



Facing The Nation's Water Challenges: Results from Resources for the Future's Roundtable Series

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About RFF

Resources for the Future (RFF) is an independent, nonprofit research institution in Washington, DC. Its mission is to improve environmental, energy, and natural resource decisions through impartial economic research and policy engagement. RFF is committed to being the most widely trusted source of research insights and policy solutions leading to a healthy environment and a thriving economy.

The views expressed here are those of the individual authors and may differ from those of other RFF experts, its officers, or its directors.

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Preface

As Resources for the Future began thinking about the development of its research and policy engagement on water resources, we recognized that there were many directions we could go based on our current expertise. There is a criticality in defining the *what* around water resources in order to sufficiently narrow the scope of research and analysis. Through a roundtable process in five cities across the country, we hoped to identify the most important issues where RFF's environmental economics expertise could enable policy, business, and industrial leaders to make better decisions on water resources management. We were surprised by the convergence of the primary issues across many regions, resulting in a reasonably short list of ideas upon which to focus our work.

In addition, by focusing on these top-line issues, we believe there is a group of decisionmakers—including utilities, municipal governments, water-focused organizations, and others—who are in a position to take up the outcome of any research and analysis done by RFF. This reinforces our mission to be policy-relevant and to have impact.

As a result of the roundtables and our follow up discussions among key practitioners, RFF will be identifying an agenda of research topics to address, leveraging our economics and policy capacity. It is our hope that the ideas in this report continue to generate discussion, investments, and action.

Sincerely,

A handwritten signature in black ink, reading "Ann M. Bartuska". The signature is fluid and cursive, with a long horizontal line extending from the end of the name.

Ann M. Bartuska
Vice President for Land, Water, and Nature
Resources for the Future

Executive Summary

As part of its Land, Water, and Nature Program, Resources for the Future (RFF) seeks to continue its contribution to advancing research and policy related to the nation's water resources. The country faces myriad water challenges, exacerbated by its growing population and the increased risks from a changing climate. Through informal interviews with water practitioners and thought leaders, group discussions, and five regional roundtables (Chicago, San Francisco, Denver, Houston and Washington, DC) with diverse water stakeholders, RFF heard confirmation that a sharper focus on the application of socioeconomic principles to these challenges could help our nation achieve a more secure water future.

Each roundtable had its own flavor, influenced by the participants and the region, yet there was remarkable consistency in the issues raised. In every roundtable and many interviews, participants raised concern about the fragmentation in the governance of water, with questions centered on the appropriate scale for water management and the benefits of consolidated management of water types (stormwater, drinking water, wastewater) and location (watershed rather than localities). Participants showed keen interest in quantifying the benefits of different approaches to water access, affordability, and equity; watershed protection and resilience; agricultural water use; green, distributed, and source watershed infrastructure; water markets, allocations, and efficiency; and demand management and forecasting. Examining these topics through the lens of climate change impacts, adaptation, and resilience was a common theme.

There was agreement that more and different types of data are needed to inform decisionmaking and advance solutions. Participants agreed that current data are insufficient, and that new information—collected through remote sensors, satellite imagery, and modeling—would allow them to look at the issues in more holistic ways. With more comprehensive data, scenario models and online decision tools can be built to help scientists, water managers, water users, and other stakeholders make better-informed decisions about how to distribute and manage water in economically sound and environmentally respectful ways. There was unanimous support for breaking down silos—not only among stormwater, wastewater, and drinking water management, but also between land-use and water-use planning.

Knowledge management and knowledge sharing were repeated concerns. Participants expressed the need for more sophisticated studies and models to address water resource issues. They recommended compiling case studies and conducting new pilot studies to share approaches and management strategies. Local and state governments and their water utilities, as well as commercial, industrial, agricultural, and domestic users, should be learning from each other to select the most economical and environmentally friendly practices to ensure their water future.

There is no shortage of ideas to help address the challenges to a secure water future; nor is there a shortage of partners interested in making progress. The ideas gathered here are not all new, and some have already received consideration, but we believe this report brings renewed attention to the issues and highlights where environmental economics could add value. The need reinforces the importance of building a stronger skill set in, and recognizing the value of, quantitative and economic analysis to address water challenges. RFF will build on these ideas to establish partnerships with those already working on these issues to accelerate progress, identify where RFF can initiate study, and seek sources of funding for this important work.

1. The Nation's Water Challenges

Americans have come to expect the availability of clean and reliable surface water and groundwater to provide safe drinking water, irrigate farmland, meet industrial needs, support healthy ecosystem functions, and sustain recreational opportunities and the tourism economy on our rivers, streams, and lakes. As the proportion of the US and global population living in cities continues to grow, the urban demand for water will increase and compete with other uses such as agriculture, industry, and ecosystem uses. The available quantity of fresh water is becoming increasingly problematic. Water of specific qualities and quantities is needed for food, energy, and industrial products; for the development and operation of infrastructure and transportation systems; and to satisfy basic human needs. Irrigation for agriculture in the United States is one of the largest users of freshwater, both surface water and groundwater.

We have been addressing water challenges in isolation until now ... It's time to start spreading out to watershed-based solutions.

— Matthew Ries, DC Water; Roundtable participant, Washington, DC

In addition to water quantity and availability, concerns about water quality are also increasingly urgent, as agricultural and urban pollution affects water supplies for human populations and ecosystem functioning. The levels of nutrients in surface and groundwater present a growing threat to public health and local economies, contributing to harmful algal blooms, contamination of drinking water sources, and damages to recreation, tourism, and fisheries. Additionally, emerging contaminants, including pharmaceuticals, additives in personal care products, and engineered nanoparticles, represent a largely unquantified danger to water quality, ecosystems, and public health. Many cities' municipal water quality has declined because of infrastructure decay and vulnerability to severe weather and other stresses, imperiling public health for millions.

Affordability and access to safe drinking water are a pressing equity issue. By some estimates, water and sewer infrastructure will require more than \$1 trillion in investments over the next two decades to maintain current levels of service. Most

of the costs will be passed on to ratepayers, so it is imperative to understand the distributional consequences of water costs and potential policies that alleviate financial burdens on low-income families across the United States.

The management of water resources at a national level has been complicated by extreme weather events, such as drought, floods, and other effects of a changing climate. Indeed, the current and looming impacts of climate change were present in every discussion, either explicitly or implicitly. Climate change and human development activity will alter the quantity and availability of fresh water, increase the variability and threaten the quality of our water supply, and strain our aging infrastructure. Waterfront communities face threats of flooding from climate change–induced storms and unpredictable rain patterns. The need for communities to build resilience to flooding and to better manage risk is important for minimizing the dangers for life and property; commensurate policies and programs to anticipate and prevent future damages are needed.

