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Commentary:

The route to water security for Texas: the 2015–2016 Texas Water Roadmap Forums

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Abstract: Three forums were held between February 2015 and November 2016, bringing together Texas water experts from business, industry, government, academia, research, and the investment community in impartially facilitated sessions to determine ways to secure Texas' water future through accelerating growth of infrastructure, technologies, research, education, and sustainable use. Consensus emerged after the first forum that Texas is approaching a water crisis reflecting matters of supply, allocation, and quality that demands immediate action to ensure water security and equitable access to this vital resource. Participant focus rested on new technology acceleration and investment, workforce education, research underway and desired by segments of the water sector, the water-energy-food nexus, outreach and public education, data management and access, water valuation, water security, and legal and regulatory frameworks. Participants also examined funding and partnership options for development of water treatment and supply infrastructure, water rights and allocation methods, aging infrastructure, and conservation, as well as the nearly ubiquitous fragmenting and compartmentalizing of just about everything having to do with water throughout the entire water sector. The forums generated and summarized a wealth of information that can be used by any party to make progress toward the goal of building a Texas water roadmap. This report summarizes the discussions and the path forward for securing Texas' water resources.

Keywords: water planning, water management, water policy, water research, water education

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Terms used in paper

Short name or acronym	Descriptive name
NSF/RCN-CE ³ SAR	National Science Foundation Research Coordination Network for Climate, Energy, Environment and Engagement in Semiarid Regions
SWIFT	State Water Implementation Fund for Texas

INTRODUCTION

In December 2014, the Wells Fargo Foundation granted funds to the Texas State University to define the most pressing water-related technology deficiencies for which applicable intellectual property or researched solutions may be available already. Work evolved through a series of partnerships into an expanded effort to develop a novel water technology roadmap that would address pressing needs of the state and use this approach to help position Texas as a global leader in water technology and sustainable water use. By invitation, key thought leaders in the water sector from throughout Texas were brought together in the Texas Water Technology Roadmap Forum to help lay that groundwork. The forum was underwritten by the Wells Fargo Foundation, with co-sponsorship by the Meadows Foundation, the Texas Research and Technology Foundation, and the National Science Foundation Research Coordination Network on Climate, Energy, Environment and Engagement in Semiarid Regions (NSF/RCN-CE³SAR). In advance, the leadership team developed the plenary and charrette facilitation process that would guide the roadmap process in the months ahead. The first forum was hosted by the Water Institute of Texas on the campus of the University of Texas at San Antonio on February 25, 2015. The meeting was also supported by AccelerateH2O, the Meadows Center for Water and the Environment and Science, Technology, and Advanced Research Park at the Texas State University. A full report on the forum was published (Rosen 2015).

The Texas A&M University System and Area 41, a special Texas A&M System project seed fund, co-sponsored the second water forum with the Texas A&M University-San Antonio serving as the host. This two-day event was held November 17–18, 2015, with sessions split between an in-town conference facility and the nearby campus of the Texas A&M Uni-

versity-San Antonio. This forum focused on the water-energy-food nexus and included identifying and developing responses to local, state, national, and global challenges and opportunities relative to water resources in research, education, outreach, and policy implementation (Mohtar and Rosen 2015). Other forum topics included holistic solutions to water security in Texas and ways to engage stakeholders at home and worldwide in dialogues aimed at preventing to the extent possible, and otherwise resolving, conflicts over water-energy-food resources. Small-group charrettes concentrated on the most critical problems facing water-energy-food resources and technology from the perspective of human, education, policy, and legal dimensions. The NSF/RCN-CE³SAR served as an independent source of facilitation for the charrettes.

The Texas Water Development Board and the NSF/RCN-CE³SAR co-sponsored the third and final forum called the 2016 Texas Water Roadmap Forum. Focused on workforce education, data management and access, and several categories of research, the forum was hosted by the Institute for Water Resources Science and Technology on the campus of the Texas A&M University-San Antonio on November 29, 2016. The NSF/RCN-CE³SAR developed the plenary and charrette facilitation process and provided facilitators. The full report on the forum also included review of key points addressed during the previous forums (Rosen 2017).

