and Grand Rapids, MI, seeks to help the cities identify and select "opportunities to cost effectively incorporate green infrastructure features in the developed urban landscape as part of planned public and private projects or as stand-alone installations. The combined runoff retention capacity of these features, as designed, is calculated as a percentage of the baseline and used to determine progress."[58]

Developing a "Sustainable Water Utility" Performance System: An Emerging Innovation

Water utilities don't have broadly recognized industry-based standards for sustainability. Nor do they have a set of recognized, accepted sustainability practices. Therefore their sustainability performance cannot be rated or certified.

Creating a "sustainable utility" certification system with established standards and practices would allow the performance of individual utilities to be compared to the standards and with each other. Scoring utility performance in this way could affect perceptions of the utility among potential investors and lenders, as well as among customers and elected officials. And that could increase pressure on utilities to manage for improved performance. This would be quite a change in emphasis for most utilities, which have a very engineering-oriented culture with good technical skills, but not strong management, relationship, or leadership skills.

Many water-reform players—including the Alliance for Water Stewardship, American Rivers, and the American Water Works Association (AWWA)—are working with different variations of performance standards for utilities. For instance, in 2012, AWWA partnered with the Institute for Sustainable Infrastructure to develop a new sustainability framework for evaluating and rating the community, environmental, and economic benefits of water infrastructure projects. In 2011 the Alliance for Water Stewardship, formed by The Nature Conservancy, The Pacific Institute, and the International Water Management Institute, among others, started a process to get input on a draft of international standards. At the same time, PricewaterhouseCoopers has developed a first-of-its-kind model to aid bond rating agencies, public utilities, and investors in understanding the potential risks of water undersupply.

More collaborative dialogue and further research are probably needed before a set of standards can be adopted and implemented. And a system in which utilities voluntarily seek certification, but are not required to do so, would have to be linked to some concrete rewards for those utilities that do undertake certification.

An Urban-Water Innovation Lab – Charles River Watershed, Boston, MA

The Charles River meanders 80 miles through 22 Massachusetts cities and towns until it empties into the Atlantic Ocean at Boston. Once notorious as "foul and noisome, polluted by offal and industrious wastes, scummy with oil, unlikely to be mistaken for water," it now is heralded by the U.S. EPA as the nation's "cleanest urban river." That's because the Charles is also a remarkable urban-water innovation laboratory.

The Charles River Watershed Association (CRWA), formed in 1965, has used science and groundbreaking

solutions to protect and revitalize the river's 308-square-mile watershed. By 2013 a combined sewer overflow plan will have eliminated nearly all sewage releases into the river. Still, the river's long-term health is threatened; the slow-moving Charles will become a "weed-choked swamp over the next few decades," said CRWA Executive Director Bob Zimmerman, unless there's an effective response to phosphorous runoff that is 54 percent more than the river can handle, based on CRWA studies of total maximum daily load of the pollutant, and increased river temperatures due mainly to low river flow. The root cause of these problems, he explained, is "the impervious surfaces—roads, buildings, and parking lots, and the water infrastructure built over the past century. It dewaters our rivers and streams, raising their temperatures, and nutrient-laden pavement runoff causes algal growth, prolific weed growth, and no-oxygen dead zones." Another CRWA study found that one reason for water depletion was groundwater that should add to river flow instead leaking *into* sewer pipes, because pressure inside the pipes is lower than in the surrounding ground. Half of the "wastewater" collected in the watershed "is really clean groundwater leaking into the pipes," Zimmerman said.

CRWA's response, a work-in-progress, combines ecological, performance management, and market principles to form a large-scale systemic solution. "We have to rethink how we collect, treat, and dispose of wastewater and how we collect and discharge stormwater," Zimmerman said. To control cityscape runoff—an estimated 55 percent of the 45 inches of average annual precipitation—CRWA works "to restore natural hydrological function to the urban environment." It analyzed soil types and historic groundwater flows to design ways to retrofit buildings and pavement, and to redesign urban neighborhoods so there will be less runoff. It persuaded the EPA to require commercial, industrial, and high-density residential sites with two acres or more of impervious cover to reduce their phosphorous runoff loads by 65 percent. This will require property owners to invest thousands of dollars in rain gardens, constructed wetlands, and other methods. To reduce owner costs, it has been developing a "stormwater credit trading market" to allow owners to buy credits from other owners with lower retrofitting costs. "The regulatory drivers and the necessary science are in place to create a market around reducing stormwater pollution," said Zimmerman.

To address low river flows, which are partly caused by water loss to regionalized sewers, CRWA has been working on alternative methods to treat and manage wastewater. This involves "limited, strategic sewering and local wastewater treatment, where the treated effluent (meeting drinking water standards) is returned to the ground near where it was originally withdrawn," Zimmerman said. CRWA is exploring using the decentralized wastewater, in combination with commercial food waste and septage, as a resource to produce renewable electric energy. And there's one other concept in play: wastewater mining might create unused space in large sewer interceptors, so CRWA has already done some rough planning about repurposing the interceptors for flood control, which may help to reduce the impact of climate change.

Of course, some cities are using green infrastructure, a number of water-trading projects are active around the nation, and waste-mining technologies are not new. "But their application to restore water balance is. Taken together, they are transformative. They provide an economically desirable and environmentally restorative path forward," Zimmerman added. "The Charles and its watershed is our laboratory," Zimmerman said, "but the principles, methods, and infrastructure approaches we have developed and are developing apply to virtually any urban watershed."

Building a Market for "Wetrofitting" Services

In three Chicago-area communities, the Center for Neighborhood Technology (CNT)[59] is pioneering a "wetrofitting" service, a one-stop neighborhood-based service to help families invest modest amounts and protect their property from flooding and sewer backups.[60] Across Great Lakes cities, CNT research found "inadequate flood control, expensive wastewater management, and outdated infrastructure that wastes water. Consumers face rising water bills while aging mains and pipes leak an increasingly vast volume of water. Millions of home owners, businesses, churches, and schools face misery from flooding. Antiquated water infrastructure leads to polluted rivers and lakes and impaired wildlife habitat."

No one knew how much all of this was costing homeowners, insurance companies, and water utilities. But CNT's research uncovered that the average "flood incident" for a homeowner required thousands of dollars to address damages and future prevention. Insurance companies provide basement flood insurance as a "loss leader" to sell house and auto insurance, so they have not been interested in the cost/benefit analysis of prevention measures. With CNT's research, insurers may see value in varying their flood-insurance rates by risk level and in reducing overall risks through prevention, and homeowners will have an incentive to implement preventative measures to reduce their insurance costs. And that will create a market for wetrofitting services.

CNT's list of potential wetrofitting services includes checking and repairing private lateral pipes; lateral insurance programs; flood insurance riders; waterproofing basements; installing overhead sewer pumps; disconnecting downspouts; street retrofitting and porous paving; rain barrels and water harvesting; bioswales and rain gardens; and wetlands and park retrofits.

Recycled Water – A Growing and Changing Practice

Water recycling—treating used water and reusing it for certain purposes such as landscaping--is not new, though it's not yet a mainstream practice. Most municipal water systems still provide high-quality potable water for all uses. But, as Pacific Institute's Heather Cooley noted, "Storm runoff, rainwater, graywater, and reclaimed wastewater are well-suited for landscape irrigation, commercial and industrial purposes, toilets, and other nonpotable uses."[61] This is part of the "fit-for-use" model in which the quality of water delivered is matched to the use—a key strategy in water-scarce areas. In southwest Florida, for example, half of all wastewater is recycled.

Now, the cutting edge of innovation is in "closed loop" reuse systems, pioneered by water-intensive corporations, and, perhaps in providing recycled water directly for household uses that currently use potable water only.

A Frito Lay food processing facility in Arizona offers an award-winning example of the closed-loop system. About 75 percent of the water used in manufacturing chips at the plant is reused water. Using biological, membrane, and filter technologies it runs the used water through 15 steps in the process of manufacturing chips. It took the company several years and many trial experiments to design the most effective combination of membranes, centrifuges, settling tanks, flow dynamics, and carbon filtering—and not use any chemicals. The recycled water tests at a "no detection" level for contaminants exceeding water quality standards for public water supply. The water is reused over and over, with an annual saving of 100 million gallons. All by-product waste removed from the water is sold as feedstock to farmers, which generates revenue that offsets the cost of the system.

In southern California, right next door to Orange County—which, since 2008 has operated what was then the world's largest wastewater purification system for *indirect* potable reuse, a $481-million facility--is the West Basin Municipal Water District, with more than 1 million customers. Sixty-five years ago the district obtained 100 percent of its water from local groundwater. Today it imports from afar about two-thirds of its water, for more than 1 million customers. Because of the uncertainties of continued importing, the district aims by 2020 to cut its importing to one-third of all supplies. How will it do this? Mainly by doubling conservation and water recycling. Failure to maximize these water-saving approaches could lead the district to turn instead to increased desalination, which is more expensive, more environmentally problematic due to impact on marine life, and uses more energy.

The district has invested some $520 million during the last 14 years on recycling, said Shavaji Deshmukh, District Assistant General Manager. "We've done water recycling successfully. We take wastewater that normally is discharged to the ocean; we've been making it potable and putting it back into the groundwater

basin." But increasing recycling even more could mean having to use treated water for *direct* supply to households, "straight from the treatment plant to the house," not just release to the groundwater basin. The district, in league with other water providers, is studying the feasibility of this.

The barriers are technical and social, Deshmukh said. One technical challenge is coming up with an "engineering buffer," a tank that holds and monitors treated water to ensure that it's safe before going directly to the customers. Right now, the groundwater basin provides that buffer (there are regulations about how long treated water must remain in the ground before being pumped into use). A second technical challenge is to conduct continuous real-time monitoring of the treated water's quality, so that if there is a problem, or "exceedence" of standards, the flow can be shut down and customers unaffected. "We've come a long way on solving these problems," said Deshmukh.