2. Applying Socioeconomic Analysis to Help Find Solutions

The management of water should be informed by economic principles and a commensurate valuation. It is surprising that we have yet to understand the true consequences of water pollution for our economies, the choices made at the household level for water consumption or conservation, and the effects of increasing flood risk for real estate and economic development. To responsibly address each of these questions, our nation needs top-notch economic analysis combined with an understanding of the science of water management and the complex policy decisions facing federal, state, municipal, and private water managers. Ensuring water security for current and future generations will require more comprehensive management of competing uses of water, as well as an understanding of the risks from uncertain water futures.

Economics provides a framework through which we interpret economic behavior; it is not just about adding up costs and benefits or focusing on bottom-line accounting. Economics provides a toolkit for understanding why people do what they do, and how to design effective policies. Such efforts include understanding behavior; designing individual and collective incentives for efficient resource use; preparing statistical measurement of causal effects; conducting nonmarket valuation; devising market-based solutions to environmental externalities and common-pool resource problems; and focusing investment in public goods. Recent examples of RFF-led work include studies on urban water management, pricing, and equity; wastewater recycling and reuse; coastal resilience and flooding; agriculture and water; water for energy development and electricity generation; and the economics of water markets.

Water is one of the most important aspects of the earth's system; economics helps understand its value.

— Betsy Weatherhead, Jupiter Intelligence; Roundtable participant, Denver

3. RFF's Approach to Designing a Water Portfolio

To ensure the relevance and effectiveness of its economic analyses, RFF invited water managers and users, conservationists, policymakers, academics, philanthropists, and local and state government officials to help design an RFF water initiative. RFF asked these experts to identify the most pressing water issues facing government agencies, utilities, businesses, and nonprofits.

RFF started by holding informal interviews with water practitioners and thought leaders known or recommended to the RFF team, including about a dozen phone conversations with water experts and funders and two small group discussions with attendees at the 2018 US Water Alliance conference. RFF then designed a series of regional roundtables to identify water issues that could be informed by socioeconomic research and information. These meetings, each with a local sponsor and/or co-host, were held in Chicago, San Francisco, Denver, and Houston—locations selected based on known regional water challenges. The participants, totaling 68, represented utilities, local and state governments, philanthropic organizations, academia, industry, and NGOs identified by the RFF team and the local sponsors. Each day-long roundtable began with a general discussion of the most pressing water challenges, followed by a more in-depth focus on two or three areas that could show progress with the right kind of socioeconomic information and study. As a final step, RFF held a half-day meeting in Washington, DC, for feedback on what the team had heard and what areas for socioeconomic study might have been missed.

RFF can provide analysis and inform policy decisions in a way that improves on-the-ground outcomes

— Tom Iseman, The Nature Conservancy; Roundtable participant, Denver

4. What RFF Heard: Lead-Up to the Roundtables

The conversations began at the US Water Alliance's 2018 One Water Summit, where the opportunity to create an RFF water portfolio was proposed; both the concept and the regional approach to gathering information received support. That affirmation was echoed in individual calls to other water thought leaders in business, government, and philanthropy.

The issues ripe for socioeconomic study that rose to the top in these conversations foreshadowed what we heard at the regional roundtables. The question of scale was central to the discussion: a national scale is too large for local decisionmakers, who want information they can easily use to make policy decisions, but a focus at the household or local level makes it difficult to know what benefits accrue to the public from individual actions. Affordability was identified as a critical issue: income-based rates disrupt the relationship between volume and cost, so it would be beneficial to compare the economic consequences of other rate structures and see how they relate to affordability and conservation. Participants recognized the importance of water for agriculture as well as the effects of farming practices on water quality. Farmers need information on the public good versus the private good before they invest in practices that protect water quality and conserve water supply. Simple economic decision tools could help farmers make these critical decisions that directly affect their livelihoods.

In water management, we don't value water the way we should.

— Elaine Dorward-King, Newmont Mining and RFF Board member; Roundtable participant, Denver

Regarding infrastructure funding, participants saw value in evaluating alternatives to state revolving loan funds and financing from the Water Infrastructure Finance and Innovation Act, in particular looking at subsidization costs versus actual costs. Businesses concerned about the risks posed by their water footprint want to exert control over their supply chain as they improve their water efficiency and minimize energy use, while at the same time making the business case for these investments. It is important to them and their investors to quantify the environmental and economic benefits of reducing their water footprint.

Risk mitigation is important to all types of water users. In particular, utility managers are looking for analyses that evaluate their customers' willingness to pay for water

access to minimize risks, and the economic effects on their business model of planning for climate change and a future with less water, including advice for impact investing. Participants also expressed interest in examining the role of conservation programs in funding best management practices for farmers, comparing the costs of such programs with the societal benefits—better water quality and more reliable water supplies.

Utilities and local governments are seeking ways to modernize and economize, and require information to weigh the costs and benefits of their choices: what are the economics of resource recovery from wastewater streams, and under what circumstances would monetary and societal benefits accrue from such practices? Local governments want to know the true (unsubsidized) costs and benefits of continuing to make centralized improvements to their water and wastewater facilities versus decentralization, and the societal consequences of those changes.

5. Outcome of the Regional Roundtable Discussions

The regional roundtables were held, in part, to validate the issues identified through stakeholder discussions as well as to further identify regionally specific issues.

The following list summarizes the challenges we heard. Below, for select topics, we discuss in more depth the socioeconomic information that could move us forward in addressing some of these challenges. At each roundtable the participants selected areas of regional concern on which to apply a socioeconomic lens. Appendix A lists the participants who took part in each regional roundtable, as well as those who contributed in separate discussions or interviews. Appendix B has a summary of the discussions held in breakout groups, with the decisionmakers, influencers, information needs, and next steps for each challenge.

Common challenges:

- Fragmentation in governance, questions of scale, and benefits of consolidation
- Water scarcity, competition, and efficient allocations
- Water access, affordability, and equity
- Benefits of distributed and green infrastructure systems
- Source watershed infrastructure and nature-based systems
 - Watershed protection, multiple hazards, and resilience
 - Flooding and stormwater management, natural floodplains, and smart growth
- Agricultural use, conflicts, and consequences for rural economies
- Need for comprehensive water data
- Demand management and forecasting
- The energy-water-land-climate nexus
- The price of water and the economics of use versus consumption
- The social cost of water pollution

Additional challenges identified that we are including for completeness include:

- Role of conservation financing
- Aging infrastructure, solutions, and investments
- Integrating multiple benefits into investment decisions
- Role of water markets

5.1. Fragmentation in Governance, Questions of Scale, and Benefits of Consolidation

Fragmentation of governance in the water sector was perhaps the issue we heard about most consistently. The fragmentation is both vertical, in terms of siloed

approaches to management of wastewater, stormwater, and drinking water, and horizontal, in terms of geographic scale and funding that follows political rather than watershed boundaries. Stormwater runoff, for example, follows watershed rather than municipal boundaries, and the associated costs and risk management make it highly visible to local governments. According to participants, many small water agencies find it difficult to meet Safe Drinking Water Act requirements: they lack modern equipment and can't take advantage of economies of scale. Related to fragmentation is the disconnect between water and land-use development. Better long-term planning and policies that consider the relationship between urban spatial structure and landscape planning for water, floodplain management, and water use are needed, as is a consideration of urban-rural connections.