THE CHARRETTE PROCESS

The water forums were held to develop consensus on how to address important water-related topics. Consensus building was conducted through an intensive facilitated process called a charrette, which involved water experts working together under compressed deadlines. Charrettes provided an interactive process that brought together a limited number of stakeholders

representing pluridisciplinary perspectives (i.e., multi-, inter-, cross-, and transdisciplinary). Participants followed a rigorous, vision-driven process to achieve specified outcome-oriented goals and objectives. The charrette process was adopted for use because it is particularly well-suited to encourage discussions that go beyond conventional thinking. It drove participants to think beyond what is to what can and must be for current obstacles to be overcome. Participants had opportunity to organize and express their thoughts in advance of the charrettes by completing a pre-charrette survey. The survey information was used to form questions and inform facilitators about areas of possible discussion, consensus, or divergence of opinion. Discussions during the sessions offered participants an opportunity to contribute information and learn from others.

Discussions were framed within a broad context that reflects the real-world complexity of dealing with water-related topics. Participants addressed this complexity by focusing group discussion around general categories of influence on planning for water security and general concern. These categories of discussion included economics, politics, social factors, environmental factors, technologies, and laws, policies and regulations. Focus on these categories helped narrow participant consensus building, but charrette facilitators also identified the interconnected, interrelated, and interdependent nature of these categories, and advised participants that water matters are also influenced by uncertainty, complexity, ambiguity and some measure of volatility (Figure 1).

Discussions during the sessions offered participants an opportunity to contribute information and learn from others. Discussion was an essential element of the charrettes, because it began the important process of developing a common understanding among participants about the topics at issue, barriers to resolution, and roles of the various stake-holding parties. Moving from generalized to detailed considerations, participants established agreements on solutions, near-term needs, gaps, and scenarios for collaboration, coordination, funding, and alignment of opportunities. After small-group sessions ended, plenary sessions provided participants an opportunity to hear highlights from each group and seek to form full-group consensus around solutions and actions.

THE FORUMS

Forum I – Texas Water Technology Roadmap Forum

The first water technology roadmap forum was convened with the idea that participants would focus on water technology identification, development, and implementation in Texas. A list of the most pressing water-related technology deficiencies for which applicable intellectual property or researched solutions may already exist was conceived as an initial target for intellectual property mapping. The results could have application in a range of water technologies and help lay the groundwork for developing a novel roadmap to guide Texas