The social problem is winning public acceptance of recycled water for direct use. Even though the treated water may be measurably cleaner than drinking water from the tap, people may react negatively. "If you hear that the water you're drinking comes from the toilet, well—I still have people asking if it's safe to drink tap water," Deshmukh said. "They think [recycled water] is good for the lawn, but not to drink."

Among the emerging technologies being applied to wastewater treatment and recycling: nanotechnology used to remove chemicals; ceramic membranes, which are more durable; sunlight photocatalysis, which incorporates sunlight, rather than expensive UV lighting, to treat water; mobile water purification systems, including biodegradable water filtration "teabags," filtration straws, and solar-powered filtration systems; Forward Osmosis, as well as Reverse Osmosis systems.[62]

Regional Water Technology Accelerators/Business Clusters

"I've had a chance to see technologies that you have not seen, truly game changing stuff: genetically engineered bacteria that can do specific things and generate electricity at the same time," Alan Vicory, Jr., told the 2012 U.S. Water Alliance conference. "The challenge is to find a way to streamline what seems to be a 15-year process to move technology through the system and out into the marketplace." Vicory is helping to lead an effort in Cincinnati-Dayton-Northern Kentucky, begun in 2010, to build a regional public-private partnership, called Confluence (www.watercluster.org), focused on commercialization of technology and based in large part on the local presence of EPA's research and technical laboratories and centers.

A cluster-building effort in Wisconsin, the Milwaukee Water Council, started several years earlier around private companies, such as Badger Meter Inc., the nation's biggest water meter company ($280 million in sales) linked to academic institutions such as the Great Lakes Water Institute and a new University of Wisconsin School of Freshwater Sciences. In August the Council broke ground on a $22 million building renovation to create a water-technology accelerator.[63] New efforts have started in Cleveland (Nortech) and Pittsburgh (Water Economy Network).

The economic potential of water technology businesses is compelling, Nancy Stoner, Assistant Administrator for Water, told the Water Alliance conference: Within the environmental sector, the biggest subsector is water equipment and chemicals. "It's a big business and growing," she said—with some $10 billion a year in exports.

Community Environmental Monitoring in Northern Michigan [64]

When a new nickel-copper mine was planned near the headwaters of the Salmon Trout River, which contains a rare trout and empties into Lake Superior, environmentalists and many nearby community members expressed concern about potential environmental damage, especially sulfide contamination of the water. Intense opposition to the mine did not prevent the state from permitting the operation. That's when a community-based NGO, the Superior Watershed Partnership, and the Rio Tinto Group, owner of the new

Eagle Mine, struck a unique agreement for monitoring that would go beyond what the mine was required to conduct by governments or by the company's standards. It would allow the Partnership to monitor whatever it thought needed to be monitored, and allowed community members to tell the Partnership what monitoring they wanted. All monitoring results would be made public. And Rio Tinto would pay for the program.

The arrangement, put in place in late 2012 after four months of intensive negotiation, was needed to maintain the company's "social license" and made financial sense, explained Simon Nish, Rio Tinto's director of Community, Communications and External Relations. "In our minds, the value proposition is like this: The community says to us, if you treat us with respect and recognize our interests; if you operate in an open, transparent way; if you operate to the highest environmental standards; if you're going to create long-term economic development for us; and if you will clean up when you go—then we will consider supporting you being here. For Rio Tinto, the value exchange is that we do certain things in exchange for community support, which is highly valuable in dollar terms to us."

The Partnership understood Rio Tinto's interest in building public confidence and trust in the mine operations, but that was not a goal it shared. "That's their hope, not ours," said Partnership Board Chairman Richard Anderson. "Our job is to deliver on an independent monitoring program and do it in a way that community members can trust and use, regardless of where they stand on the issue of the mine's environmental impact." The final agreement states that the joint purpose of the monitoring program is "to build a comprehensive and accurate picture of the Eagle Mine's environmental impacts… based on the highest scientific standards." And it ensured the Partnership's independence. Rio Tinto's funding, which can be added to by other parties, goes through the local community foundation, which has final say in any disagreements between Rio Tinto and the Partnership.

These innovations are exciting developments, but to be clear: innovation has not reached the mainstream of the water sector; it hasn't transformed much yet. The path forward to sustainable water markets/systems is neither clear nor assured. Quite simply, **sustainable water is in the early stage of becoming a *field of practice* with potential transformative impact**.

A field is a critical mass of people and organizations linked and working in a variety of ways on a common problem. Vibrant fields of work embrace diverse perspectives, reflect multiple entry points and methods for addressing practical problems and policy barriers. The people and organizations in a field share some values, vocabulary, information, literature, objectives, and a repertoire of tools. They develop knowledge, individual and organizational capacities, and systems for professional development, standards, and best practices. They support experimentation and the cross-pollination of thinking and practice. Robust practice fields create the "ecology" out of which many innovations emerge and reach scale.

Through our work with many fields, we've observed that fields evolve through four distinct stages.[65] Often they start as aspirational movements, before they become more technical and develop practices and standards.

Evolution of Practice Fields	
Stage	**Characteristics**
1. Framing	Conceptual framing and isolated practice examples.
2. Networking	Networking of innovators and the proliferation of practices. Practices are fragmented and often considered "proprietary."
3. Maturation	Maturation of practices; convergence around common methods and tools; integration of previously differentiated practices; development of a professional implementation support network.
4. Standardization	Practices become highly standardized, and incorporated into formal training; credentialing and certification systems. Practices are considered "commodities." Reward systems reinforce desired behaviors.

The sustainable-water field is in between stages 1 and 2, Framing and Networking, respectively—with lots of conceptual talk and writing, a growing number of experiments with particular solutions, and some networking among practitioners. This is encouraging and important, but most of the experimentation has not yet yielded the "proof of concept" that makes clear what results the innovation can produce and at what cost. Experimentation is being done by innovators and some early-adopters, but is not ready to penetrate the mainstream. The methodologies and outcomes from pilot and demonstration projects are inconsistent, so more work is needed to determine effective, best practices. And not much experimentation has yet amounted to the "ensembles" of innovations that are transformative at operating system scale. Practice innovations form the beginning of developing and testing new solutions for many different problems with the traditional system. "We're collecting lots of disconnected anomalies," reflected David Rankin, Vice President of Programs at the Great Lakes Protection Fund, "but there are just a few early stage signals of coalescing."

At the same time, it's routinely observed by people in the field that the field itself is fragmented in ways that reflect the many geographic and system silos in the water marketplace; they have unique situations and different points of view, and so don't collaborate well across issue areas.

Ahead, then lie stages 3 and 4 of field development. These are Maturation and Standardization, achieved by: advancing innovation work through proof of concept and integrating innovations into large-scale systems; the convergence of practitioners around a set of proven, reliable, standardized solutions; and development of sustainable institutional capacities for the field that, for instance, support practitioners in implementation--embedding new knowledge into research, training, and professional credentials. Typically, it takes a field several decades or more to advance through these stages and become fully established.

For the sustainable-water practice field to evolve as quickly as possible and gain greater impact, it must develop a critical mass of proven innovations, highly connected and collaborating practitioners, and a coherent systemic approach.

4. Some visionary leaders are finding ways to broker cross-sector alignment and political will for large-scale innovation and investment in developing sustainable water systems.

Joanne Mahoney, a newly elected Republican county executive in New York State, considered replacing parts of a job-creating grey infrastructure plan in the City of Syracuse to clean up Lake Onondaga with a large amount of green infrastructure. She was under pressure to approve construction of the third of five treatment plants. The local unemployment rate was high. The city and county had long-standing feuds. Instead, Mahoney asked state and federal regulators for time to study an option that incorporated less costly green infrastructure into the clean-up plan. "I had an obligation to pursue a better way than just building another sewage treatment plant in downtown Syracuse." Mahoney went to major employers and the local state university leaders to discuss the options. Then, in partnership with the city, she pulled the plug on construction of three water treatment plants and approved a large-scale "Save the Rain" green infrastructure effort in Syracuse. Three years and 100 green infrastructure projects later, the U.S. EPA had designated it as one of the nation's 10 leading green infrastructure models. Since then, suburban communities have asked for, and received, green infrastructure projects of their own. Projected savings for the green infrastructure, compared to the grey infrastructure-only projects are $20 million.[66]

Jim Lochhead, CEO/Manager of Denver Water, has been working at the local and regional level to address the water supply issues and advance an array of innovations. "Risk and uncertainty are on my mind every single day. Our customers will probably need to accept greater cost in the delivery of their water, and have a greater understanding about how they use water and manage their demand. The traditional utility model is that it's our job to take, treat, and deliver water at the lowest cost. Instead we need to engage our customers in how to use and manage our water supply so they are efficient. We're definitely pushing for water reuse. We're having lots of discussions about greywater and rain catchment. Proposed [real estate] developments in Denver are looking a greener infrastructure, at zero-water footprint." The Colorado River Basin (from which Denver draws water) is at the edge of innovation for sustainable water, Lochhead said.

"It's the most highly developed river in the world: big urban communities, big agricultural users, environmentalists, and a recreation economy, all intersecting." An experienced water-allocation negotiator, Lochhead has been developing relationships with the California, Arizona, and Nevada water districts that also draw from the Colorado basin. "We've made some progress," he said, "in terms of working together to solve water-supply issues in common. It will be interesting to see if we can broaden the conversation to the basin as a whole over the next several decades. Major paradigm shifts will need to occur."

Bob Zimmerman, head of the Charles River Watershed Alliance in Massachusetts, scrapped together enough funding during nearly 15 years to develop the information, policies, tools, and pilot projects for a new "cap-and-trade" market to reduce phosphorus runoff into the Charles River (see sidebar). "We've been keeping this entire initiative going on a shoestring—dribs and drabs of funding and strategic application of hard-to-come-by unrestricted funds," said Zimmerman. He needs $5.5 million more during the next five years to take the potential market to watershed scale. "That's what it would cost if we were to fully fund the job. The up-front science is all done, now we have to work through the politics and policies and the investment phase."

