Colorado State University

U.S. Perspective on the Water-Energy-Food Nexus

Colorado Water Institute
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Sumary of Case Studies
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Summary of Case Studies

1. Water/Food/Energy Nexus Case Study (Coca-Cola)

Presented by Jonathan Radtke, Director of Water Resource Sustainability, Coca-Cola North America

The Coca Cola Company's sustainability framework–called "Me, We and the World"–is about three things: people, communities, and the environment. As a company, we are committed to achieving ambitious goals in each of these areas. Within this framework, we are hyper-focused on three priorities that have the biggest impact on our business and for the people and communities we serve: Well-Being, Women, and Water. In the water stewardship space, our goal is to balance our water use, or in other words, achieve "water neutrality." We work to safely return to nature and communities an amount of water equivalent to what we use in our beverages and their production. This is performed through reduction, recycling, replenishment, and risk management. They also actively promote sustainable agriculture to:

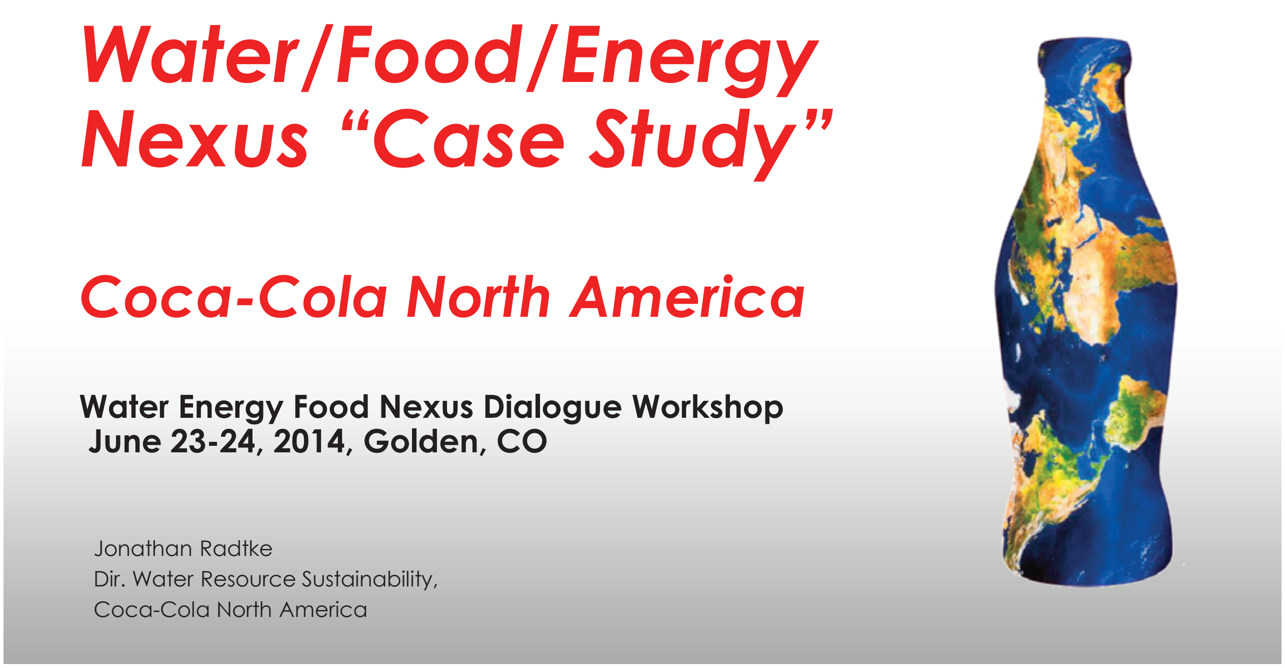
- Enhance brand by improving social and environmental outcomes at the farm
- Increase continuity and resiliency of their agricultural supply chains through more strategic supplier relationships
- Support required top line growth through increasing yields
- Protect their license to operate in developing geographies dependent on agricultural economies

For their Sustainable Agriculture Replenish Projects, which include treatment wetlands, variable rate irrigation, and no-till farming, they partner with farmers, WWF, NRCS, CSU, MSU, Walmart, etc. Based on their nexus approach studies, the followings are concluded: a nexus approach needs multiple stakeholders, who understand common goals; it is challenging to upscale from pilot to wide-spread adoption; incentives are required to get stakeholders involved; a long-term vision is required. They also identified gaps as: not all sectors are engaged; government policies/subsidies don't align with sustainability strategies and goals; there is a lack of public engagement/understanding. They believe that contribution of corporate sector can influence supply chain, leverage political clout, influence peer companies, and promote communication with consumers.