Because fragmentation keeps us from innovating, we should be looking at questions of scale and the benefits of consolidation. Participants recommended compiling information about consolidations. What were the drivers, how did this affect governance structure, and were the outcomes more centralized or decentralized? What were the demographics of each case, in terms of racial and economic diversity?

Issues related to fragmentation lend themselves to the application of institutional economics. For one or more selected watersheds, a study that presents a hierarchy of consolidation scenarios, assesses the benefits and consequences (e.g., loss of local political voice), and uses economics as an integrator to address ecosystem costs and benefits could be instructive to policymakers.

The Chicago roundtable proposed the Chicago region's water management as a case study on the value of consolidation or shared governance. Such a study could project future scenarios that optimize operational and economic outcomes, then use those scenarios to inform supportive policies and practices. Included would be a consideration of entities responsible for integrated water resource management and regional governance, like the Metropolitan Water Reclamation District of Greater Chicago. This roundtable also stressed the importance of revising grant mechanisms to work at the watershed level.

5.2. Water Scarcity, Competition, and Efficient Allocations

This challenge is of special concern in the arid West but is becoming a nationwide issue as water demands increase while water supplies become less predictable. Growing cities and industries as well as agriculture are experiencing pressure on their water supplies—even in Chicago, where the Great Lakes are a water source. Economics could help with the equitable resolution of current and future allocations, looking at cost-effective alternatives both now and long term for maintenance and sustainability in over allocated river basins. In addition, considerations of aging and inadequate infrastructure play into access to and competition for water. Denver

roundtable participants agreed on a need to make water and land-use choices more sustainable through integrated decisionmaking, rather than decisions made in isolation. Houston participants talked about educating the public about the water supply consequences of various water-use scenarios and emphasizing the role of fit-for-purpose use in conserving water.

5.3. Water Access, Affordability, and Equity

Everyone deserves affordable access to clean and safe water, yet that is not the case in all parts of this nation. Participants suggested looking at water rate affordability through a lens other than the commonly used Median Household Index. Fragmentation of governance also separates affluent users from poor communities, making it harder to set rates that are affordable and equitable. It is important to assess what local governments can do to address the affordability of water while maintaining service, especially for disadvantaged communities. The financial health of water utilities—not to mention their public image—has been harmed by shutoffs, which can cost more than working with residents to keep current on water bills. It would be valuable to know the costs versus the benefits of providing a basic increment of water to everyone for free, as well as the cost to water agencies of direct installation programs (which install water-efficient pumping in homes and businesses) to reduce water loss in disadvantaged communities. A January 2019 draft report by the California State Water Resources Control Board, *Options for Implementation of a Statewide Low-Income Rate Assistance Program*, begins to incorporate some of these considerations, but there is demand for understanding the economics behind water affordability policies.

At the Chicago roundtable, participants said municipalities and communities needed insight on the benefits of regionalization and water service alternatives, including privatization of water systems, to provide equitable service to all.

5.4 Benefits of Distributed and Green Infrastructure

Participants would like to see more focus on green and distributed infrastructure, especially in urban environments, to address water challenges at lower cost while dealing with affordability and accessibility. Distributed infrastructure (DI) refers to decentralized water management strategies and technologies—indoor water-efficient fixtures and appliances, graywater systems, and the like—deployed over many properties; unlike conventional water infrastructure, DI is generally not owned or operated by water agencies, but it functions in concert with built infrastructure. Green infrastructure (GI) comprises strategies that protect, restore, or mimic the natural water cycle.

Credible research is needed on the potential for DI and GI options to serve as effective and cost-effective water management strategies compared with more

conventional approaches. Also of interest is how a shift to DI and GI can alter the economics of addressing the cost of water for disadvantaged communities. For GI, data are needed on barriers to adoption, such as undefined costs, uncertain financing mechanisms, and confidence in the long-term solution. Full consideration of the multiple benefits provided by DI and GI is also important. The Pacific Institute¹ has been comparing distributed water efficiency actions with centralized solutions and calculating the economic benefits of DI: how does DI affect local rates, what financing mechanisms are available, and what are the opportunities for impact investment and job creation?

Participants noted the value of a decision matrix that a locality could use to compare the economic benefits of sustainable water management strategies with those of traditional infrastructure approaches. To develop such tools, economists need to document the real-world costs, including avoided costs, of investing in DI and GI options; case studies of successes and failures would be instructive. The potential range of rate impacts of investing at scale in DI and GI, as well as available financing mechanisms, is also important for decisionmakers seeking a sound basis for new policies.

5.5 Source Watershed Infrastructure (Nature-Based Systems)

Several challenges involve protecting source watersheds and natural infrastructure for their value in providing downstream water quality and quantity, stormwater management, flood control, and ecosystem services. Natural systems used in lieu of traditional infrastructure provide multiple benefits, such as resilience to hazards like drought, flood, and wildfires. Storage of source waters in times of abundance for later use downstream can also encourage water conservation. Such approaches can be a building block for smart growth and the integrated consideration of water and land uses in regional planning. The economic benefits of natural treatment processes versus engineered solutions need to be assessed.

In isolated cases (e.g., New York City and the Catskills), protection of source watersheds helps to preserve water quality and decreases the cost of water treatment. Increasingly, utilities are investing in source water protection (e.g., Denver Water is working with the US Forest Service and The Nature Conservancy) to ensure their water supply. The San Francisco roundtable participants expressed support for providing information on the business case for these investments, as well as a scenario-based model to show costs and benefits to both the community and the watershed so that this approach can gain acceptance where appropriate. A survey of large-scale, water basin examples would be beneficial. In addition, a comparison of the costs and benefits of source watershed protection versus those of traditional gray infrastructure, incorporating avoided costs from flooding, would

1 Pacific Institute, Urban Water Conservation and Efficiency Potential in California (2014) and The Cost of Alternative Water Supply and Efficiency Options in California (2016).

be helpful. Funding mechanisms are also important; water funds have been used to date, but whether the utility, the users, the landholders, or the government should pay remains a question.

Land trusts and state legislators need information on how land conservation cycles through the economy. Philanthropies and companies are looking at conservation impact investing. Information is needed on the return on investment for utilities that reduce treatment costs by conserving land upstream. Such a study would factor in multiple benefits, including societal value, regulatory benefits, and the value of natural systems.

5.6. Agricultural Use, Conflicts, and Consequences for Rural Economies

Access to water is critical for rural economies. For instance, agriculture represents 80 percent of water use in California, yet urban needs trump farmers' needs in the allocation process. Solid information is needed on the conflicts between water uses and the consequences for food production and the economy. What types of investments can reduce water risk, and how does the mass transfer of water from rural to urban landscapes affect food production and agricultural economies? Practical decision tools to help stakeholders develop scenarios and plans could prove useful.