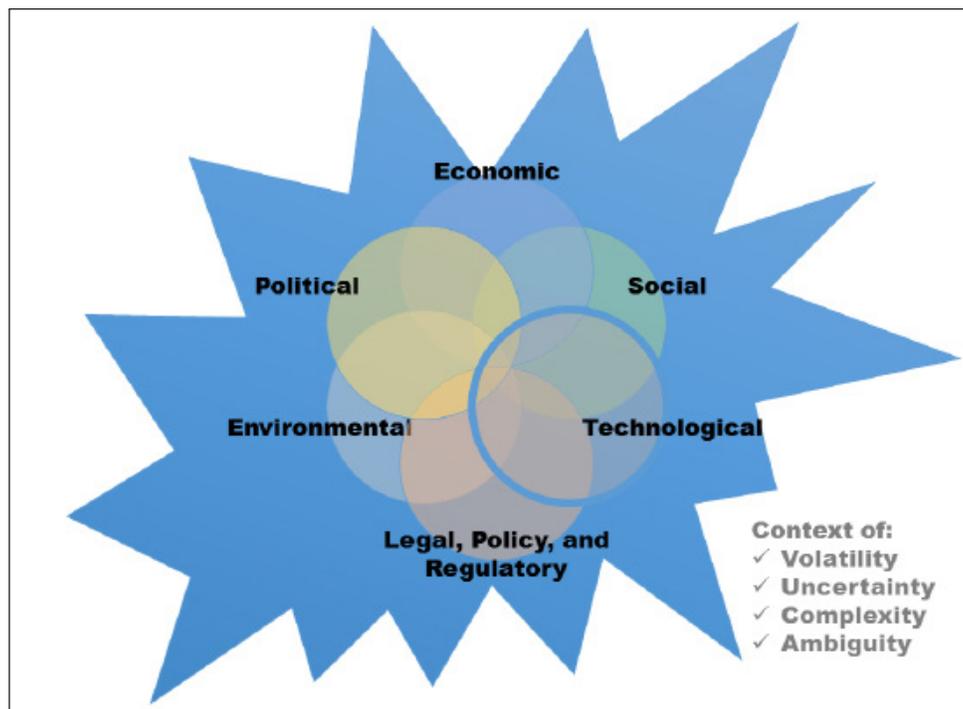


Figure 1. The charrette process.

toward global leadership in water technology and sustainable use. By invitation, nearly 100 key thought leaders in the Texas water sector from business, industry, government, academia, research, and the investment community were brought together to help meet the objectives laid out for the forum.

Participants met in plenary and breakout charrette sessions (Figure 2). A remarkable result was that, regardless of topic assigned, participants in each breakout session identified nearly identical problems in the water sector as critical and offered similar priority solutions. While participants agreed that new technology will play some role in Texas' water future, they concluded that many of the most critical matters to address have little to do with the availability of new technology or questions of science, engineering, or planning. Consensus emerged that Texas is rapidly approaching a water crisis reflecting matters of supply, use, and quality that demand immediate action to ensure water sustainability and equitable access. Participants described an immediate need to focus on regulatory and financial constraints to water management; deal with inadequate public investment in water infrastructure; address the undervaluation of water; upgrade and repair aging water infrastructure; enhance education about water; and increase data access, quality, and quantity. Participants agreed that failing to act now could have dire economic impacts to Texans through increased costs of water affecting the economy, loss of fresh water in some areas, effects on public health, civil unrest caused by disparities in access to and cost of water, adverse environmental impacts, and reduction of food production and consequent increase in cost. Participants believed that with action now, Texans can have a sustainable supply of safe water for all uses, including support of future growth in population and the economy.

Because the goal of the first water forum required a focus on water technology, participants also provided considerable insight on water technology development, despite their advice that technology alone was unlikely to solve the multiple problems identified as most important to securing Texas' water future. Participants urged continued development and implementation of water-smart technologies. In addition, water reuse should be expanded and supported by new technology along with creation of new markets for water residuals, such as for saline and gray water, and for water processing byproducts.

The key challenge for bringing technology to market was described as reducing the length of time it takes to bring technology products from the laboratory to general application. A need for reliable, unbiased evaluation of emerging and competing technologies also was identified. Participants identified fragmentation in the water sector and a dysfunctional system for water technology innovation. They believed a lack of adequate investment, with investors misunderstanding the current market environment, including inadequate and inaccurate valuing of water as a commodity, to be among the top con-



Figure 2. Participants in working sessions at Forum I.

straints in moving technology to market and application. A high degree of regulation, not just over public safety concerns, but also across acquisition and supply chain management, was thought to obstruct bringing innovative water technology forward. Participants called for regulatory relief, industry standards, and accelerated research, development, demonstration, and deployment of new technology facilitated by technology-specific demonstrations.

Forum II – Resource Nexus: Water, Energy, Food – Water Forum and Technology Roadmap

The second water forum was a two-day event that brought together 75 water experts, including many from outside of Texas. Participants were charged with enhancing discussion and improving understanding of the water-energy-food nexus in Texas. Topics addressed included identifying and responding to local, state, national, and global challenges and opportunities relative to water resources in research, education, outreach, and policy implementation. Other topics included seeking holistic solutions to water security in Texas and ways to engage water stakeholders in dialogues that will prevent to the extent possible, and otherwise resolve, conflicts over water-energy-food-related resources. The forum was timely because competition for water usage between food production, energy development, and general residual and commercial needs provides a compelling nexus globally. A striking example is found in the San Antonio region where a three-way demand on water resources for agriculture, hydraulic fracturing in energy production, and general residual and commercial use pull at a supply limited by natural availability, water quality concerns, and need for environmental flows in the region's streams.