For more information:

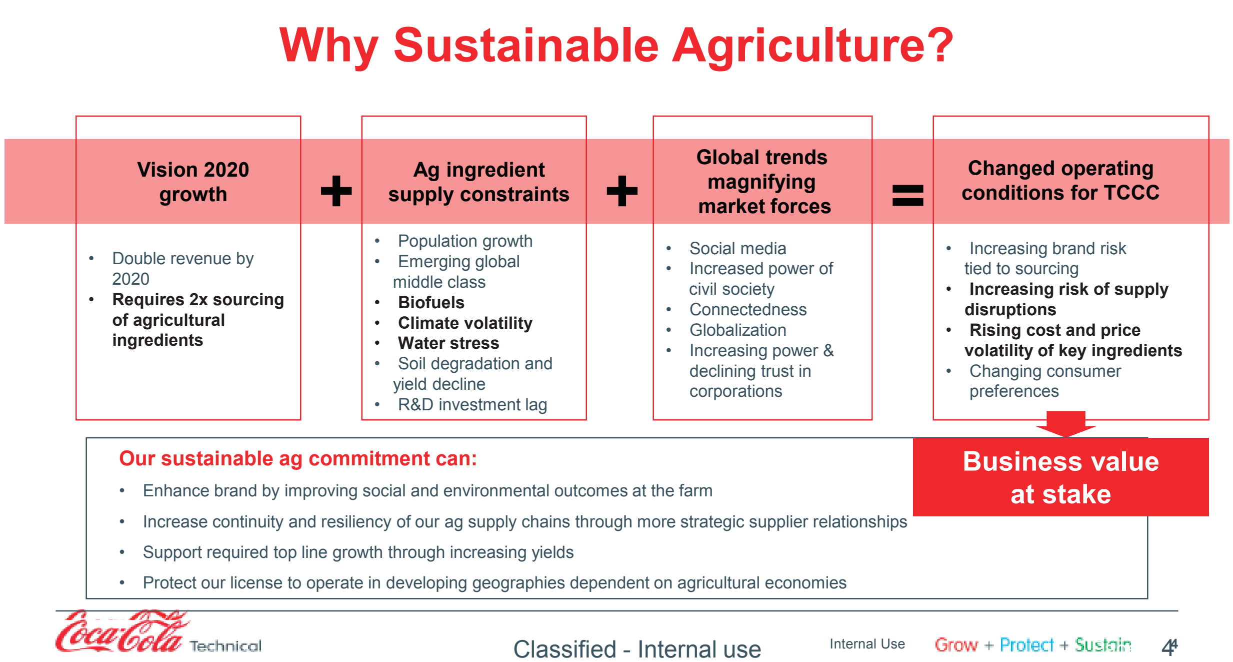
http://www.coca-colacompany.com/sustainabilityreport/world/water-stewardship.html

http://www.coca-colacompany.com/water-stewardship-replenish-report/



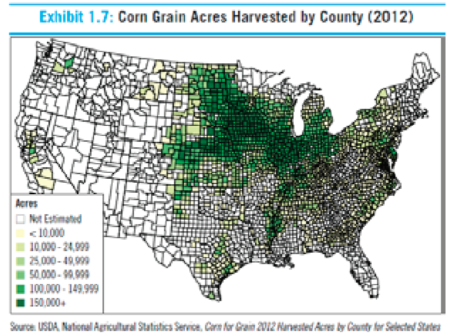

ME
WE
WORLD
WELL-BEING
Active Healthy Living
Beverage Benefits
Responsible Marketing
WOMEN
Sustainable Communities
Human & Workplace Rights
WATER
Packaging
Energy/Carbon
Sustainable Agriculture

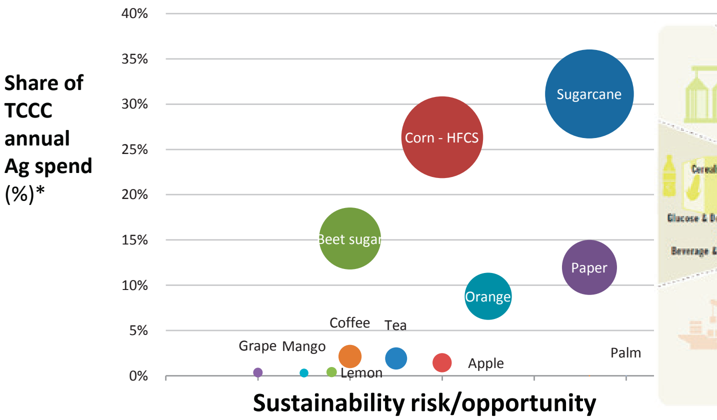

Water Stewardship Goal – "Water Neutrality"
We work to safely return to nature and communities an amount of water equivalent to what we use in our beverages and their production
Reduce
25% by 2020
Replenish
100% by 2020
Recycle
100% compliance
Risk Management
SVA/SWPP
100% compliance