In these and other cases, it took visionary leaders with the skill and persistence to broker coalitions—across water provider segments, multiple levels of government, among economic, environmental, and community interests—to get important experiments off the ground. It's never easy or risk-free. When Kansas City municipal officials took the idea of green infrastructure to the low-income neighborhoods that would be affected, recalled council woman and political-point person Cindy Circo, "It wasn't a kumbaya moment." Lillian Kuri, program director with Cleveland Foundation described what she had seen it took to advance integrated watershed planning in that Ohio region: "You can't do this kind of [innovative] work without leadership, strong partners, and without taking risks."

But vision, smarts, and courage are not all that's needed. Long-term political stability is a huge factor in whether or not a place-based system can make transformative progress, said Paul Reiter, Executive Director of the International Water Association. This is because it takes time—years or even decades—to achieve transformation. Much can be done on a project by project basis to advance a sustainable water system, but ultimately, a stable political culture that supports sustainability—not just a bold leader—will need to be in place to support the huge investments systematic overhauls require.

IV. RECOMMENDATIONS FOR INVESTING TO ACCELERATE DEVELOPMENT OF SUSTAINABLE WATER MARKETS AND SYSTEMS

Most analyses of opportunities to invest in developing sustainable water systems in the U.S. generate plenty of options for supporting innovative practices or addressing needs in various places. Look at where the most water is being used or wasted and you'll understand the value of getting agriculture and thermoelectric generation to change their practices and become more efficient. Look at where the most pressure is on water systems due to supply constraints, excessive withdrawal, or regulatory mandates and you'll see the value of investing in new practices for stormwater and wastewater management, ecosystem restoration, and recycled water. Look at the breadth of ecological or financial-investment needs and opportunities in water markets, as, for example, the Pacific Institute and Ceres have done, and you'll see the value of a multi-pronged strategy. The Pacific Institute has advanced five strategies that combine innovative policies and practices: urban water conservation and efficiency; stormwater management; environmental restoration and remediation; alternative supplies; and agricultural water efficiency and quality.[67] Ceres, with American Rivers, identified three strategies focused on stimulating investment in water infrastructure: transparency, market formation, and valuing water, each with a set of innovative practices already conceived and, in some cases, being tested.[68]

We have used a somewhat different lens to identify investment opportunities. We've asked where the most leverage may exist to accelerate *system-level transformation*. Given our findings that the system's market dynamics are shifting; that big new drivers of change in water systems (the economy and climate change) are growing in power); and that a new system-level paradigm is emerging and being tested in a growing number of practice-based experiments—it made sense to look for "leverage points" in the water system that would affect the entire system over time. This led us away from focusing on the largest users of water, from trying to address all or even most of the big issues in water, from drilling down on a particular set of innovative practices, and from embracing a broad agenda of practices/policies for change. It led us to five system-level "hot spot" or leverage points for philanthropic investment to accelerate sustainable water system/market progress:

1. Development of the emerging **practice field** of sustainable water management.
2. Development of sustainable-water **measurement and performance standards** for U.S. water providers in the U.S.
3. Development of innovations that leverage **financing, insurance, and other markets** to drive water providers to adopt sustainable water practices.
4. Development of innovations for transformation of **"urban water" systems**.
5. Support for **visionary leading practitioners** who are building civic and political will and implementing transformative innovations for sustainable water systems.

Recommendation 1: Build a coalition of funders that supports development of a strategic plan for building the sustainable water management field.

Accelerating the development of sustainable water systems in the U.S. depends importantly on field building. Right now, as we described earlier, the field is situated in stages 1 and 2 of a 4-stage evolutionary path. As shifts in water market conditions increase the need and opportunities for sustainable water, the capacity of the nascent sustainable-water field is not yet strong enough to supply proven, reliable innovations and implement them in complex, often resistant, contexts. The field needs to move as quickly as possible beyond early-stage conceptualization and experimentation. By demonstrating that applied solutions work—"proof of concept," in innovation terms—the field can build clarity about and confidence in the new paradigm principles and operating systems. This will accelerate adoption and the reaching of critical mass.

In general, building a field involves supporting a capacity, distributed among a number of organizations and individuals that collaborate, to enable the following activities at as large a scale as possible:

1. Define the scope—content and boundaries—of the field.
2. Build strong connections among leading innovators in the field.
3. Generate strategic knowledge about the "edge of innovation in the field"—the problems the field is tackling and the current state of innovation development.
4. Align innovators around a high-priority innovation-development agenda, the implementation of which they will guide and participate in.
5. Support disciplined innovation-development processes based on the field's innovation agenda.
6. Gather rapid feedback on innovation developments and share results in a knowledge-creating cycle that leads to adjustments, replication of proven innovations, and new problems to solve.

When a field has become robust enough to sustain itself, it will continuously redefine itself in light of activities that have occurred: expand the networks of innovators, reassess the edge of innovation, and develop a new innovation agenda around emerging problems.

Many organizations—public entities, NGOs, businesses, associations, and coalitions—are involved in sustainable water activities. This is not the same as intentionally building a field's capacity to undertake the activities described above. Although we have not conducted a comprehensive scan of the sustainable-water field's capacities, we can begin to map this terrain.

Type of Field Capacity	Examples in Field
Water-System Applied Research	Pacific Institute, Water Environment Research Foundation, others
On-the-Ground Innovation Laboratories	Charles River Watershed, Center for Neighborhood Technology
Innovation Development Working Groups (e.g., Green Infrastructure, Infrastructure Financing)	Stormwater Infrastructure Working Group, U.S. Water Alliance, many others
Standard Setting Processes (e.g., Sustainable Utility Performance Indicators)	Ceres, Alliance for Water Stewardship, others
Policy Advocacy	Pacific Institute, many others
Commercialization of Technologies	Water Technology Clusters (Cincinnati, Milwaukee, others)
Innovation Investment Fund	Great Lakes Protection Fund
Leadership Development (e.g., academies, fellowships, professional education)	American Association for the Advancement of Science
Technical Assistance for Practitioners	EPA
Formal Associations	Water Reuse Association, National Association of Clean Water Agencies, Water Infrastructure Network, Water Utility Climate Alliance, U.S. Water Alliance, Alliance for Water Efficiency, others
Convening of Field (or sub-field groups)	Johnson Foundation (for funders), Green for All, many associations hold convenings
Publications & Other Dissemination about Innovations (e.g., best practices)	Many Web sites, conferences, publication series

Every type of capacity in the sustainable water field must be strengthened—but this should be done with a clear strategy developed in collaboration with key players in the field.

A coalition of funders should support development of a long-term (5-10 year) strategic plan for building the sustainable water field. This effort would be undertaken in collaboration with key players and

organizations in the field. It would identify overarching definitions/frameworks, existing competencies/capacities, capacity gaps to be filled, network-weaving opportunities, potential high-impact activities, and potential resources for field building. Even more ambitiously, it could design an initial shared innovation-development agenda for the field.

Some key elements of this strategic plan include:

- Development of shared definitions of "sustainable water management."
- Identification of the basic and applied research needs of the field, and development of research networks/consortia to carry them out.
- Identification of professional development needs of the field and of strategies to build skill development and certification systems.
- Identification of key shared water-industry standards that are needed to drive change, and a strategy for supporting their development.
- Identification of state and federal policy changes that are needed to support sustainable water management.
- Development of an innovation-development infrastructure that supports collaborative work across sectors on transformative innovations.
- Identification of the key personal and professional networks that are needed to seed innovation and share best practices.

Accelerating the development of the sustainable water field will take years because of the complexity and scale of the endeavor. This is precisely why philanthropy has a unique opportunity and role to play. It has substantial financial resources not controlled mostly by the owners and operators of the last-generation water-system model. It can be highly intentional about field-building, rather than leaving this to whatever spare time sustainable-water practitioners on the ground can set aside. And it can invest in long-term outcomes, rather than having to respond constantly to short-term demands. Field building is a powerful way for philanthropy to achieve large-scale impact, suggested Michael Porter and Richard Kramer in a 1999 article in the *Harvard Business Review*: "Foundations can create the greatest value by funding research and a systematic progression of projects that produce more effective ways to address social problems. At its best, such work results in a new framework that shapes subsequent work in the field—making every dollar spent by philanthropists, government, and other organizations more productive."[69]

Recommendation 2: Support development of sustainable water measurement and performance standards.

Performance measurement and standards are necessary for the implementation of the Performance Management and Markets principles in the sustainable-water paradigm depend crucially on performance measurement and performance standards that guide management and investment decisions, as well as water-user behaviors. These are "threshold practices"; if they are not in place it is difficult to implement and effectively use other innovations.

Unfortunately, as described earlier in the report, just about every aspect of the water system has a critical need for consistent, widely used standards. "Without common methods and standards," concluded the Center for Neighborhood Technology after surveying 100 water utilities in the Great Lakes region, "water professionals lack the tools they need to fix the problem."[70] In reviewing the adoption of greywater-treatment technologies, the Pacific Institute noted "a clear need for industry standards… When comparing greywater treatment options, manufacturer-provided information can be confusing and relatively limited. Standards could provide information to a consumer regarding the ability of different systems to treat particular contaminants."[71]

What's needed is a comprehensive collaboration among the many innovators of performance measurement and standards for various water provider segments; alignment around which innovations have been proven to work, and around a development agenda and strategies for reaching scale across water systems and markets. "Spread best practices," urged a 2011 study of performance measurement in California's water systems. "Urban utilities, groundwater districts, and watershed groups… would all benefit from more capacity-building and diffusion of best practices for performance measurement."[72] Exactly right, but this won't happen effectively without a high level of coordination/cooperation in the field. An example might be the partnership between the Alliance for Water Efficiency (AWE) and the American Council for an Energy Efficient Economy to promote and innovate in water systems' energy efficiency. In 2011 they released a "blueprint" for research and policy efforts.[73] Work is needed, said AWE's Dickinson, on a wide range of items, starting with measurement: determining how to measure "embedded" energy in water; which best practices deliver energy efficiency in water systems; water/energy footprinting methods; and the development of voluntary standards and mandatory codes, which link water and energy management to green building standards/codes and land-use planning. Some of the specific types of standards that need to be developed include:

- Standards on the kinds of meta-level market data (similar to the Bureau of Labor Statistics data for labor markets) need to be aggregated to understand high-level dynamics of water markets.
- Enterprise-level standards for sustainable water management, including a LEED-like certification system for water and wastewater utilities.
- Common operational definitions for specific aspects of water management, such as definitions of water loss/leakage.
- Financial transparency standards to inform investor decision making.
- Standardized risk assessment methodologies and reporting.