The forum drew information and perspectives from a broad range of stakeholders, representing all aspects of the nexus community. It also engaged a comprehensive spectrum of the Texas A&M University System water experts currently working on aspects of the water-energy-food nexus. The Texas A&M Uni-

versity System already serves as a testbed for global efforts to bridge the gap between water availability and water demand, drawing on resources available at the Norman Borlaug Institute for International Agriculture, the Energy Institute, Texas A&M AgriLife Extension Service, the College of Engineering, the Bush School of Government and Public Service, a body of alumni working in the Texas water sector, and partnerships with government, business, and industry. Participants held a common interest in accelerating an understanding of nexus and related technologies.

There was consensus among participants on the consequences of failure to educate decision-makers and the public about water-energy-food, changes needed in education systems, barriers to action, and benefits if action is taken. There also was general agreement on what is most important to fix first and what needs to be done to fix it.

Strategic actions recommended during the forum's charrettes follow; specific examples, actions, and justifications are contained in the full report.

- Education and outreach is needed to develop understanding and support by the public for work on the water-energy-food nexus.
- Basic principles of the nexus as well as significance for future economic and environmental sustainability need to be taught to students through formal and informal educational means starting as early as possible and continuing through higher education.
- Technical and higher education must adapt their models for curricula development and research more quickly and place higher value on solution-based research and public-private-university partnerships to address nexus subject areas, related technologies, and workforce needs that accompany technology advancement. Participants believed that without such change, universities will become even less effective and increasingly irrelevant at meeting the needs for workforce education and become even farther removed from the technologies universities are helping create.
- Because responsibility for water, energy, and food programs is spread across many different work groups, agencies, colleges, departments, and other institutional divisions in government, industry, and universities, communication is critical among these separate responsible parties.
- Participants believed Texas' current legal and regulatory framework fails to fully reflect basic science (i.e., the fundamental physical processes) underlying the lifecycle of water and use by humans. They recommended education and outreach to create greater levels of awareness about the nexus, and for water in particular, to help pave the way for science-based policy change.



Figure 3. Kathleen Jackson, Texas Water Development Board member, addresses participants at Forum III.

- Universities and private research organizations should play a role as independent, unbiased evaluators of demonstrations of nexus-related technologies to accelerate commercialization and application.

Forum III – 2016 Texas Water Roadmap Forum: workforce education, data, and research

Focusing on workforce education, data, and several categories of research, the third water forum brought together more than 60 Texas water experts from technical, academic, research, management, and business backgrounds with a heavy emphasis on university sector participation (Figure 3). Participants were asked to envision a future Texas where water security is assured for people, industry, food production, and nature. They were then tasked through the charrette process to develop plans to set priorities for action and frame key milestones for progress with an overall goal of securing Texas' water future. Plenary sessions focused on state funding programs for water infrastructure development, such as the State Water Implementation Fund for Texas (SWIFT), and development of partnerships in water project financing, implementation, and related research. Four small-group charrettes were held to address four specific areas of focus identified in previous forums where progress can and must be made. These were (1) data management and information sharing; (2) workforce education; (3) research on water sources and transport; and (4) research on water use and enabling technologies. These charrettes were followed by two larger-group charrettes dedicated to examining funding and partnership opportunities available to take action in the areas identified by the smaller group charrettes. A short summary follows, with detail and listed points of action contained in the full report.