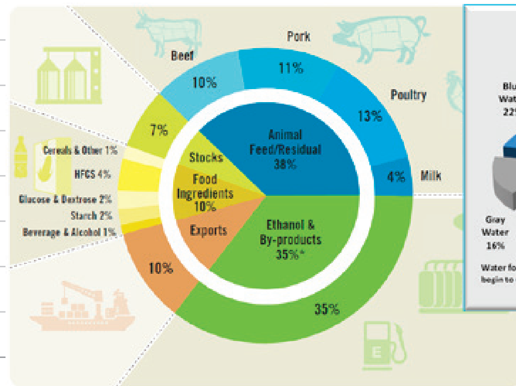

Why Sustainable Agriculture?
Vision 2020 growth
+
Ag ingredient supply constraints
+
Global trends magnifying market forces
=
Changed operating conditions for TCCC
Double revenue by 2020
Requires 2x sourcing of agricultural ingredients
Population growth
Emerging global middle class
Biofuels
Climate volatility
Water stress
Soil degradation and yield decline
R&D investment lag
Social media
Increased power of civil society
Connectedness
Globalization
Increasing power & declining trust in corporations
Increasing brand risk tied to sourcing
Increasing risk of supply disruptions
Rising cost and price volatility of key ingredients
Changing consumer preferences
Business value at stake
Our sustainable ag commitment can:
Enhance brand by improving social and environmental outcomes at the farm
Increase continuity and resiliency of our ag supply chains through more strategic supplier relationships
Support required top line growth through increasing yields
Protect our license to operate in developing geographies dependent on agricultural economies
Technical
Classified - Internal use
Internal Use
Grow + Protect + Sustain
4

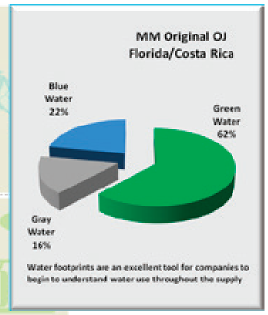
Our ag supply chains are critical to achieving our revenue goals and protecting our brands

- TCCC system ag system spend over **$12.5 billion** annually
- Primary Ag ingredient in US is **corn**
- "Sustainable sourcing" based on our SAGP









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Sustainable Agriculture Replenish Projects

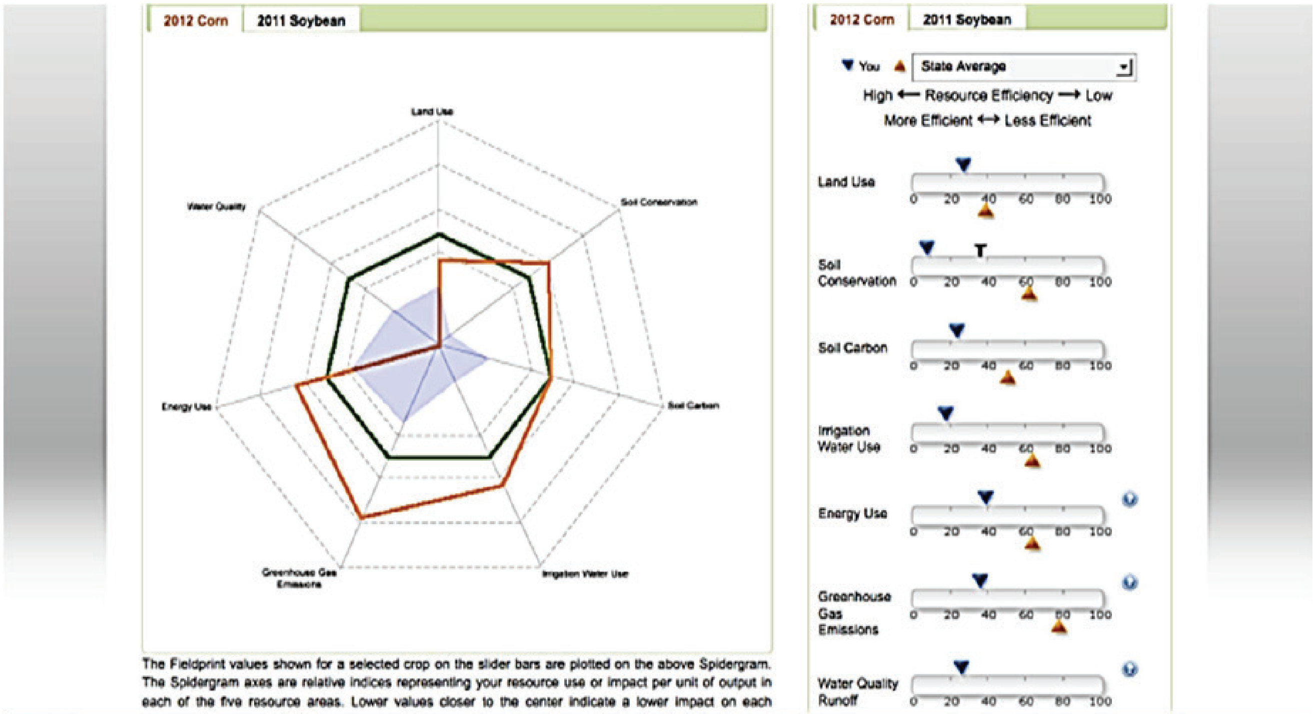
(Partners: Farmers, TNC, WWF, NRCS, FtM, CSU, MSU, Walmart, etc.)