Programs in the Farm Bill can influence agricultural markets and farmers' decisions, which in turn affect the amount of water used for crops. It might be valuable for the next Farm Bill to include funding for analyses of individual farms' water uses and watershed-wide consumption, such as a scaled-up analysis on water-use practices from individual farms to a complete watershed, considering the effects of changing weather cycles and new technologies and practices on productivity.

Areas of water scarcity need incentives for conserving water rather than taking a use-it or lose it approach to allocation. Information on the economic value of conservation practices to producers would help with decisionmaking and adoption of water-saving practices. For instance, what is the value of a particular crop versus the value of the water saved for aquifer recharge or a water market? Existing research on this topic could be summarized and made available in a useful form for decisionmakers. San Francisco roundtable participants raised the idea of spreading the concept of fairness by redoing water allocations for the future under new climate and water regimes, supported by an economic analysis of the value of senior versus junior water rights to provide a basis for market trading between rights holders.

5.7. Need for Comprehensive Water Data

Participants agreed on the need for more and better water data collected in innovative ways. Efforts include, most recently, the Internet of Water being coordinated by the Nicholas Institute for Environmental Policy Solutions at Duke University. The challenge is unlocking water data from all sectors and developing products that increase the discoverability, usability, and interoperability of data.

These new sources of data can be beneficial in a socioeconomic sense. For instance, participants want to be able to consider climate information in water decisionmaking. Having good data on water use, not just from cities but at varying geographic scales across the country, would also be valuable. What, for instance, are the costs of sustaining water yields on a long-term basis? For water- and land-use decisionmaking, data on how housing densities influence water-use decisions would be helpful. These are just some of the possibilities that can tap into the Internet of Water.

5.8. Further Ideas from Regional Roundtables

The following topics were identified at one or more of the roundtables as being important, and are included for completeness. They did not receive the same level of attention but were deemed important to key stakeholders.

5.8.1. Demand Management and Forecasting

Demand management and forecasting are important for a utility in making long-term decisions, such as setting rates and promoting water efficiency and conservation while retaining equitable outcomes, and in making planned investments to support demand growth. They can also help with decisions on distributed systems or traditional approaches. A better way to do this, using market principles, is needed by utilities and localities.

5.8.2. The Energy-Water-Land-Climate Nexus

Because many water management issues cross sectors, policies and strategies from other sectors may help. An example identified at the Houston roundtable concerns the uses of water in energy extraction and opportunities for creative use of recycled wastewater.

5.8.3. The Price of Water and the Economics of Use Versus Consumption

Many have tried to determine the true value of water, but the answers are elusive because the price depends not only on supply and demand but also on behavior as influenced by subsidies and politics. How might economic incentives be changed and behavior altered to structure water markets? How can economics of use versus consumption be reflected in pricing?

5.8. The Social Cost of Water Pollution

A model that could be used for decisionmaking at all levels would have immense value. Consideration of all ecosystem services provided, not just water supply and water quality, can help make the business case for changing approaches to water management and water use. This information is also needed to craft sound policies for water. RFF University Fellow Catherine Kling (Cornell University) presented on such an approach to the WASHINGTON DC roundtable.

6. What's Next

Despite the many challenges to a secure water future, there is no shortage of ideas to help address them or partners interested in making progress. The ideas gathered here may not all be new, and some have already received attention. The next step is to find out where RFF can partner with those already working on these issues to accelerate progress, where can RFF initiate study, and what sources of funding might support this important work. Specifically, we will work to identify topics in which RFF's skillset will leverage and amplify efforts underway.

WaterNow Alliance, our co-host of the San Francisco roundtable, has conducted surveys of water leaders indicating a growing interest in more environmentally sustainable strategies, particularly approaches capable of delivering equivalent or better water management services and outcomes at lower cost than conventional alternatives. Furthermore, the availability of credible data and research to support decisionmaking is of paramount importance. This is where RFF, with its mission to improve environmental, energy, and natural resource decisions through impartial economic research and policy engagement, can play a critical role.

Based on the roundtables, interviews, and RFF's experience, several clear themes for socioeconomic research emerge as ripe for study. There is general agreement that One Water approaches, whereby the traditional siloed approach to water management by type and geography is abandoned in favor of consolidating water management by watershed, work better. However, RFF heard that decisionmakers do not yet have enough information to change their traditional siloed approaches. The Spring 2018 *Aspen-Nicholas Water Forum: One Watershed—Reaching Watershed Scale through Cooperation and Integration*, focused on how regional integration between geographies, sectors, or functions could help address water challenges. Some are taking a deeper dive into how One Water can work for them, as detailed in The Cynthia and George Mitchell Foundation February 2018 publication, *Advancing One Water in Texas*. More information is needed on the economies of scale that can be realized by consolidation, and how localities can retain some degree of managerial and political control over such systems. At the same time, a better understanding is needed of how decentralization can improve efficiency and cost-effectiveness for water treatment, distribution, and conservation within consolidated systems.

The importance of source watershed protection for our infrastructure system is gaining recognition. A 2017 report by The Nature Conservancy, *Beyond the Source: The Environmental, Economic and Community Benefits of Source Water Protection*, explores the value of such nature-based solutions and provides a template for further work.

Economic decision tools are needed not only for local governments and utilities but also for producers who are considering trade-offs between water use and conservation as they allocate a limited resource. It is important to show how linking land-use and water-use planning can improve sustainability at less cost.

The topics identified above are not intended to be a comprehensive list of water resource issues, but they do reflect a consensus of thought from many experts across the country. Through additional outreach, topic-specific convenings, and strategic partnerships, RFF will be developing a focused water resources and economics research agenda. This document will frame further work and serve as a living guide to be used by RFF and others to accelerate progress on addressing the nation's water challenges. Although the impetus for the roundtables and this report was to inform the future direction of RFF, the ideas generated can also be used by other organizations to validate or provide direction.

Appendix A: Participants

Listening sessions at the One Water Conference, US Water Alliance, July 10-12, 2018

Joel Beauvais, Partner at Latham & Watkins LLP

Lynn Broadbuss, President, Broadview Cooperative

Mary Ann Dickenson, President and Chief Executive Officer, Alliance for Water Efficiency

Bill Hollman, North Carolina Director, The Conservation Fund

Jeff Hughes, Director, Environmental Finance Center, University of North Carolina, Chapel Hill

Paula Kehoe, Director of Water Resources, San Francisco Public Utilities Commission

Cynthia Koehler, Executive Director, WaterNow Alliance

Clare Lindahl, Chief Executive Officer, Soil and Water Conservation Society

Ann Mills, Executive Director, Agua Fund

Karen Pallansch, Chief Executive Officer, Alexandria Renew Enterprises

Rebecca Power, University of Wisconsin-Madison College of Agriculture & Life Sciences Extension

Matthew Ries, Director of Sustainability and Watersheds, DC Water

Carrie Sanneman, Clean Water Manager, The Willamette Partnership

Kevin Shafer, Executive Director, Milwaukee Metropolitan Sewerage District

Roger Wolf, Director of Environmental Programs and Services, Iowa Soybean Association

Phone or In-Person Interviews

Andrew Ayers, Office of the Chief Economist, Environmental Defense Fund

Brooke Barton, Senior Program Director, Water and Food Programs, Ceres

Susan Bell, Managing Director, Water Funder Initiative

Monika Freyman, Director of Investor Engagement, Water, Ceres

Peter Gross, Water Skipper, Emerson Elemental, Emerson Collective

Maurice Hall, Associate Vice President, Ecosystems, Environmental Defense Fund

Ann Hayden, Senior Director, California Habitat Exchange & Western Water, Environmental Defense Fund

Laura Meadors, Corporate Water Program Lead, Global Energy and Sustainability, Apple Inc.