Recommendation 3: Support efforts to leverage financing, insurance, and other markets to promote adoption of sustainable water practices.

Markets are one of the most powerful ways to scale up innovation. It's clear that water systems will need an enormous amount of capital to pay for new or repaired infrastructure, as well as many of the sustainable-water innovations, such as green infrastructure and new technologies. Most of the funding will have to be borrowed from capital markets. This is an opportunity to drive change into water systems, as Ceres and others have pointed out for several years. A leverage point here is the standards that lenders will require water system borrowers to meet. Right now, the sustainability and/or resilience of water utilities—whether, for instance, they are managing water demand, addressing water leakage, adopting new pricing strategies, reducing vulnerability to supply disruption, and other factors—are not a part of lending criteria. But as investors broaden their view of the risks involved in financing water providers and start asking about and requiring a greater degree of sustainability and resilience, the pressure on water systems will be enormous to comply by implementing recognized solutions. Presumably, those that do will be rewarded by receiving lower risk and interest ratings for their borrowing. This is also the case with some privately owned water companies, which the U.S. Securities and Exchange Commission now requires to disclose water risks.

A similar risk-awareness dynamic is at work in the insurance market. An example is the "wetrofitting" innovation developed by the Center for Neighborhood Technology (see sidebar). Because insurers treated basement flood insurance as a loss leader, they had little interest in preventative measures that homeowners could take. But CNT worked to put together a flooding database for the Chicago region that combined data from federal emergency management, the National Flood Insurance Program, and insurance company claims—and its analysis showed lots of money being spent on flood remediation of damages and

future prevention. This provides insurers with an incentive to pay new attention to the market and incentivize homeowner flood-control practices.

When the Great Lakes Protection Fund (GLFP) sought to reduce the environmental damage resulting from ballast releases of invasive species by freighters, it organized cross-disciplinary teams of university researchers, engineers, utility companies, ship owners, policy specialists, and government agency staffers. This collaboration resulted in design, installation, and testing of the world's first ballast water filtration and control system on a working vessel. It also resulted in other anti-pollution and monitoring processes.[74] That's when the complex process of leveraging markets became possible, as GLPF Vice President David Rankin explained: "The idea was that a shift from broad insurance coverage for ships to one that excluded coverage for invasive-species releases would 'activate' the market for control technology. The exclusions started to happen, and that created an appetite for ballast standards by both the carriers (ship owners) and regulators. The broader thinking was that by launching a 'good-enough' working prototype technology, several levers could be flipped roughly simultaneously: marine engineers/architects would see opportunity for improvements and efficiencies; 'no treatment' would no longer be a responsible choice for carriers; regulators would have performance targets, since there would be operating data); and financiers, capital markets, and insurers would see, and hopefully price, a new category of risk." These levers started to succeed, and subsequently the International Maritime Organization established guidelines for ships to maintain specific ballasting standards. "Small moves started to yield big impact."

Developing market-based approaches like these takes deep research, understanding and working with players in the targeted markets, designing new standards or products/services that meet market requirements, identifying water practices that can reliably meet the standards—and gaining market acceptance for all of this. In April 2012 Ceres/American Rivers identified a broad agenda of innovations for financing water systems, most of them in the early stage of development: including creating "robust" market information, jumpstarting off-balance sheet financing for distributed water systems, and piloting market-based watershed improvement programs.[75] Adding to the complexity, as Ceres' reports have noted, is the need to address out-of-date accounting standards, which affect an entity's lending/borrowing potential, and don't have a way of taking into account some sustainable-water innovations, such as green infrastructure.

Market leveraging requires expertise, creativity, and endurance—but the impact can be very high. What's needed is a weaving/amassing of substantial financial and technical resources to support a portfolio of the most promising market-driven approaches under development. Think of this as a combination of an early-stage "venture capital" fund and an institute for market-driven solutions for sustainable water. Pieces of this capacity exist, but they tend to be unconnected to each other and undercapitalized.

Recommendation 4: Focus resources on advancing key innovations in "urban water" system transformation.

Among the many water user groups, urban/metropolitan areas don't use the most water—agriculture and thermoelectric power do. They don't contain within their jurisdictions most of the nation's surface water and groundwater, or the headwaters and snowpacks that source many natural water systems. And yet, metropolitan areas have enormous potential leverage over the future of sustainable water markets/systems in America. They have the people and the economy. In the 21st century most Americans live and work in one of the nation's more than 700 urban/metro areas; in just the top 25 metro areas alone you'll find nearly half of the U.S. population and more than half of the nation's $15 trillion annual economic production.[76]

About 20 percent of all water withdrawn in the U.S. is "municipal water," meeting the needs of people and organizations in cities, towns, and small communities.[77] Public utilities provide the great majority of this water, but small portions are supplied by privately owned utilities, or are self-supplied by residential and industrial users. But the tentacles of urban control over water spread into the countryside for hundreds, even thousands, of miles; urban areas own or have access rights to distant reservoirs, watersheds, and land atop aquifers. Still, concerns about water scarcity are growing and in some places—the Atlanta region,

metropolitan areas tapping the Colorado River, for instance—shortages are a way of life. Atlanta's difficulties, for example, have triggered a three-state legal water war. Anticipating substantial population growth in metro America and therefore more municipal water demand, the Pacific Institute warned that "meeting this new demand… with existing water resources will be extraordinarily difficult, expensive, and potentially environmentally damaging."[78]

Urban areas are mammoth producers of stormwater and wastewater and, due to economic activity and often poor urban design, of pollution in waterways. As a result, they have king-sized water infrastructure problems. Much of the metropolitan water infrastructure is deteriorating, with water leakage probably accounting for 10-15 percent of total withdrawals.[79] A 2012 survey of 55 water providers serving 500 municipalities in the Great Lakes region found their pipes leak an estimated 66.5 billion gallons of water a year.[80] Meanwhile, flooding is an urban problem whose magnitude is not fully understood. For instance, a 2012 study by the Center for Neighborhood Technology reported that "Great Lakes cities experience frequent flooding. The effects of urban flooding—sewer backups, basement seepage, property damage, and street ponding—collectively cause millions of dollars of damage each year. Unlike flooding in rural areas, urban flooding typically affects areas with a high density of population and assets, thus increasing the loss to the economy and to society."[81]

Finally, as mass consumers of most of the nation's food and energy, metropolitan areas send compelling demand-signals to agriculture and energy-production systems about quantity, quality, and price. And, as they realize widely predicted population gains, their potential political clout in state legislatures and the U.S. Congress will grow.

The importance of Urban America in shaping the nation's water future cannot be underestimated, even if metropolitan water systems have not yet exercised substantial collective force or built up a critical mass of innovation momentum. Urban water's potential is not just about its own needs as a segment of the water market/system. It's also about how changing urban/metro dynamics could affect other water market/system user groups and provider segments.

Metropolitan water systems can be the brokers of large-scale, long-term rearrangements of water allocation. This is particularly important in the West, where growing cities have "junior" claims on water, usually behind agriculture. Denver Water's CEO Jim Lochhead, for instance, argued that the key to water sustainability in the West lies in the growing urban areas. "We're seeing a shift, as we have greater population growth in the West, climate change, the uncertainties of the economy, the development of regionalism—and a greater focus on urbanization in metropolitan areas. When you look at the risk of the failure of the Colorado River Basin, whose water is over-allocated and will be more so due to climate change, I see a partnership emerging between municipalities, agriculture, recreation, and the environmentalists. Municipal water is reaching out to those groups and our message is, 'We can't succeed unless you do.' I'm doing a lot of outreach to the business community in the Denver area, saying that our economic future is tied to the health of our watershed and the agriculture community that surrounds Denver." Lochhead has discussed with the water CEOs of Las Vegas, Phoenix, and southern California water districts—all of which tap the Colorado—the reasons to form a western urban water coalition. "I would argue that we have to nurture urban development in the West. If you want to preserve agriculture and the environment, and do it in ways that don't waste massive amounts of water and energy, then you have to have vibrant, dense urban living as a model for the West."

Metropolitan areas contain most of the private sector's water-related businesses: tens of thousands of small suppliers to utilities, industry, and households; electricity-generation plants that use water for cooling; and many of the facilities of corporations with intense water use, such as beverage firms and food processors. As noted earlier, some of these enterprises have begun to focus heavily on reducing their water use; they are leaders in water-efficiency innovation and are forming alliances with other water-reform efforts to influence public policies for sustainable water.

Metropolitan water systems may muster their communities' consumer-market buying power to influence the water behavior of economic sectors, such as agriculture, energy, and manufacturing, and relevant state and federal government policies. Consumer and community approval is an important factor in the efforts of some leading corporations to manage and reduce their water footprint, and add "sustainable water" to their brand identity. Corporate effort to earn "social license" is a growing phenomenon, with one of the key drivers being environmental concerns. "Water security is in our planning, and water management is a material issue," said Simon Nish, Director of Community, Communications and External Relations for Rio Tinto Group, the fourth largest mining company in the world. "Our performance around water use will be an important part of our license to operate and is increasingly driven by community concerns that go beyond regulatory requirements." In addition, metropolitan water systems are potentially huge players in financial and insurance markets and, as discussed earlier, their behavior/innovation can be affected by demands from these providers. And metro areas are becoming important sources of ecosystem restoration. Catherine Nagel, executive director of the City Parks Alliance, noted that new urban parks are being designed as a part of stormwater green infrastructure, citing the example of Houston's Buffalo Bayou flood control restoration.