Treatment Wetlands

VRI

No-Till Farming

Innovative Tool - Fieldprint Calculator



Field Print Calculator is a handy "farmer recruiting tool". Fieldprinting helps producers' farm management decision-making to ultimately increase agricultural efficiency, water quality and source water quantity protection across the watershed

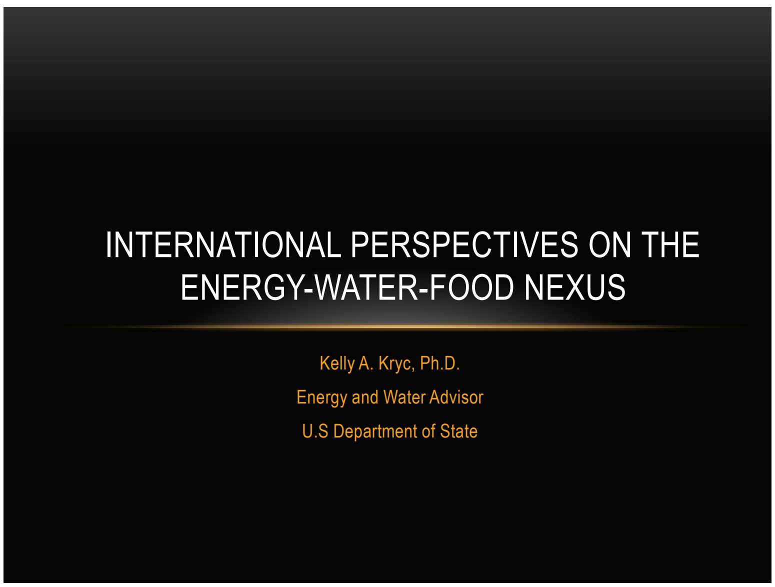
Preliminary Results from Nexus Case Study on Corn

- Lessons Learned from Nexus Approach
  - Need multiple stakeholders – understand common goals
  - Pilot scale to wide-spread adoption
  - Incentives
  - Need long-term vision
- Identified Gaps
  - Not all sectors are engaged
  - Government policies/subsidies don't align with sustainability strategies and goals
  - Lack of public engagement/understanding – more data?
- Contribution of Corporate Sector
  - Influence supply chain
  - Leverage political clout
  - Influence peer companies
  - Communicate to consumers
- Global Application
  - Technology transfer

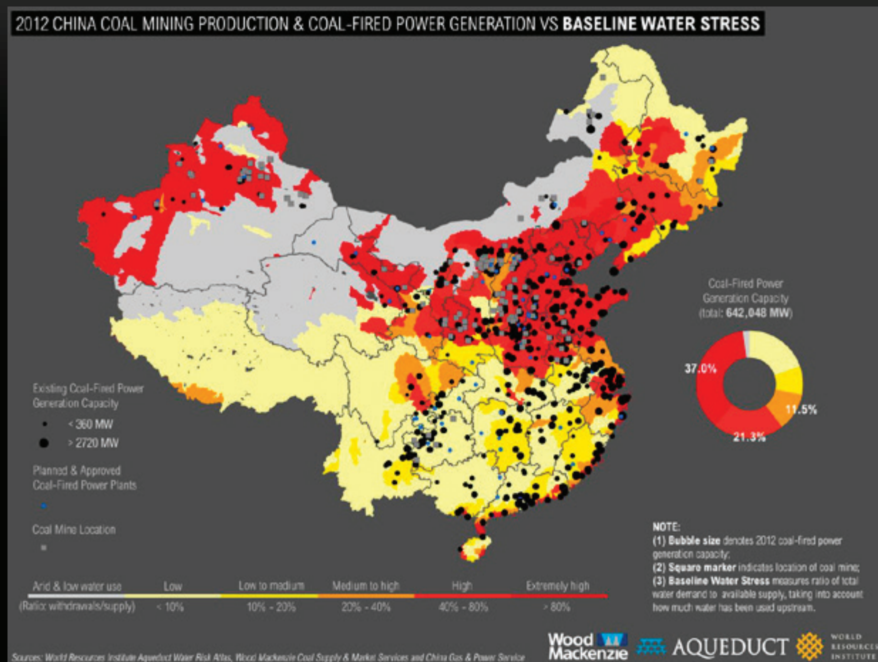
2. International Perspectives on the Energy-Water-Food Nexus