Kevin Moran, Senior Director, Colorado River Program, Environmental Defense Fund

Jill Ozarski, Program Officer, Environment Program, Walton Family Foundation
Michelle Perez, National Water Initiative Director, American Farmland Trust
Sarah Richards, Water Program Officer, Cynthia and George Mitchell Foundation

Chicago Roundtable, Shedd Aquarium, September 27, 2018

John Andersen, President, Greenleaf Advisors (co-host)
Dominic Brose, Associate Scientist, Metropolitan Water Reclamation District of Greater Chicago (MWRD)
Sarah Cardona, Manager, Chicago Metropolitan Planning Council
Katie DeMuro, Associate, Greenleaf Advisors
Andrea Densham, Senior Director of Conservation Policy and Advocacy, Shedd Aquarium
Susan Donovan, Illinois Director of Government Relations, The Nature Conservancy
Tim Eder, Program Officer, Charles Stewart Mott Foundation
Josh Ellis, Vice President, Chicago Metropolitan Planning Council
Steve Frenkel, Executive Director, Current Innovation
Danielle Gallet, Director of Water Resources, Chicago Metropolitan Planning Council
Simone Lightfoot, Director National Urban Initiatives Program, National Wildlife Federation
Paul May, Assistant Executive Director, Northwest Suburban Municipal Joint Action Water Agency (JAWA)
Peter Mulvaney, Group Leader, Jacobs Engineering
Marcus Quigley, Chief Executive Officer, OptiRTC
J. David Rankin, Executive Director, Great Lakes Protection Fund
Sabina Shaikh, Director, Program on Global Environment, Environmental and Urban Studies, University of Chicago
Jennifer Wasik, Supervising Aquatic Biologist, Metropolitan Water Reclamation District of Greater Chicago (MWRD)

San Francisco Roundtable, California Academy of Sciences, October 2, 2018

Newsha Ajami, Director of Urban Water Policy, Stanford University
Amadou Ba, Branch Chief, California Department of Food and Agriculture
Mark Cady, Senior Environmental Scientist, California Department of Food and Agriculture
Heather Cooley, Director of Research, Pacific Institute

Alvar Escriva-Bou, Research Fellow, Public Policy Institute of California

Pablo Garza, California Political Director, Ecosystems, Environmental Defense Fund

Max Gomberg, Water Conservation and Climate Change Manager, California State Water Resources Control Board

Katrina Jessoe, Associate Professor, University of California Davis

Paula Kehoe, Director of Water Resources, San Francisco Public Utilities Commission

Caroline Koch, Water Policy Specialist, WaterNow Alliance

Cynthia Koehler, Executive Director, WaterNow Alliance (co-host)

Caryn Mandelbaum, Water Director, Environment Now California Program, Leonardo DiCaprio Foundation

Carrie Sanneman, Clean Water Manager, Willamette Partnership

Kathy Viatella, Program Officer, Resources Legacy Fund

Laurie Wayburn, Co-founder, Co-Chief Executive Officer, and President, Pacific Forest Trust

Denver Roundtable, Newmont Mining, October 16, 2018

Ken Bagstad, Research Economist, US Geological Survey

Joan Card, Of Counsel, Culp & Kelly, LLP

Anne Castle, Senior Fellow, Getches-Wilkinson Center for Natural Resources, Energy, and the Environment, University of Colorado

Otto Doering, Professor of Agricultural Economics, Purdue University

Elaine Dorward-King, Executive Vice President, Sustainability and External Relations, Newmont Mining (co-host)

Clint Evans, Colorado State Conservationist, Natural Resources Conservation Service

Briana Gunn, Environmental Director, Newmont Mining

Claire Harper, Program Manager, US Forest Service

Megan Holcomb, Water Supply Planning Program Manager, Colorado Water Conservation Board

Tom Iseman, Director of Water Scarcity and Markets Strategy, Global Water Program, The Nature Conservancy

Alicia Karspeck, Climate Scientist, Jupiter Intelligence

Amanda O'Conner, Commercial Sales Manager and Remote Sensing Domain Expert, Harris Geospatial

Patrick Pfaltzgraff, Director of the Water Quality Control Division, Colorado Department of Public Health and Environment

Nicole Silk, Executive Director, River Network

Jordan Suter, Associate Professor, Colorado State University

Travis Warziniack, Research Economist, US Forest Service

Elizabeth “Betsy” Weatherhead, Director, Earth and Ocean Systems, Jupiter Intelligence

Tony Willardson, Executive Director, Western States Water Council

Alison Witheridge, Watershed Scientist, Denver Water

Houston Roundtable, Center for Houston’s Future, November 9, 2018

Jesse Backstrom, Department of Agricultural Economics, Texas A&M

Michael Black, Department of Agricultural Economics, Texas A&M

Joni Charles, Associate Professor in Finance & Economics, Texas State University

Joseph Dean, Permitting Manager, Williams

Gavin Dillingham, Program Director, Houston Area Research Center

Deborah January-Bevers, President and Chief Executive Officer, Houston Wilderness

Rigoberto Lopez, Assistant State Conservationist for East Texas Field Operations, Natural Resources Conservation Service

Maria Modelska, Associate Director, Research Center, University of Houston

Richard Newell, President and Chief Executive Officer, Resources for the Future

Brett Perlman, Chief Executive Officer, Center for Houston’s Future (co-host)

Frank Sanclementi, Environmental, Health, and Safety Advisor, Hess Oil

Richard Seline, Executive Director, Accelerate H2O

Daniel Shannon, Water Product Manager, Schlumberger

W. Douglass Shaw, Professor of Agricultural Economics, Texas A&M

Jeanne-Mey Sun, Energy Solutions, GE Baker Hughes

Ritu Talwar, Energy and Environmental Policy Manager, Enbridge

Brian Wenberg, Acting State Conservation Engineer, Natural Resources Conservation Service

Richard Whisnant, Professor, School of Government, University of North Carolina, Chapel Hill