There's another potential impact. In metropolitan areas, water links deeply into other sustainability issues that have risen to the top of urban agenda, such as revamping land use/urban form to promote density, reducing energy consumption, and fostering "locational equity" among neighborhoods and metro communities. For example, when Philadelphia designed its $1.6 billion investment in green infrastructure, said Glen Abrams, Manager of Strategic Policy and Coordination in the Philadelphia Water Department, it was able to locate projects in many different neighborhoods. "The investments are decentralized throughout the city. People will see tangible benefits: greener recreation centers and schoolyards, or improved streetscapes. It's a part of greening Philadelphia." This, Abrams added, fit well with an emphasis by the city's mayor, Michael Nutter, on urban sustainability.

What's needed is development of an investment portfolio and a set of long-term urban-water "innovation laboratories," like the Charles River Watershed Association has stitched together (see sidebar), that support two types of big opportunities in urban water:

- *Threshold management practices for transforming the water operating system.* Integrated watershed planning; sustainable water utility performance standards; resilience/risk/vulnerability assessment and planning, especially in response to the threat of climate change: These all appear to be some of the "threshold" practices—or, practices that have to happen before other practices can be put into place—for making a transition to a sustainable water operating system.

  Some of these practices are becoming more prominent. For instance, new patterns of extreme weather have caught the public's eye and may move resilience planning to the forefront. "We have a 100-year flood every two years now," said New York Governor Andrew Cuomo in the wake of Hurricane Sandy's devastation. This was not news for everyone. "For nearly a decade," *The New York Times* reported the day after Sandy hit, "scientists have told city and state officials that New York faces certain peril: rising sea levels, more frequent flooding and extreme weather patterns."[82] In 2012, more than half of the counties in the U.S. had a federally declared disaster, many of them due to extreme drought, noted Nathan Engle, a scientist on loan from the American Association for the Advancement of Science to U.S. Senate Majority Leader Harry Reid's office. And that was before Hurricane Sandy. "I think there's a really good opportunity to start the conversation [about water-system change] in the context of resilience. It captures the idea of climate change without having to talk about climate change. If we interpret resilience from a risk-management and preparedness perspective, and couple that with economic costs and benefits—we need the research and data, a round of studies that would show the cost-benefit of doing more in the water sector to proactively prepare for climate risks."

- *Transformative sustainable-water system/market innovations ready to be taken to greater scale or to be tested.* Green infrastructure is a leading example of the practices that are gaining momentum at the

metropolitan level. Energy efficiency efforts by water and wastewater utilities may be another. In short, identify innovations that are "ready to scale" or that, like "wetrofitting" and "sustainable utility performance standards and certification," that are in the early "ready to prove" stage of development, but have strong prospects—and then organize investment strategies to accelerate their progress.

Recommendation 5: Support leading practitioners implementing system-transforming innovations.

Leadership in the sustainable-water field has two dimensions: leaders who are advancing sustainability in specific places, showing what can be done, like Bob Zimmerman in the Charles River Watershed or Jim Lochhead at Denver Water, and leaders who are building the field itself, typically by creating field-spanning organizations, such as Ben Grumbles at the U.S. Water Alliance or Peter Gleick at the Pacific Institute. Among the leadership characteristics of these and other innovators is a willingness to collaborate and look for new ideas; deep experience with the ins and outs of the field; skill in assembling and aligning stakeholders; and understanding political complexities. Looking at the wide range of work needed to develop sustainable water systems, participants in a Johnson Foundation convening declared it essential to "support and empower visionary leaders at all scales of society that champion freshwater and facilitate collaboration across jurisdictions, disciplines and sectors to implement durable freshwater solutions."[83]

A field-building agenda for leadership development should include support for both leaders in "high pain" places and leaders of "next stage" institutional transformation in the water sector, especially in professional management of water systems.

- *Broker-Leaders in "High Pain" Places.* Although innovation is occurring and can occur in many places, we see the "targets of opportunity" as places with *both* substantial water stress—"high pain" places due, for example, to water shortages or EPA consent decrees concerning stormwater/wastewater system—and visionary brokers, leaders willing and able to engage cross-sector dynamics and build civic and political alignments that redefine water systems. This leadership category includes top managers of water systems—professional water managers—who must take water management out of the engineering model and into a performance-management model.

- *Leaders in "Next Stage" Field-Building.* The early stages of field development typically involve the emergence of separate "gurus" who pioneer and advocate innovations, often with a proprietary approach. The next stage requires a different sort of field leadership that fosters networking among pioneers and advocates; convergence around common method and tools; and integration of innovations into ensembles and systems.

What's needed is a strategy that links leaders in these categories to resources they need to support their work, expand their impact, and increasingly influence the future development of professionals in sustainable water management.

V. NEXT STEPS

Our analysis identified five "leverage points" where philanthropic investment could accelerate the transition to sustainable water systems/markets—by supporting the development of the emerging practice field of sustainable water management; measurement and performance standards; innovations in financing, insurance and other water-related markets; innovations for transformation of urban-water systems; and visionary, leading practitioners.

As our findings showed, there is already momentum in pursuing change at each of these leverage points, some of it propelled by philanthropic funders. A field is emerging, standards are being developed, financing and insurance innovations are under development, urban-water systems are changing, and skilled leaders are making a difference. The opportunity and need now is to accelerate momentum by creating a more focused and cohesive strategy that attracts resources and deploys them effectively.

Practical next steps could include:

- Development of a specific **"sustainable water funders network"** that links foundations deeply interested in building and pursuing a shared and strategic approach to field building. A starting point could be the circulation of this report and other key documents to selected funders, who would then together develop an initial outline of the elements—a table of contents—for a strategic plan, and commission further strategic planning work. Further planning would require additional research about existing field capacities, and could be tied to the work of a handful of innovation teams as described below.

- Creation of **"innovation teams"** to work on each of four leverage points: measurement and performance standards, market-based innovations, urban water innovations, and leadership support/development. Funding for those teams would support a six-month development process so they can map in detail what is already happening at the leverage point and identify the "edge of innovation" where increased funding would accelerate transformation. Each team would present findings about specific high-potential innovation projects. These teams would be a temporary planning structure. An example of what this might look like in part is the process that Ceres and American Rivers—"Restoring Flows"—used to identify the big ideas in market development for sustainable water. However, that process yielded concepts worth exploring, not specific projects to undertake.

Philanthropy, Sustainable Water, and Field Building

In 2008, the Johnson Foundation started a process that brought together more than 100 freshwater experts, as well as five foundations, and resulted in a shared vision and a set of high-level recommendations issued in 2010 as "Charting New Waters." This collaboration was both promising and somewhat rare among water funders.

In 2011, according to the Foundation Center, U.S. foundations made 1,577 grants for water in the U.S., totaling $221 million. Ten foundations made 30 percent of the grants, a total of $32.8 million.[84] There's no analysis of this national funding flow, but many of our interviewees offered descriptions of what they thought was the prevailing philanthropic approach:

- "Foundations find this is a complicated, fragmented, contentious, and very technical area to be working in."
- "There is a fairly limited set of funders investing in water issues. Many are focused on conservation or very specific watersheds."
- "Funders share the liability of the water field: we're fragmented, siloed."

- "Many water funders are environmental funders who think of themselves as water funders. They're very much about picking a place and making sure protections are in place or restoration occurs."
- "The place-based grants, which most everyone is doing, miss the bigger systems that need to be changed."
- "The majority of water-related grant making is focused on water conservation, preservation and restoration issues, as opposed to the core 'water market' of waste and wastewater utilities, stormwater management, agriculture management, etc."

Given this perceived pattern, it seems essential that a field-building approach for philanthropic investment should *not* require lock-step coordination of many different foundations' investments. Instead, investing in strategic field-building efforts should be offered as a new choice, a hopefully compelling menu of high-impact possibilities. Designing a field-building approach along the lines of our recommendations does require shared vision, analysis, and strategy among foundations. But it can also let foundations pick their spots within a broader philanthropic-investment strategy map, tailoring their investments to innovation opportunities that fit their institutional interests <u>and</u> the shared strategy.

VI. MAXIMIZING THE ECONOMIC IMPACT OF SUSTAINABLE WATER MARKET DEVELOPMENT

The development of sustainable water systems/markets in the U.S. offers several important ways that philanthropic investors can advance their interest in economic opportunity for low-income people.

First, and most important, ***a transition to sustainable water systems is crucial to the future economic viability of metropolitan areas, where most low-income Americans live***. Disruptions in the supply of water to the very large water-using economy—due to drought, extreme weather events, failure to comply with pollution regulations, and other factors—can reduce economic activity, with loss of wages and even employment. For example, just days after Hurricane Sandy struck, economists estimated up to $50 billion in economic losses.[85] Investing in the development of resilient, adaptive water systems in metropolitan areas is the best insurance against this happening. At the same time, the redevelopment of urban water systems can enhance efforts to promote smart growth, low-impact development, and other sustainable urban forms.

Second, ***investments in sustainable water grey and green infrastructure can generate economic activity that directly provides jobs for low-income people, as well as improves conditions in low-income neighborhoods***. These investments depend mostly on decisions made in metropolitan areas by government owned or controlled water and wastewater utilities, some of which are under federal pressure, and the financial markets that fund their infrastructure/capital expenditures. The potential in this niche has been studied in some metropolitan areas, and is being partially realized in some areas' implementation of large-scale green infrastructure initiatives. With the extensive damage from Hurricane Sandy and other super storms in recent years, it's likely that there will also be a boom in capital expenditures—and job creation—to protect metropolitan areas on the Atlantic and Pacific coasts from future water surges.