Presented by Kelly A. Kryc, Energy and Water Advisor, U.S Department of State

The energy-water nexus is an important issue for the United States domestically and internationally as we strive to strike a balance between energy access and supply and sustainable development of our natural resources. By 2050, 80% more energy, 55% more water, and 60% more food will be required to supply population demands. To overcome this global challenge, governments and industry should work together and use innovative technologies and policies and also share experiences in what works and what doesn't. Solving the problem requires new ways of cooperating and coordinating across sectors from local to international scales. Sufficient data acquisition, technology development and employment, increased synergies, and incentivizing conservations are keys to solve the problems associated with this global challenge. We need to better understand the problem, the connections, and the impacts by generating, using, and openly sharing improved sources of data. We can implement existing, innovative, off-the-shelf technologies that promote energy and water efficiency, use non-traditional sources of water for energy production and generation, or create water and energy from waste. Energy and water decision-makers must work together to ensure that decisions made by one sector don't impact the other. We can help by strengthening institutions and establishing mechanisms for joint planning and development across sectors. Incentives are an effective tool to encourage conservation of water and energy. We can start working to create policy and regulatory frameworks that strengthen local capacity and enable businesses to serve as a catalyst for change.



CHINA



UNITED ARAB EMIRATES

MORE WITH LESS

- The energy/water nexus is an important issue for the United States domestically and internationally as we (and others) strive to strike a balance between energy access and supply and sustainable development of our natural resources.
- By 2050, there will be 9 billion people on earth requiring 80% more energy, 55% more water, and 60% more food than today.
- This is a global challenge, but there are solutions.
- Governments and industry working together can overcome these challenges using innovative technologies and policies and sharing our experiences in what works and what doesn't.
- Solving the problem requires new ways of cooperating and coordinating across sectors at local, national, regional, and international scales.

NEXT STEPS

- **Get data**. We need to better understand the problem, the connections, and the impacts by generating, using, and openly sharing improved sources of data.
- **Deploy technology**. We can implement existing, innovative, off-the-shelf technologies that promote energy and water efficiency, use non-traditional sources of water for energy production and generation, or create water and energy from waste.
- **Work together.** Energy and water decision-makers must work together to ensure that decisions made by one sector don't impact the other. We can help by strengthening institutions and establishing mechanisms for joint planning and development across sectors.
- **Use incentives.** Incentives are an effective tool to encourage conservation of water and energy. We can start working to create policy and regulatory frameworks that strengthen local capacity and enable businesses to serve as a catalyst for change.

NEXT STEPS

- Internationally, the State Department is supporting nexus dialogues to share best practices that can help countries address their energy and water challenges.
- The United States is committed to finding and implementing solutions to these problems and welcomes the opportunity to partner with other governments in this effort.

CHARGE TO PARTICIPANTS

- Summarize current practices
- Identify key challenges
- Propose new methodologies to improve management and governances
- Define best practices and select case studies to communicate internationally

IUCN IWA
NEXUS DIALOGUE ON WATER INFRASTRUCTURE SOLUTIONS

7th World Water Forum 2015
Daegu & Gyeongbuk, Rep. of Korea

3. Columbia River Treaty Nexus Presentation

Presented by Jim Barton, U.S. Army Corps of Engineers, Northwestern Division, Chief, Columbia Basin Water Management Division

This case study involves the implementation of the Columbia River Treaty (Treaty) between the U.S. and Canada. The Columbia River System is a very large and diverse river system that is comprised of close to 100 different water resource projects that are operated by many different entities to achieve a number of different objectives. Approximately 15% of the basin is in Canada, but on average about 38% of the river flow originates in Canada. The U.S. and Canada signed a Treaty in 1964 that is focused on flood risk management and hydropower. This Treaty provides an excellent framework for trans-boundary governance, planning, and operations that can be used to address water and energy security.