- In the area of data management, forum participants listed their vision for the future and actions to achieve the endpoints envisioned through enhanced data storage, use, and access. They concluded that governmental entities, but not any single one, are best suited to build and maintain water data platforms. They suggested a measured evolution by working through large-scale collaborations to create data repositories, develop standards and norms for the format and content of databases, and use big data analytic platforms and dashboards for data interpretation and visualization.
- For workforce education, participants recognized the challenges of meeting the needs of an industry rapidly evolving as new technologies and regulatory requirements change water workforce education requirements. They suggested students be offered a broader curriculum than is generally available through traditional civil engineering degree programs and supported establishing internships to provide students with experiential learning opportunities. They also advocated locally offered education for water industry jobs to address the need for the water workforce to be reflective of the society it serves and to meet the varying nature of water infrastructure of differently sized and rural communities.
- Participants listed and differentiated between research underway versus research that industry and government currently need. The two lists were markedly different, with only one broad area of overlap: desalination technologies and related energy demand. Participants from industry indicated a need for considerable research on human dimensions of water use and public understanding about water, while there was little indication of ongoing research at universities addressing these matters. There is a need for better communication among researchers, government, and industry, and coordination of needs and opportunities for research. Participants proposed follow-up response by forum attendees in 10 areas of water-related research or action: water planning, water availability, water policy and regulation, baseline data, use of big data, climate, identification of the body of existing information, local water supply and demand, meeting the water needs of society, and anticipating future needs.
- For funding and partnership development, participants believed that it will be more effective to work through existing partnerships than to create new ones. There is significant opportunity for new work on capital-related projects through the SWIFT and state revolving fund, with funding criteria flexible enough to allow for innovation on traditional water projects as well as development of water efficiency and conservation efforts that

include the need for investment in capital infrastructure. Participants agreed to explore a series of collaborations, including two that received the greatest attention: (1) collaborating on a large-scale to improve dataset use and access, with the discussion to be hosted initially by the Texas Water Development Board; and (2) forming partnerships with small communities for new work on capital-related projects to help support community access to financing available through the SWIFT and the state revolving fund.

CONCLUSIONS AND FUTURE ACTIONS

The forums progressed from a point of departure initially focused on new water-related technology and how to accelerate the development of that technology from laboratory through marketing and on to industry application. It seemed like a relatively simple undertaking at the first forum to design a water technology roadmap to help advance Texas' water future. Participants were quickly confronted with the complexity of water, however, which frustrated completing that task as envisioned. The water sector is affected by historical, economic, social, environmental, political, regulatory, legal, and technological challenges. Furthermore, the water sector exists in a context of complexity, volatility, uncertainty, and ambiguity. The participants heard that many—perhaps most—of the problems the state faces in the water sector will not be solved through use of new technology. A different route emerged to help create a sustainable water future for Texas.

Critically important to Texas' water future is addressing obstacles such as undervaluation of water, counter-productive policies, old and failing infrastructure, inadequacy of higher education to adapt curricula to meet the needs for training the water workforce, failures to connect surface water and groundwater in policy and management, investment and market challenges, and compartmentalizing of just about everything related to water. All were considered impediments to achieving water security in Texas, while technology development was seen as providing new tools of value to achieve incremental gains.

Building on results of the first forum, the second focused on the nexus of water, food, and energy and how these coupled systems lack coherence at the policy, regulatory and organizational levels. This forum brought together participants from both within and beyond Texas to share their experiences. Despite the obvious linkages of water, energy, and food programs, education and research in these areas by the state's agencies, institutions, and industries are fragmented and generally unconnected. This lack of coherence thwarts implementation of truly sustainable solutions on the nexus of water, food, and energy. Current higher education systems are too slow in responding

to the need for more integrated curricula in water degree programs, and they are failing to deliver job-ready workers for rapidly changing water industries. Participants expressed deep concern over a growing gap in public understanding about water matters, the water-energy-food nexus, a need to provide better outreach about water to all sectors of society, and the need for improved technical data storage and delivery industry wide.

The third forum explored challenges identified in the first two forums by attempting to further define communication, information management, data access and associated research regarding water resources. Forum participants also described needed improvements in education and training of a water workforce that will see considerable turnover and repositioning in the near future. This forum also brought a focus on available funding to address water development and partnership opportunities. This emphasis was made possible through support of the forum by the Texas Water Development Board and by examination of SWIFT and state revolving loan funds.