Richard Woodward, Professor of Agricultural Economics, Texas A&M

Washington DC Roundtable, Dentons, December 4, 2018

Jimmy Daukas, Senior Program Officer, American Farmland Trust

Peter Debaere, Professor of Business Administration, University of Virginia

Monica Grasso, Chief Economist, National Oceanic and Atmospheric

Administration

Chris Hornback, Deputy Chief Executive Officer, National Association of Clean Water Agencies

Catherine Kling, Tisch University Professor, Cornell University

Linda Langner, RPA Assessment National Program Leader, US Forest Service

Robert Litterman, Chairman Risk Committee, Kepos Capital, LP

Al McGartland, Director, National Center for Environmental Economics, Environmental Protection Agency

Joan McGrath, Technology Officer, LOR Foundation

Robert McGuire, New Business Development, BASF Corporation

Kathleen Merrigan, Executive Director Center for Sustainable Food Systems, Arizona State University

Jennifer Morrissey, Of Counsel, Dentons (co-host)

Matthew Ries, Director of Sustainability and Watersheds, DC Water

Jennifer Saleem-Arrigo, Advance Science Lead, US Global Change Research Program

Morgan Snyder, Program Officer, Environment Program, Walton Family Foundation

Aparna Sridhar, Water Policy Advisor, The Nature Conservancy

Nancy Stoner, President, Potomac Riverkeeper Network

Kelsey Voytovich, Director, Federal Government Affairs, ConocoPhillips

Marca Weinberg, Director, Resource and Rural Economics Division, US Department of Agriculture Economic Research Service

Korena Wilson, Media Officer, LOR Foundation

Robert Wood, Director Engineering and Analysis Division, Environmental Protection Agency Office of Water

Curtis Zimmerman, Manager, Government Liaison, BASF Corporation

Appendix B: Study Ideas from Roundtables

Safe, Affordable Water (Chicago)

Issue identification

- Everyone does not have access to safe, affordable water.
- The right information is not getting to the right community members and decision makers; partnerships to utilize information are underdeveloped
- The condition of infrastructure is not fully known (e.g. lead lines, leaks).
- Utilities and municipalities are fragmented
- What is the risk and cost of poor water quality (e.g. lead) in drinking water?

Decision makers and influencers

- General public
- Policymakers (municipal, federal, state),
- Partners (academics, economists, legislators, NGOs),
- Funders

Information needs

- GIS boundaries
- Water rates and affordability
- Infrastructure (aggregate measure)
- Financial reports
- Past policies (until 1986 Chicago required lead service lines)
- Institutional details
- Willingness to pay for certain levels of water service

What needs to happen

- Provide insight to municipalities and communities on the benefits of regionalization and model alternative options
- Model the cost of shutoff policies related to collecting payment and public health impacts
- What is the willingness to pay to upgrade/update water infrastructure and level of service?
- Model decision making from behavioral psychology and economics
- What are the potential costs and benefits to changing structure around drinking water (e.g. reduced revenues for municipalities)?
- Explore privatization of water systems

Flooding and stormwater management (Chicago):

Issue identification

- Water infrastructure is disconnected, and its governance is fragmented—but the resource is not
- We are not spending capital most efficiently to work jointly
- Transition from water as a public good to a club good (i.e. privatization)—good for water management but need to consider transparency and equity effects
- We could create governance structure to remain democratic in how it deals with the public.

Decision makers and influencers

- Real authority is not at the watershed level; dollars go to utilities and decisions are made at that level
- Regulators, including those who decide on rules for State Revolving Fund loans
- Local governments
- Rate payers

Information needs

- Model how integrated and shared governance can give higher performance and is cheaper
- Conduct prospective analysis of communities that we should talk to about joining together; look at capital improvement plans, governance structures, proximity, problems with flooding; then model outcomes of those communities looking at their ability to pay, rate structures, etc.
- Conduct study on value of consolidation or shared governance—build on existing efforts by Metropolitan Water Reclamation District of Greater Chicago (MWRD) and City of Chicago to include examples of where this has happened and how it has worked as well as modelling the concept (enabling and sustaining conditions)
- Look at economics of Chicago River reversal if Supreme Court decision is reversed

What needs to happen

- Acknowledge a regional entity as responsible for receiving funding
- Manage more holistically on watershed basis that cuts across engineered barriers to have a more resource respectful system.
- Provide incentives to utilities to give grants at watershed level not just within their jurisdiction
- Trading schemes on regional level to put more stormwater solutions in the places most in need

- Create market system to allow for trading
- More reliable and consistent funding for stormwater and flooding—right now depend on grants and finding dollars that go to highest priority needs. State Revolving Fund could be prioritized to address certain stormwater issues—and with trading on the table a more experienced community to put together the application
- Chicago rate structure restrictions need to be changed to enable cooperation (right now they have to charge suburban users no more than lowest city ratepayer)
- Wise use of allocations—move commodity asset out efficiently from those who aren't using their allocation to those who need it. What is GDP return on Lake Michigan water under current scenario and if allocation was fully used?
- Potential Project Focus—Chicago Region Water Management
 - Project future scenarios yielding operational and economic outcomes that are optimized; then utilize those scenarios to inform supportive policies and practices. Consider MWRD becoming the party responsible for integrated water resource management and regional governance (storm, sewer, potable).
 - Consider replicating Northwest Suburban Municipal Joint Action Water Agency where shared threats/opportunities exist across communities.
 - Consider net benefits of returning Chicago River flow to Lake Michigan (build upon Chicago Area Waterway System Study) and impacts to Illinois River watershed.
 - Target specific policy frameworks to enable the above with authorities and funding sources (both public and private sectors).

Source Watershed Infrastructure (San Francisco)

Issue identification

- What is the rational economic approach in maintaining a source watershed?
- Expanding the infrastructure definition umbrella to include natural infrastructure
- Legal obligation around watershed is part of water infrastructure
- Public perception around the role of watersheds in our water system
- Service for investment is spread across a broader group of beneficiaries
- Public understanding on the value of upper watershed is limited so we need to raise public awareness.
- Mismatch between 21st century infrastructure needs and institutions/governance systems/geographical fragmentation
- Defining/identifying beneficiaries

Decision makers and influencers

- Define beneficiaries: public, local-state water agencies, electric utilities, emergency response entities, landowners, insurance companies, water contractors
- Regulatory agencies
- NGOs
- Legislature
- Academics
- Private land-owners, ranchers/ag
- Labor/jobs

Information needs

- What are the suite of additional benefits of maintaining infrastructure
- Peer-to-peer learning
- Identifying what are the triggers of change
- Think about the data we do not have but need under this new paradigm rather than collecting the usual information
- Federal/state programs need to incorporate natural infrastructure approach into their guidance, funding programs
- New performance metrics and policy approaches for our 21st century infrastructure model
- Jobs numbers