Some of the key lessons that can be learned from this Treaty are that it: (1) provides good processes and procedures for trans-boundary water management planning and operations; (2) incorporates flexibility and advance planning to help manage the uncertainty in river operations; (3) is based on a collaborative approach with an effective governance structure and dispute resolution mechanisms that can be used if needed; and (4) incorporates shared data, models, and analysis.

For more information:

http://www.nwd-wc.usace.army.mil/PB/PEB_08/crt.htm

http://www.crt2014-2024review.gov/Default.aspx

http://www.crt2014-2024review.gov/files/10aug_hyde_treatypastfuture_finalrev.pdf

Columbia River Treaty Nexus Presentation

Jim Barton, P.E.

U.S. Army Corps of Engineers, Northwestern Division

Chief, Columbia Basin Water Management Division

Columbia River and Treaty Summary

- Large international river basin, managed for hydropower, flood risk, ecosystem, navigation, other purposes
- 15% of river basin in Canada, 38% of average river flow originates in Canada
- Very successful trans-boundary treaty between Canada and U.S. for managing Columbia River system
- Treaty focused on hydropower and flood risk management, but improves overall management for many river uses
- Treaty provides effective governance structure, planning, and operations framework

Key Lessons Learned

- Treaty provides clear water management plans and procedures: improves ability to achieve goals and objectives, reduces chances for miscommunication
- Treaty requires advance planning: reduces uncertainty about meeting future energy and water requirements, etc.
- Treaty incorporates flexibility: adaptable to changing conditions
- Treaty involves collaborative approach: encourages innovative solutions to new requirements and challenges
- Treaty utilizes effective governance structure: enables effective implementation, oversight, and issue resolution
- Treaty requires shared data, models, and analysis: ensures transparency, use of latest technology

Gaps

- Treaty primarily focused on hydropower and flood risk management, does not formally include other purposes such as ecosystem as a primary focus
- Funding available for some water resource projects in basin inadequate for increasing operating demands being placed on aging infrastructure

Contribution to Water Energy Food Nexus

- Provides good model for international water management collaboration in a complex river system
- Allows both U.S. and Canada to achieve changing energy, water, and related objectives through advance planning and analysis

Other Examples

- Pacific Northwest Coordination Agreement: Regional agreement among public and private hydropower owners in Pacific Northwest to plan and coordinate operation of their projects as if they were one utility, optimizing energy production