Third, ***growth in private business activity in sustainable water is most likely to center on technology development and sustainable water-system management.*** Increasingly this will be driven in metropolitan areas through research-and-commercialization clusters of collaborating businesses, governments, universities, and NGOs. Although regional industry-cluster development is not a new phenomenon, building water-related clusters is.

Fourth, ***the ongoing rise in water and wastewater pricing will disproportionately increase pressure on low-income household budgets***. This raises concerns about equity and ability to pay when it comes to financing some parts of the transition to sustainable water systems/markets. Large-scale adoption of water-conservation practices would mitigate some of this growing financial burden. In addition, some progressive communities are experimenting with differential pricing schemes that reduce the burden of cost increases on low-income households.

It turns out that each of these opportunities focuses on metropolitan areas, which were also a principal point in the previous section on accelerating development of sustainable water systems/markets. That's because metro areas are where most of the nation's population and economy is found--including low-income households; where much of the nation's water infrastructure exists; and where most of the water-related businesses and research laboratories are located.

We will return to these opportunities after examining the structure of the water economy. Unfortunately, literature about water systems doesn't shed much light on the amount of economic activity and job creation that might be generated by efforts to make U.S. water systems more sustainable. There is some high-level national data about the economics of water, and there are a small but growing number of case studies at the on-the-ground project level. And, in between the high- and ground-levels, a handful of studies look at the economic impact of investing in water infrastructure, grey and green. The overall lack of information, however, isn't surprising. One reason for the analytic gap is that most advocates for sustainable water have been motivated by concerns, such as environmental quality, that have nothing to do with the

economic impacts of sustainable water. Another is that the professional economic development community has rarely regarded the water-providing sector as having the potential for strong growth, especially compared to other sectors.

That said, we have pieced together a framework based on the incomplete information that exists—looking at the national water economy, metropolitan area water economies, and occupations in the water economy.

National Water Economy

There are two "water economies" in the U.S., the supply side (water-providing sector that directly provides water supply and services to users) and the demand side (the many water-using sectors, such as agriculture and thermoelectricity, which obtain water to produce goods and services they sell to customers). In one, water is the product; in the other it is an input or "factor of production."

The U.S. water-providing sector generates an estimated $130 billion in economic activity annually, and is growing. This is a very small fraction of the total U.S. economy of more than $15 trillion. In 2008 Goldman Sachs projected 3-5 percent growth in the water sector of the U.S. and other developed nations, mostly on the strength of upgrades in water and wastewater infrastructure.[86] The Summit Group's 2012 review of the global water sector and the U.S. "hydrocommerce" sector predicted "strong and very consistent growth opportunity over the long term—there is virtually no way that the size of the water industry is going to shrink."[87]

As Goldman Sachs noted, "there is no single water sector." It divided the sector into many subsectors: pumps, valves, water testing, water and wastewater treatment, industrial water treatment, residential water treatment, filtration, desalination, infrastructure, automation systems, engineering and consulting services.[88] This segmentation matters for any deep analysis of economic potential, since different subsectors have different growth potential and also different occupational structures. And it includes businesses that export water equipment, technologies, and chemicals, a driver of economic growth. In 2010, according to U.S. government data, water-industry exports amounted to $114 billion, with Canada and Mexico the biggest markets totaling about $32 billion.[89]

The other water economy, the sectors that directly or indirectly use water, is many magnitudes larger than the water-providing sector. The U.S. EPA estimated the economic output of agriculture, mining, manufacturing, and electricity, which use 88 percent of U.S. water, to be nearly $2.9 trillion, or about 19 percent of the U.S. Gross Domestic Product.[90] In other words, nearly a fifth of the U.S. economy depends on water as a critical direct input. In these sectors, what matters most is the availability of water. As the cost of water goes up, it is passed on to customers as much as possible. But shortages in supply interrupt and may curtail economic activity. Some water-intensive companies and even sectors have begun to aggressively manage and reduce their water use—to reduce their vulnerability to supply disruption, cost increases—and, as mentioned earlier, to brand damage.

In the water-providing sector, the dynamics of cost and supply work somewhat differently. For instance, many water utilities that sell water to households still use volume pricing, meaning that the more water a user uses, the lower their rate. They often run into financial difficulty when users conserve water, because while their revenue is volume-dependent, the majority of their costs are fixed; when usage declines, the costs do not. Or when utilities want to upgrade or replace water infrastructure to reduce the amount of water lost to leakage or to improve wastewater and stormwater system effectiveness, they have to borrow money to pay for the projects and, typically, have to raise prices on users to pay back the debt. "The vast majority of funds for water and wastewater systems come from the utility fees users pay to receive water services," noted the Pacific Institute's Heather Cooley.[91] But prospective price increases by municipal water and wastewater utilities can become politicized since they are subject to the decisions of elected officials.

Metropolitan Water Economies

Although we can describe a national water economy, a great deal of water economic activity plays out in local or regional markets/systems. The geographic distribution of enormous water-using sectors varies considerably. For example, agriculture in the West is a huge water user and economic generator, while the northwest has a large portion of the nation's hydropower generation. Within the much smaller water-providing sector, some subsectors such as equipment (e.g., pumps and valves) and engineering have national and international distribution systems, but a great deal of economic activity is likely localized ecologically to the watershed level and sometimes economically to the metropolitan level. In other words, it is localized due to source of water and/or the presence of large customer markets.

One of the few studies of a metropolitan-level water economy is for Los Angeles. A 2011 study estimated that the Los Angeles water-providing sector had an annual total of $35 billion in sales and more than 200,000 jobs, from a mix of 17,000 (public and private) businesses divided into two tiers. First, businesses that build, operate, and maintain the water/sewage infrastructure, manufacture water systems equipment, and engineer improvements in water use. Second are businesses that supply goods and services to the first tier.[92] (Because of many difficulties with the data, the study acknowledges that these sales and employment numbers probably overstate what is produced by the water-providing sector.) The first tier was much smaller economically—about 8 percent of the water-providing economy, and owned mostly by governments. Its biggest sales and jobs components, making up more than 60 percent of the total tier, were sewage treatment facilities and water system operations. The second tier's economic activity was spread across firms in more than 35 industries, nearly all of them privately owned. (A Philadelphia study identified a similar profusion of private businesses in that region's "green" stormwater supply chain: nearly 2,500 firms with $7.4 billion in sales.[93])

It's not clear to what extent the Los Angeles water-providing sector may look like such sectors in other metropolitan areas. The study's analysis found that much more of the LA sector's employment is concentrated in sewage treatment, water supply, and irrigation systems than across the rest of the nation. This could be due to local conditions. For example, the Los Angeles is a major importer of water and the mix of its customers—residential, industrial, agriculture, etc.— and is quite different from other areas.

Water Sector Occupations

Within the water-providing sector, occupations can be divided into three broad categories: professional/management jobs, "middle skilled" blue-collar jobs, and "green" jobs. "Little empirical data are available to quantify the jobs created in each occupation involved in sustainable water strategies," noted the Pacific Institute in 2012 when it examined the linkage between water and jobs. "Until recently, efforts at assessing and developing green jobs largely ignored the connections between water resources, energy, and job creation."[94]

In the professional and middle-skilled groups, the skills required are quite different, as are the wages paid. The Los Angeles study found that about 15 percent of all jobs in the water sector were tied to "water efficiency" work and that these were in 14 different occupations, including the operation and maintenance of municipal water infrastructure, wastewater

"Water Efficiency" Occupations (LA Study)

- Landscaping and Groundskeeping Workers
- Grounds Maintenance Workers, All Other
- Tree Trimmers and Pruners
- Septic Tank Servicers and Sewer Pipe Cleaners
- Pesticide Handlers, Sprayers, and Applicators, Vegetation
- Meter Readers, Utilities
- Pipelayers
- Plumbers, Pipefitters, and Steamfitters
- Water and Wastewater Treatment Plant and System Operators
- Environmental Scientists and Specialists
- Geoscientists, Except Hydrologists and Geographers
- Conservation Scientists
- Environmental Engineers

systems, water systems equipment and services, related engineering services, and residential and commercial landscaping maintenance. Skill levels varied from low to high and only some of the occupations had low-skill entry-level jobs. Mean wages in these occupations ranged from $28,390 to $99,430 annually.

Green Roofing: Becoming a Formal Occupation

"The skill sets from roofing are only one of the skills needed for green roof design and installation, and roofing skills are not the most critical. However, landscapers cannot simply start planting on roofs. Knowledge of plants, soil, and civil engineering are more critical skills, but in the embryonic state of the industry, the typical "Green Roofer" is a hybrid of one or more of the skills above. As the field matures, a more formal occupation may emerge, but at this time there are no accepted standards for Green Roofs as a product or service, let alone accredited training, despite several competing efforts in those regards."