What needs to happen

- A scenario-based model to evaluate how the value/cost of maintaining upper watershed trickles down.
- Decision tool that helps identify beneficiaries, partners, benefits
- Estimating avoided cost of maintaining upper watershed versus building additional gray infrastructure is important. A comparison tool, including metrics on water quality, using a direct and avoided outcome benefit focus.
- Framework gray and green solutions—look at hybrid systems and assess function
- How adaptive is the built infrastructure versus source watershed management?
- iTree tool model
- Analyzing various governance models
- Perceived risk and risk mitigation analysis: enhanced water availability, endangered species, insurance cost and payout, fire and flood intensity
- Adaptive models and metrics
- Farm Bill as a trigger to enable more strategic investment.
- Funding sources—investigate whether WRDA and Watersense, etc. can be used; also, Corps flood control funding (note corps does not finance green solutions)

Utility management/consolidation/ Green and Distributed Systems (San Francisco)

Issue Identification

- Need to move to 21st century utility management, capable of adapting to 21st century challenges; this includes addressing workforce, infrastructure aging, climate change including fires, water supply
- It is hard to integrate new practices such as green infrastructure (GI) and distributed systems into old financial models and practices
- What economies of scale and scope can be realized?
- Equity issues need to be at the forefront
- Need utility leadership—both elected officials and staff—to celebrate innovation

Decision makers and influencers

- Local elected officials (nature of governance matters, whether there are special districts, public or private systems, small versus large systems, incentive structures, political structures)
- Utility leadership
- State agencies/regulators
- Legislature
- Big data companies
- Trade associations
- Ratepayers/customers
- Voters

Information needs

- Demand forecasting model is needed that accounts for actual conditions—drought or flooding, reduced demand from conservation and behavioral changes, etc.—build these into the forecast to get a more accurate demand scenario—then use this to set rates.
- On green infrastructure and distributed systems multiple benefits need to be assessed—does project meet cost benefit comparison sufficient for implementation? For GI it's not just retention of stormflows there are water quality and community benefits that should be included in the calculation
- An online decision tool would be helpful
- Develop different financial models, include municipal bonds and other funding mechanisms
- There is no statewide database of green or nature-based infrastructure solutions
- Identify real world costs of investing in green and distributed infrastructure projects—develop case studies to share. Real costs should include avoided costs as well.

- Smaller systems have trouble staying in compliance with stricter limits—look at how consolidation could help in risk context—have this information for decision makers—relative benefits and costs
- For regionalization, what is the optimal size for program implementation, considering opportunities for scale, ownership, local versus regional control.
- Communicate the value of water through market mechanisms

What needs to happen

- Re-examine California Prop 218—it is a product of the 1990s that puts a limit on municipal spending—covers water services and stormwater and places checks and controls on processes a locality can use to price these services. Result is that you cannot subsidize ratepayers or have a rate structure to include conservation incentives. A utility can do cost of service analysis to prove their rates but they usually don't. A true cost/benefit analysis of this approach is needed, with outreach to utilities, rate payers, NGOs, state and regional groups.
- Democratize utility management—there are 3,000 community water utilities with different rules, no diversity in management/elected boards—utility governance should be reflective of the community;
- Provide a pathway for looking at multiple benefits and demand forecasting for nontraditional approaches like GI and distributed—put out report to get folks to do projects voluntarily as a prelude to putting into regulations. Look at benefits from property owner level to utility to whole community and how these approaches play into rate structures
- Questions of scale and regionalization of programs—look at programs that are regional and how they compare to more localized programs (look at how energy sector does this).
- Most utilities have rainy day funds so risk sharing could be possible in a regional approach.
- Look at decision making process for a local utility and provide information to elected officials that will help them make the case for new approaches

Agriculture use conflicts and economic consequence to rural communities (San Francisco)

Issue Identification

- Use conflicts over water supply, including reliance on groundwater over surface water, and issues with over withdrawal.
- Water quality considerations are also important, given impact over use of fertilizers
- Have antiquated water rights structure that determines who gets water when
- Changing rules and regulations and climate change are creating new and deepening existing conflicts for agriculture users

- Need recognition that farms drive the local economies, and that there are real consequences to the economy from reduced water supplies
- Need to balance agriculture as a resource with environmental stewardship
- Effects of supply chain on loss/consolidation of smaller farms, and impacts to rural communities

Decision makers and influencers

- Water right holders
- Federal and state water contractors,
- Investors who push certain crop types
- NGOs
- Regulators
- Commodity groups—Western growers, farm bureau, dairymen, etc.
- Legislators
- Courts

Information needs

- What are best crops to grow for sustainability and market value
- What is price of water—can pay different amounts in same basin or between basins
- What is actual water usage—need new techniques to measure
- What are the impacts on farm profits of consolidation into fewer larger farms, impacts on rural economies, demographics and employment rates
- What are the best adaptive irrigation technologies
- What will agriculture look like in 20, 40, 60 years under different climate, storage and efficiency scenarios?
- Feasible environmental approaches to encourage water users to provide more flows and mitigate for reduction of water within a basin—can you put dollar figures on the environmental benefits and analyze willingness to pay

What needs to happen

- Policies to mitigate impacts to wells—residential versus agricultural uses
- Protecting residential water—create priority for human health and safety
- What if there was a collective guarantee for minimum amount of water—collective pool for risk management
- Could there be an in-basin water market—impacts on land size, crops grown, labor, etc.
- What is most cost-effective way to provide clean and safe water for rural communities—bonds, public goods charge, ratepayers, etc.
- Policy instrument to mitigate for nitrate contamination
- Do something similar to California energy conservation bill for water focused on agriculture needs; energy bill involved revolving loans to government buildings to become more energy efficient, payback depends on energy savings. For agriculture you could measure water use via satellite, and then

based on that give loans to become more water efficient. This idea has already gotten traction in California. Note that RFF already has grant from NASA to look at value of their satellite data; could also add in sensor and drone data—create a system to use all this information.

- Managing water quality/quantity is non-uniform over space and time so hard to implement a cap and trade program—think about what water trading should look like in broader context
- Spreading concept of fairness as redoing water allocations for the future under new climate and water regime, is there an economic analysis to be done on value of senior to junior water rights to provide basis for market trading between right holders

Water and land-use decision planning (Denver)

Issue Identification

- Change the way water and land-use decisions are made in isolation to make these decisions more sustainable through integrate decision making
- Take an all watershed, holistic approach, and identify beneficial uses and values first before discussing how to protect them
- Recognize that there are competing uses, principal and ancillary uses. Current approaches are fractured from ownership and uses, multiple threats to uses—some continuous, some intermittent

Decision makers and influencers

- Problem is having siloed decision makers for water and land use and stakeholders don't have decision ability
- On land use side—planning departments and land-use authority (elected officials)
- On water provider side –utilities, state regulators
- Influencers—developers, utilities, trade groups and organizations, farmers, downstream users