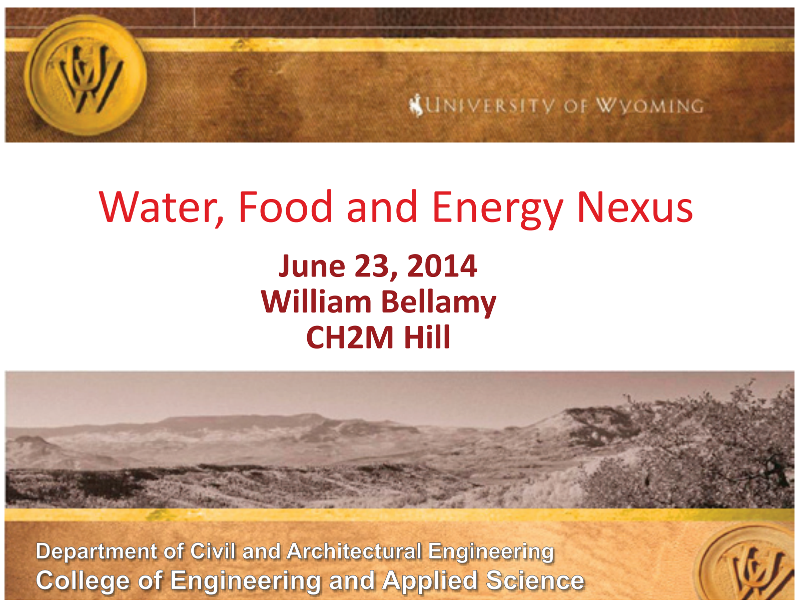
4. Water, Food, and Energy Nexus

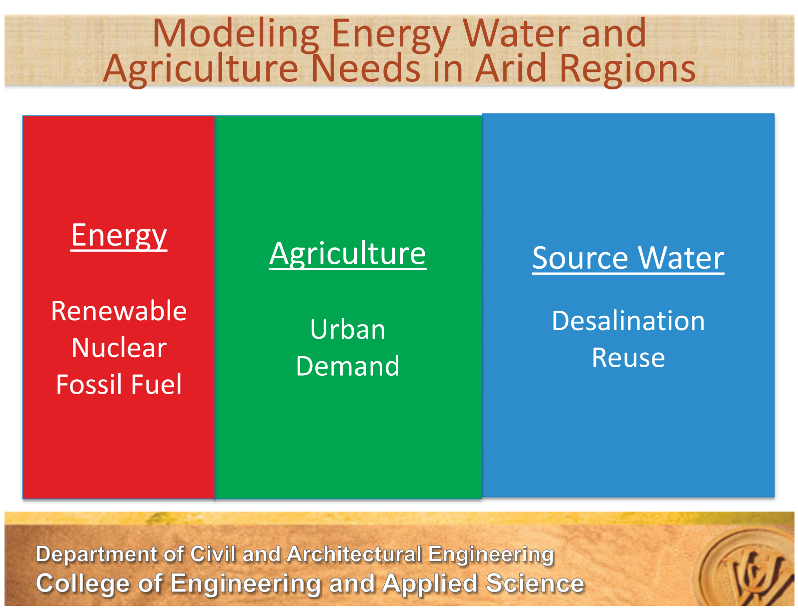
Presented by William Bellamy, Fellow and Senior Vice President of Water Technologies, CH2MHILL; Professor of Practice, University of Wyoming

This case is based on balancing water, power, and agricultural needs in Saudi Arabia. It analyzes food security based on cost of water by desalination of sea water with renewable energy, i.e. solar energy. They used an integration of salt management technologies to supply agricultural water. For water source, they used desalinated water, groundwater, treated groundwater, and treated pervaporation water. The irrigation system was equipped with standard spray or drip irrigation, and pervaporation system. They also used hydroponics to grow plants.

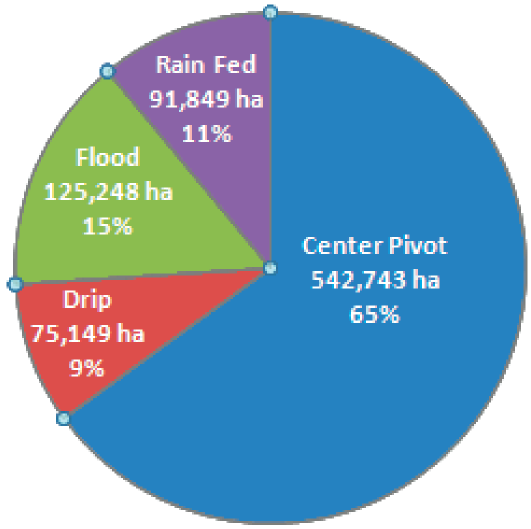
Main lessons learned from this study include:

- Each case has specific needs and different drivers that must be considered
- Dynamic simulation provides a tool to consolidate information for assessment and decisions making
- A wide range of expertise is necessary to integrate technology's involved (water, energy, ag, modeling)
- Today's technologies are effective and can be integrated into a full energy, water, food program
- Costs are high but economically achievable
- Policy and governance must lead to initiate change (e.g., secure loans, subsidies, policy changes, etc.)





Agriculture Water Use in Saudi Arabia



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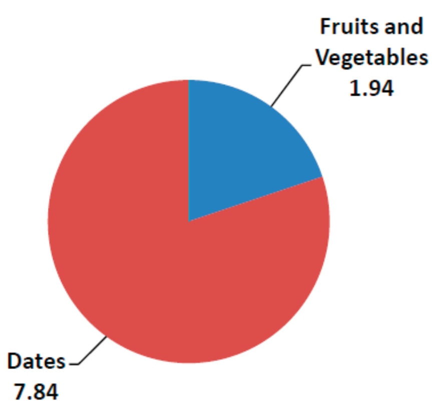
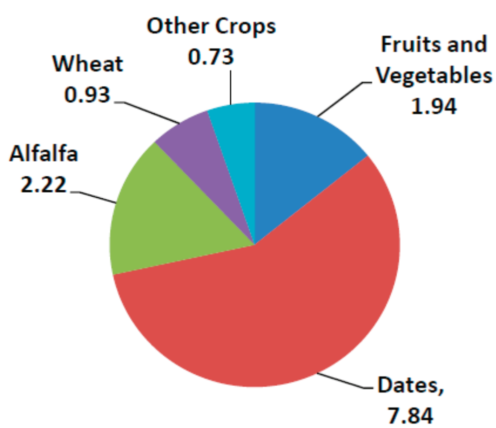
Balancing Water Power and Ag Needs in Saudi Arabia