--Philadelphia study, "Capture the Storm"

In the water sector, "green" jobs are typically thought of as jobs that are related to economic activity designed to move the sector toward more sustainable outcomes. These would not exist if those outcomes weren't being sought. The green-jobs group in the water sector is emergent, small, and doesn't fit the official occupational classifications. For example, the Philadelphia study of green jobs produced by investing in stormwater infrastructure found that they "defy many of the traditional occupational classifications as well as fundamental constructs such as career ladders. In some ways, green stormwater occupations are no different than occupations in other emerging fields in this regard, except that what is unique about green stormwater is that there may be multiple points of entry and a variety of horizontal and lateral career paths. People can enter the field from any one of a number of different disciplines (civil engineering, landscape architecture, horticulture, construction, and a variety of skilled and unskilled trades)."[95]

"Most of the occupations associated with water infrastructure projects" in Philadelphia "do not require high levels of formal education," reported Green for All in "Water Works." Noting that 13 of the 15 occupations listed typically require only a high school degree plus some post-secondary education or training, it said that "the vast majority of jobs in these occupations (with the exception of environmental engineering and construction management) are accessible to workers who do not have a four-year college degree."[96] When the Philadelphia study examined the prospect of job growth within the stormwater sector, it found four occupations were predicted to have above average increases in jobs, mostly involving professional/management: water and liquid waste treatment plant and system operators, pipelayers, environmental engineers, and construction managers.[97] Of these, the study added, "The two occupations with the highest above average growth projections—Environmental Engineers and Construction Managers—are also those occupations requiring the highest levels of education. The demand for skilled workers has increased over the last few decades, due to the continual trend of firms employing more sophisticated technology in their operations." There will also be some increased demand for lower-skill occupations, but, the study, concluded "the need for large numbers of lower skilled workers will initially lag the demand for higher skilled workers."[98]

The analyses in Los Angeles and Philadelphia—when combined with the broad water-sector trends toward more integrated planning and management of water systems and increased reliance in the market on technologies for water efficiency and quality—suggest a long-term shift in the water-providing sector's "occupational profile" toward more professional/management and emerging green occupations. Large new investments in infrastructure would increase job growth in the sector, but might not blunt the shift in occupational profile.

Summary Implications

At the beginning of this section, we summarized four key dimensions of the intersection of sustainable water markets and economic opportunity for low-income people. Each of these dimensions has implications for how to maximize this opportunity. These are summarized in the table below.

Dimension	Implications
A transition to sustainable water systems is crucial to the future economic viability of metropolitan areas, where most low-income Americans live.	• Sustainable water systems investments should target the economic regions where water supply disruptions are most likely to have economic impact. • The benefit of these investments cannot be directly connected to low-income populations, but will benefit them along with other participants in the economy.
Investments in sustainable water grey and green infrastructure can generate economic activity that directly provides jobs for low-income people, as well as improves conditions in low-income neighborhoods.	• Many large-scale plans that could drive a great amount of growth in the water economy will be made by publicly owned or controlled entities, urban water, wastewater, and stormwater utilities, in particular. Yet, this is where important innovation is needed and starting to occur: innovations in integrated planning and risk assessment and, at the financing end, innovations in lending standards for sustainability and in generating revenue through new pricing structures. • If portions of the potential growth are to be targeted for the benefit of low-income people, then both the businesses and the people will need access to effective support systems for training, placement, and other workforce development services. Although this has not been a norm in the water sector, there have been some efforts to link training to emerging demand for water occupations, driven especially by impending workforce turnover. (For example, many community colleges offer American Water Works Association accredited training programs.)
Growth in private business activity in sustainable water is most likely to center on technology development and sustainable water-system management.	• Increasingly, the state-of-the-art in metro economic development is focusing on the development of business clusters—a geographic concentration of interconnected businesses, suppliers, and associated institutions in a particular industry sector. As mentioned earlier, a handful of urban areas are developing water-technology clusters. • This sort of organizing and collaboration is new in the water sector. Water technology clusters should increasingly be a focus of regional economic development activities. In addition, analysts in Philadelphia have pointed to the potential of a green stormwater cluster of firms that provide architecture and engineering green design; various types of green infrastructure (e.g., permeable paving); water meters and sensors; and "greenscape" services.[99] It makes sense to partner with the economic development community to target the development of water technology clusters in economic regions across the country and to link those clusters with each other to maximize the potential for innovation.
The ongoing rise in water and wastewater pricing will disproportionately increase pressure on low-income household budgets.	• Systems for moderating the impact of water costs on low income households should be refined and expanded.

Interviews

Glen Abrams	Manager, Strategic Policy and Coordination, Philadephia Water Department, Green City, Clean Waters Plan
Joya Banerjee & Allison Taylor	Program Officers, S.D. Jr Bechtel Foundation
Lynn Broaddus	Director, Environmental Programs, The Johnson Foundation at Wingspread
Chuck Clarke	CEO, Cascade Water Alliance
Heather Cooley & Juliet Christian-Smith	Pacific Institute
Shivaji Deshmukh	Assistant General Manager, West Basin Municipal Water District, Los Angeles
Mary Ann Dickinson	President & CEO, Alliance for Water Efficiency
Nathan Engle	Office of U.S. Senate Majority Leader Harry Reid, Nevada
Michael Hamm	C.S. Mott Professor of Sustainable Agriculture, Michigan State University
Carroll Keim	President & CEO, Hidell – Eyster International (an international beverage consulting Firm)
Kai Lee	Program Officer, Conservation and Science, David & Lucille Packard Foundation
Sharlene Leurig & Marselle Alexander-Ozinsky	Ceres
Michael Lemon, Bob Anderson, Joe Volpe, & Chris Pitre	Golder Associates Ltd. (an international water engineering company)
Jim Lochhead	CEO/Manager, Denver Water
Gary Mongeon	Vice President, Bleakly Advisory Group
Simon Nish	Director of Community, Communications and External Relations, Rio Tinto Group
Rich Overmoyer	President, Fourth Economy Consulting
Sam Passmore	Program Director, C.S. Mott Foundation
David Rankin	Vice President of Programs, Great Lakes Protection Fund
Paul Reiter	Executive Director, International Water Association
Jim Renner	Principal Senior Geologist, Golder Associates, Ltd.
Erika Spanger-Siegfried	Co-Director, Energy and Water in a Warming World initiative, Union of Concerned Scientists
Kathy Tholin & Harriet Festing	Center for Neighborhood Technology
Alisa Valderrama	Center for Market Innovation, Natural Resources Defense Council
Robert Zimmerman	Executive Director, Charles River Watershed Protection Association

Conferences Attended

- "Stormwater Infrastructure Working Group—National Convening" (March 1-2, 2012)
- "Investors' Circle Virtual Venture Fair" (March 2012)
- "Meeting of the Minds"(October 9-11, 2012)
- "Urban Water Sustainability Leadership Conference"—U.S. Water Alliance (October 15-18, 2012

Notes

All quotations in report are from interviews or conference presentations, unless noted below.

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[1] Steve Maxwell, in the Introduction to "The Business of Water – A Concise Overview of the Challenges and Opportunities in the Water Market," American Water Works Association, 2008.
[2] Steve Maxwell, "2012 Water Market Review," p. 8, citing data from *Environmental Business Journal, 2011.* According to Maxwell, about two-thirds of the U.S. water market is in the public sector. The U.S. is the world's largest single nation water market, roughly a quarter of the world market.
[3] It's estimated that there are 55,000 water utilities and 16,000 wastewater utilities in the U.S.
[4] Peter Gleick, "Water of the United States" in Juliet Christian-Smith and Peter Gleick, *A Twenty-First Century U.S. Water Policy* (Oxford: Oxford University Press, 2012), p. 9.
[5] Daigger quoted in Cynthia Barnett, *Blue Revolution: Unmaking America's Water Crisis* (Boston: Beacon Press, 2011).
[6] Gleick, "Water of the United States," pp. 14-16,
[7] http://pubs.usgs.gov/circ/1344/pdf/c1344.pdf, p. 19.
[8] Goldman Sachs Group, Inc., "The Essentials of Investing in the Water Sector; version 2.0," March 24, 2008, p. 6.
[9] Kevin McCoy, "Nation's Water Costs Rushing Higher," *USA Today*, September 28, 2012, pp. 1A, 5A.
[10] Goldman Sachs, "The Essentials of Investing in the Water Sector; version 2.0," p. 1.
[11] Maxwell, "2012 Water Market Review," p. 2.
[12] Juliet Christian-Smith, "Water and Agriculture," in Juliet Christian-Smith and Peter Gleick, *A Twenty-First Century U.S. Water Policy* (Oxford: Oxford University Press, 2012), p. 198.
[13] Ceres, "The Ripple Effect: Water Risk in the Municipal Bond Market," November 2010.
[14] Goldman Sachs, "The Essentials of Investing in the Water Sector; version 2.0," p. 9.
[15] Steven Solomon, *Water: The Epic Struggle for Wealth, Power and Civilization* (New York: Harper, 2010), p. 451.
[16] Steve Maxwell cites water-use data from the United Kingdom: the average person uses 40 gallons in direct use daily and 30 times that much, 1,220 gallons, in indirect or "virtual" use.
[17] Juliet Christian-Smith, "Water and Agriculture," in Juliet Christian-Smith and Peter Gleick, *A Twenty-First Century U.S. Water Policy* (Oxford: Oxford University Press, 2012), p. 205.
[18] Johnson Foundation Freshwater Summit, "Charting New Waters: A Call to Action to Address U.S. Freshwater Challenges," September 2010, p. 3.
[19] http://www.frbatlanta.org/podcasts/transcripts/sep/08jan_se_water_supply.cfm?d=1&series=Podcasts.
[20] Johnson Foundation, "Charting New Waters," p. 8.
[21] The litany of large-scale environmental and infrastructure problems cannot be ignored. It includes 40% of U.S. rivers categorized as polluted; many of the country's 79,000 dams rated as no longer functional or safe; depletion of aquifers; 17% of treated water lost to leaky pipes, according to the EPA. The Environmental Working Group found tap water in 45 states and the District of Columbia was contaminated by 316 different pollutants, more than half of them not regulated by the EPA; 49 of the 91 regulated chemicals in water supplies were at excessive levels. Nancy Stoner, the EPA's Acting Assistant Administrator for Water, told the October 2012 U.S. Water Alliance that 8% of drinking water does not meet national drinking standards and a third of waterways do not meet national clean water standards.
[22] Pacific Institute, "Water Scarcity & Climate Change: Growing Risks for Businesses & Investors" (Ceres, 2009), p. 2.
[23] Summit Global Management, Inc., "The Case for Water Equity Investing 2012," p. 4.
[24] http://growingblue.com/water-in-2050/
[25] 2030 Water Resources Group, "Charting Our Water Future: Economic frameworks to inform decision-making," Executive Summary, 2009.
[26] Summit Global Management, Inc., "The Case for Water Equity Investing 2012," p. 8.
[27] Tetra Tech, "Evaluating Sustainability of Projected Water Demands Under Future Climate Change Scenarios," July 2011, p. iii.
[28] Ibid., p. 3.
[29] Pacific Institute, "Water Scarcity & Climate Change: Growing Risks for Businesses & Investors" (Ceres, 2009), p. 17.
[30] http://growingblue.com/water-in-2050/
[31] Intergovernmental Panel on Climate Change quotation cited in Heather Cooley, "Municipal Water Use," in Juliet Christian-Smith and Peter Gleick, *A Twenty-First Century U.S. Water Policy* (Oxford: Oxford University Press, 2012), p. 179.
[32] Pacific Institute reported these estimates, from the Electric Power Research Institute, significantly underestimate water-related energy use "because the technology assumptions are too conservative… [and they] exclude end-use energy,

such as energy used in homes, businesses, and institutions to pump, heat, and treat water." See Heather Cooley and Juliet Christian-Smith, "Water and Energy," in Juliet Christian-Smith and Peter Gleick, *A Twenty-First Century U.S. Water Policy* (Oxford: Oxford University Press, 2012).