Information Needs

- Need refined information to allow decisions on what land uses people want to allow—water usage data by different land configurations
- Cost benefit analysis specifically for water use in the context of land use decisions
- Water and land use in the context of sustainability—what is the target relationship between water use and yield that could be considered sustainable and how does that impact land use decisions
- Need long term vision considering all stakeholders, future water needs, consideration of acceptable risk

- Need reference information on expected water use by different land configurations to help with planning
- Need climate information for sustainable design, perhaps design standards

What needs to happen

- Develop a consensus-based land use decision model that is meant to serve shared mission and values in the context of known constraints
- Develop a city-wide water budget and all new proposed projects must comply
- Case studies on best and worst practices, planning model—could be an economic study
- General best practice guidelines

Infrastructure and investment: Economies of scale and scope for consolidating water and wastewater systems, and creating markets for water resource and waste load allocations (Denver)

Issue definition

- How do we build resilience, flexibility and sustainability, and certainty into our water infrastructure?
- Water is a basic human right: both access to safe clean drinking water, and keeping watersheds meeting all of their intended uses
- Keeping the status quo is going to be difficult when the status quo is changing
- Provide for economic and non-economic uses, and balancing competing priorities
- Sufficient infrastructure and limited resources for investment.
- Should there be a need for the government to provide for the common good, in terms of financing or cost sharing?
- Must ensure that environmental justice issues are addressed
- How does the support for the implementation be maintained in real time as opposed to simply being reactive?
- How do you convince people that water is a right that must be purchased?

Decision makers and influencers

- Government (federal, state, local, tribal) in terms of investment, regulatory action, shaping priorities
- NGOs (environmental, human rights, human health) influence and shape public opinion, and focus public opinion
- Industry bears costs in terms of revenue and investment and share the responsibility of maintaining the public resources
- Public bear the cost of revenue and shape the outcome vis-à-vis public opinion and voting.

Information needs

- Conduct a review of what others doing globally with respect to how they buy, sell, trade, and access water rights and the ability to pollute
- Assemble a history of water market policies, both successes and failures
- Look at or update existing needs surveys of water and wastewater infrastructure and how consolidation could help reduce or meet the needs
- What are the factors for consolidation and what are the obstacles? What are the opportunities for vertical and horizontal consolidation?

What needs to happen

- Create/implement a trading market for water/wastewater
- Perfection of water rights and the creation of certainty
- Political will to recognize and pay for what we have determined to be a public value
- Change from being reactive to proactive

Agriculture Productivity (Denver)

Issue Definition

- Long-term, integrated, landscape-scale planning to ensure stability in food production, water supply, and water quality
- Water, energy and food production are integrated
- Ensure USDA programs or other conservation investments are coordinated with long term plan (e.g. for EQIP understand multiplier/cycling/ripple effects of investments)
- Socio-Economic Trends: Mega Farms

Decision makers and influencers

- Congress and Administration, Federal and State Agencies
- Farmers and Ranchers (individual farmers, influencers and associations like farm bureau and cattleman's beef association and dairy)
- NGOs
- Water Managers, Irrigation Districts, Utilities and Administrators
- Energy Utilities

Information Needs

- Information for decision-makers that is understandable and useful
- Data that integrates at a bigger scale and identification of data gaps
- Look at municipal, agriculture, industry, environmental and other needs at a whole system scale, and how it compares to water availability, including snowpack and groundwater

- How environmental markets can be established using conservation easements as a revenue source: for example, easements that allow producers to market/ lease water in the event there is surplus, to diversify farm income/revenue
- What practices can farmers deploy that enhance production and revenue but also may free up water to meet growing demands or build resilience?

What needs to happen

- Convene farmers, ranchers, forest owners and water managers along with economists and land grant universities to identify paths forward
- Develop federal policies that allow for regional flexibility and that involve an integrated approach and participation from energy and water utility sectors
- Re-examine existing subsidies and whether they meet the outcomes we want to achieve
- Consider regional pilot projects
- Host panel meetings and breakouts at various sector events (AMS, AGU, tradeshow).
- Break down swim lanes
- Consider environmental markets for surplus water
- Bi variate decision making—flexibility to address variable hydrology and make optimal management decisions

Nexus between energy, water, land/food including climate effects (Houston)

Issue Definition

- Focus on water use in hydraulic fracturing
- Resiliency of critical systems to both drought and flooding
- Water governance affects oil & gas development
- Use efficiency, especially the efficient allocation of water of different qualities
- Disposal of wastewater creates additional problems
- The specific value of water is tied to the quality that must be used
- Scarcity of water
- Supply chain of the water and transportation of water
- Efficiency of water use per well and per unit of oil or gas

Decision makers and influencers

- Regulators: FERC & NRC, Texas Railroad Commission
- Energy and water regulators
- Groundwater conservation districts
- Surface water rights holders
- Oil & Gas Producers
- Landowners who are leasing mineral rights (and sometimes selling water)
- Ag sector

- Municipalities
- Whoever controls water infrastructure
- Environmental stakeholders

Information needs

- Innovations in water efficiency in fracking
- Water quantity and quality data at multiple points of use and return
- Monitoring of water use perhaps via metering
- Prices paid for different types of water
- Data on land subsidence, seismic issues, and water depletion is needed related to specific uses

What needs to happen

- Limit rights for groundwater
- Measurement of the externalities may help identify where natural internalization can be achieved and where regulation is needed

Water Scarcity and Efficient Allocation and how to Incentivize Stewardship in Water Use (Houston)

Issue Definition

- Efficiency is about arriving at an allocation where there is no further option of improvement without making someone worse off
- Supply and demand do not determine water markets as it should because water is undervalued; risk does help determine and complicates the price to buyer and seller
- Market revolves on perception vs. material considerations
- Good stewardship involves accountability
- Efficient allocations for various water uses should be done jointly not one supply at a time
- To address the supply side people should use the lowest quality of water they need—fit for purpose of use

Decision makers and influencers

- Local government, state legislators, local utilities
- Agriculture (farmers), ranchers, and industry
- Homeowners/citizens
- Environmental groups
- Recreational users

Information needs

- Water metering data and analysis of trends and patterns

- Remote sensing of quantities and location (surface and groundwater)
- Data about who the buyers and sellers are
- Data on future supply and demand and on water availability
- Satellite imagery can identify how much and where water is—company called Sourcewater that does this—then can set price of water
- Study to show the value of infrastructure (a reality-check for users and citizens)
- Costs/benefits study on updates to infrastructure and its importance

What needs to happen

- Data would be the foundation for setting price for efficient allocation (make it like buying a shirt; either the price is worth it to you or not)
- Block rate pricing (meters)
- Provide information about water quality and quantity at level the public understands
- Provide a linkable indicator—something that indicates technical measurement in a salient, understandable way
- Address people's differing perceptions of 'quality of water'
- Markets help with efficient allocation of resources and good stewardship.
- Know real costs vs. subsidized costs in a transparent way
- Change in culture about taxes, rate increases, mistrust in government, government
- Non-pecuniary incentives/moral suasion, social norms