As a result of the road-mapping process, there has been action to follow through on initiatives outlined during the forums. In particular, a series of regional research projects on various aspects of the water-energy-food nexus in Texas are now underway and a grant from the National Science Foundation was received by the Texas A&M AgriLife Research and Extension, Texas A&M University-San Antonio, and University of California-Riverside to provide research on decision support for water stressed food-energy-water decisions, with much of the work to be centered in the San Antonio region. This initiative was driven in part by discussions at the second forum. A new water science and technology degree program now in the final approval process at Texas A&M University-San Antonio was conceived specifically to adapt to water workforce needs and resolve curriculum deficiencies noted by participants at all three forums. The new degree program was developed cooperatively with Northwest Vista College and the Texas A&M Engineering Extension Service, with recommendations from water sector experts at the forums on how to best structure a new water education program. Discussions have also begun around formation of a large-scale collaboration on improving dataset use and access. An initiative discussed at the third forum that may continue is initiation of discussions about support and partnerships with small communities for work on water project financing through SWIFT.

The forum reports may be among the most significant compendiums of impartial ideas available today to support accelerating growth of water infrastructure, technologies, industries, and sustainable water use to provide a secure water future for Texas. Although there has been progress on implementing specific recommendations on the water-food-energy nexus, workforce education, and data management, there were many other

recommendations arising from the forums where progress has been more limited. Recognizing the importance and sensibility of acting on the shared recommendations, additional effort is needed by industry, government, academia, and the investment community to secure funding and stakeholder support required for continued implementation.

As a next step, the originally envisioned water roadmap should be completed. The forums have provided much of the basic information on essential areas of focus to get the process underway. A concise and clearly articulated roadmap can serve as a tool for communicating the broad-based consensus regarding water-related issues and means to resolve those issues. Although work toward achieving the recommendations has been modest to date, the high level of consensus on the need for and form of action on many of the matters identified at the forums has established a solid foundation for moving forward. Already, we have seen where action on the nexus, workforce education, and data management may have been hastened along by the forums. In other cases, activity may have been initiated with no specific connection to any particular forum. An example of such work may be the emphasis on better characterizing surface water and groundwater interactions, flows, and availability.

At the end of the final forum, the lead facilitator reflected on all three by urging participants to engage in one or two of the tangible action plans outlined in the forums. He advised that it would be impossible to solve all the issues identified through the series of one- and two-day forums. He suggested that even if the forums only resulted in efforts to address one, two, or three of the many challenges presented by participants, the forums will have been successful. With work underway on the water-food-energy nexus, workforce education, and data management, some measure of success is already assured.

The forums provided a wealth of information that can be used by any party to explore pathways for beneficial action on water in Texas in combination with, or in addition to, existing plans and action. Building a roadmap is a time- and resource-intensive process. Roadmaps are often used as a means to display and simplify complex processes where stakeholders help create consensus around performance targets, pathways, linkages, assets, priorities, obstacles, and time frames for research, development, demonstration, and deployment. Given the extent and complexity of information now available from the three forums, development of a water roadmap for Texas remains a reasonable goal should sufficient resources become available to support it.

Regardless of how results of the forums may be organized in the future, the forums have assembled basic information of importance about Texas water that is available nowhere else. Participants came from throughout the water sector to work collegially together without political or industry sector agen-

das. The forums were managed and documented in a similar fashion, with neutral facilitators and objective reporting. The result is an impartial listing of positive actions that can be taken to solve pressing needs in the various parts of the water sector in Texas. Information in the forum reports, participant consensus, and statements of action are compelling and constitute a call for action, along with basic directions on how to proceed forward.

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Forum II: Underwriting Sponsor: Area 41. Co-sponsors: The Texas A&M University System, Texas A&M University-San Antonio, and Texas A&M University Water-Energy-Food Nexus Initiative. Co-sponsor and facilitator: NSF/RCN-CE³SAR. Individuals: James Abbey, Nuala Martinez, Cynthia Matson, Jon Mogford, Claudia Pollard, Mallory Stocker, and Mary Schweitzer.

Forum III: Co-sponsor: Texas Water Development Board. Co-sponsor and facilitator: NSF/RCN-CE³SAR. Host: Texas A&M University-San Antonio. Individuals: James Abbey, Sam Marie Hermitte, Kathleen Jackson, Robert Mace, Nuala Martinez, Cynthia Matson, and Andrew Sansom.

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