[33] Heather King, "View from the C-Suite: American Water CEO Jeff Sterba," Reuters, June 13, 2011, http://www.reuters.com/article/2011/06/13/idUS64301901220110613.

[34] Christopher Gasson, "Water risk vs. water value," *Global Water Intelligence*, September 2012, p. 5.

[35] "Introduction: The Soft Path for Water," in Juliet Christian-Smith and Peter Gleick, *A Twenty-First Century U.S. Water Policy* (Oxford: Oxford University Press, 2012), p. xviii.

[36] Maxwell, "2012 Water Market Review," p. 7.

[37] Quotation from "Financing Sustainable Water Infrastructure," cited in Ceres/American Rivers, "Restoring Flows: Financing the Next Generation of Water Systems," April 2012, p.5.

[38] Peter H. Gleick, "The Water of the United States," in Juliet Christian-Smith and Peter Gleick, *A Twenty-First Century U.S. Water Policy* (Oxford: Oxford University Press, 2012), p.3.

[39] Thomas Mercer and Jon Christensen, "Measuring Performance of Water Systems in California," Water in the West Working Paper 2, April 2011 (Woods Institute for the Environment and Bill Lane Center for the American West, Stanford University), p.3, 4.

[40] Maxwell, "2012 Water Market Review," p. 23.

[41] Ceres, "The Ripple Effect."

[42] Among the entities: Alliance for Water Stewardship, American Rivers, American Water Works Association, Institute for Sustainable Infrastructure, National Association of Water Companies, and ReNUWIt: The Urban Water ERC / Stanford University's Woods Institute for the Environment & Center for Water in the West.

[43] Mercer and Christensen, "Measuring Performance of Water Systems in California," p. 22.

[44] Ibid., p. 23.

[45] Pacific Institute, "Overview of Greywater Reuse: The Potential of Greywater Systems to Aid Sustainable Water Management," Pacific Institute, November 2010, p. 21.

[46] Ceres/American Rivers, "Restoring Flows," p. 7

[47] Mercer and Christensen, "Measuring Performance of Water Systems in California," pp. 13-14.

[48] 2030 Water Resources Group, "Charting Our Water Future:."

[49] Ceres/American Rivers, "Restoring Flows," p.5.

[50] Maxwell, "2012 Water Market Review," p. 14.

[51] Johnson Foundation Freshwater Summit, "Charting New Waters," p. 17.

[52] Tennessee Water and Wastewater Energy Efficiency Partnership: http://www.tn.gov/environment/tnwweep/

[53] U.S. Environmental Protection Agency, "Growing Toward More Efficient Water Use: Linking Development, Infrastructure, and Drinking Water Policies."

[54] Presentation at "Urban Water Sustainability Leadership Conference"—U.S. Water Alliance (October 15-18, 2012).

[55] Johnson Foundation Freshwater Summit, "Charting New Waters," p. 32.

[56] Johnson Foundation Freshwater Summit, "Charting New Waters," p. 29.

[57] U.S. Water Alliance, "Statement of Principles in Support of Green Infrastructure Solutions to Stormwater Pollution," circulated at October 2012 national conference.

[58] http://www.cnt.org/water/green-infrastructure/gips.

[59] Disclosure: Two members of the report project team—John Cleveland and Chinwe Onyeagoro—are also on the CNT board of directors.

[60] http://www.cnt.org/news/media/Factsheet-Wetrofit.FINAL.pdf

[61] Heather Cooley, "Municipal Water Use," p. 183.

[62] Water-Technology.net.

[63] http://www.bizjournals.com/milwaukee/news/2012/08/13/work-begins-on-milwaukee-water-council.html?page=all

[64] Disclosure: One member of the report project team—Richard Anderson—is on the SWP board and a second member of the team—Peter Plastrik—wrote an article about the CEMP.

[65] Among the fields of practice with which the report project team is familiar are Total Quality Management, Environmental Sustainability, Lean Manufacturing, Corporate Social Responsibility, Community Development, Development Finance & Microfinance, Regional Equity, and Urban Sustainability.

[66] Information from Lisa Balcerak, "A Better Way Forward," *Municipal Sewer And Water,* September 2012, at http://www.onondagacreek.org/sites/default/files/A%20Better%20Way%20Forward%20_%20(Sep2012)MuniSewer&Water.pdf and Nancy Stoner, "Green Infrastructure in Onandaga County," at http://blog.epa.gov/blog/2012/07/green-infrastructure-in-onondaga-county/.

[67] Pacific Institute, "Sustainable Water Jobs," July 2012, in manuscript.
[68] Ceres/American Rivers, "Restoring Flows."
[69] Michael E. Porter and Mark R. Kramer, "Philanthropy's New Agenda: Creating Value," *Harvard Business Review*, November-December 1999, p. 125.
[70] Center for Neighborhood Technology, "People, Water, and the Great Lakes: Ready for Change?" August 2012, p. 5.
[71] Pacific Institute, "Overview of Greywater Reuse: The Potential of Greywater Systems to Aid Sustainable Water Management," Pacific Institute, November 2010, p. 33.
[72] Mercer and Christensen, "Measuring Performance of Water Systems in California," p. 30.
[73] http://www.allianceforwaterefficiency.org/blueprint.aspx?terms=ACEEE.
[74] http://www.glpf.org/ideas-in-action/protecting-biological-integrity.
[75] Ceres/American Rivers, "Restoring Flows."
[76] GDP data from 2010 U.S. Bureau of Economic Analysis, http://en.wikipedia.org/wiki/List_of_metropolitan_areas_in_the_United_States_by_GMP. Population data from U.S. Census.
[77] Heather Cooley, "Municipal Water Use," in Juliet Christian-Smith and Peter Gleick, *A Twenty-First Century U.S. Water Policy* (Oxford: Oxford University Press, 2012), pp. 169-170.
[78] Heather Cooley, "Municipal Water Use," p. 174.
[79] Ibid., p. 169.
[80] Center for Neighborhood Technology, "Water Loss Control in the Great Lakes States," July 2012.
[81] Center for Neighborhood Technology, "Urban Flooding in the Great Lakes States," July 2012.
[82] David Chen and Mireya Navarro, "For Years, Warnings that It Could Happen Here," *New York Times,* October 30, 2012, http://www.nytimes.com/2012/10/31/nyregion/for-years-warnings-that-storm-damage-could-ravage-new-york.html.
[83] Johnson Foundation Freshwater Summit, "Charting New Waters," p. 10.
[84] The 10 most prolific grant-making foundations (with number of grants) were: The Oregon Community Foundation (78); The Coca-Cola Foundation, Inc. (66); The New York Community Trust; The David and Lucile Packard Foundation (58); The McKnight Foundation (56); Boston Foundation, Inc. (51); The San Diego Foundation (42); The Seattle Foundation (41); Bill and Melinda Gates Foundation (39); Charles Stewart Mott Foundation (37).
[85] Mary Walsh and Nelson Schwartz, "Estimate of Economic Losses Now Up to $50 Billion, *New York Times*, November 2, 2012, http://www.nytimes.com/2012/11/02/business/estimate-of-economic-losses-now-up-to-50-billion.html?hp.
[86] Goldman Sachs, "The Essentials of Investing in the Water Sector; version 2.0," p. 36.
[87] Summit, "The Case for Water Equity Investing 2012," p. 14.
[88] Goldman Sachs, "The Essentials of Investing in the Water Sector; version 2.0," p. 36.
[89]http://export.gov/build/groups/public/@eg_main/@byind/@envtech/documents/webcontent/eg_main_034883.pdf.
[90] U.S. Environmental Protection Agency, "The Importance of Water to the U.S. Economy Part 1," September 2012, Public Review Draft.
[91] Heather Cooley, "Municipal Water Use," p. 176. "Between 1991 and 2000, investment in water and wastewater systems totaled $670 billion. Local governments and municipalities provided about 90 percent of the funds spent on water and sewer infrastructure development, rehabilitation, and operations nationwide."
[92] Patrick Burns and Daniel Flaming, "Water Use Efficiency and Jobs," Economic Roundtable, 2011, www.economicrt.org.
[93] Business United for Conservation Industry Partnership, "Capturing the Storm: Profits, Jobs, and Training in Philadelphia's Stormwater Industry," 2010, p. 2.
[94] Pacific Institute, "Sustainable Water Jobs," in manuscript, July 2012.
[95] Business United for Conservation Industry Partnership, "Capturing the Storm," p. 2.
[96] Green for All, "Water Works," 2011, p. 29.
[97] Business United for Conservation Industry Partnership, "Capturing the Storm," p. 12.
[98] Ibid, p. 13.
[99] Ibid., p. 9.