Full Cost of Water



Subsidies Required

Analysis of food security based on cost of water
Desalination of sea water with renewable energy

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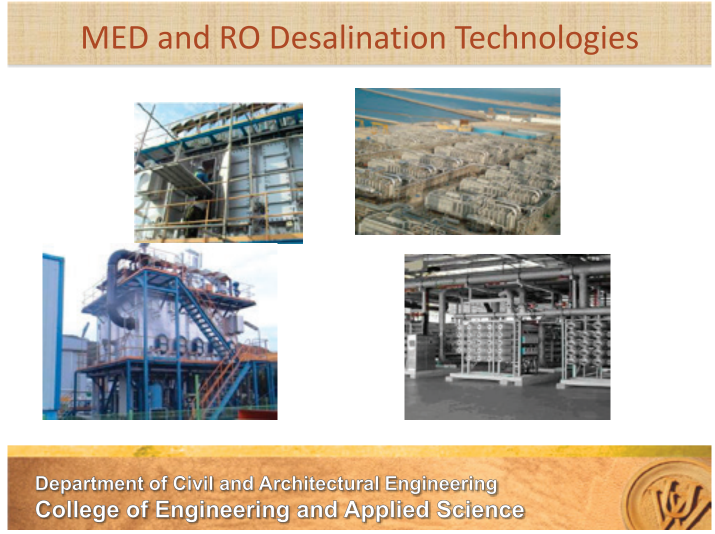
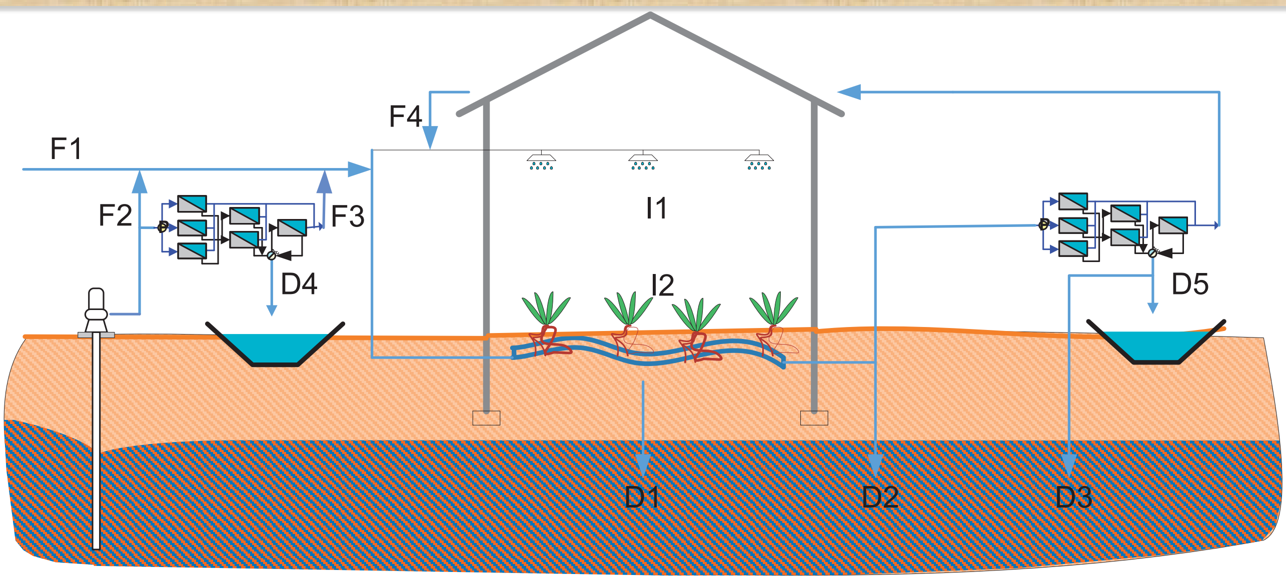


Integration of Salt Management Technologies



- Water sources
  - Desalinated water (F1)
  - Ground water (F2)
  - Treated ground water (F3)
  - Treated pervaporation water (F4)
- Irrigation waters
  - Standard spray or drip irrigation (I1)
  - Pervaporation system (I2)
- Water discharge or drain
  - Discharge from greenhouse drainage (D1)
  - Tail water from pervaporation (D2)
  - RO brine to evaporation pond (D3)
  - RO brine to evaporation pond (D4)

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Pervaporation Research with High Salinity Water – University of Wyoming

Contact: Satish Muthu, smuthu@uwyo.edu, or Dr. Jonathan Brant at UW

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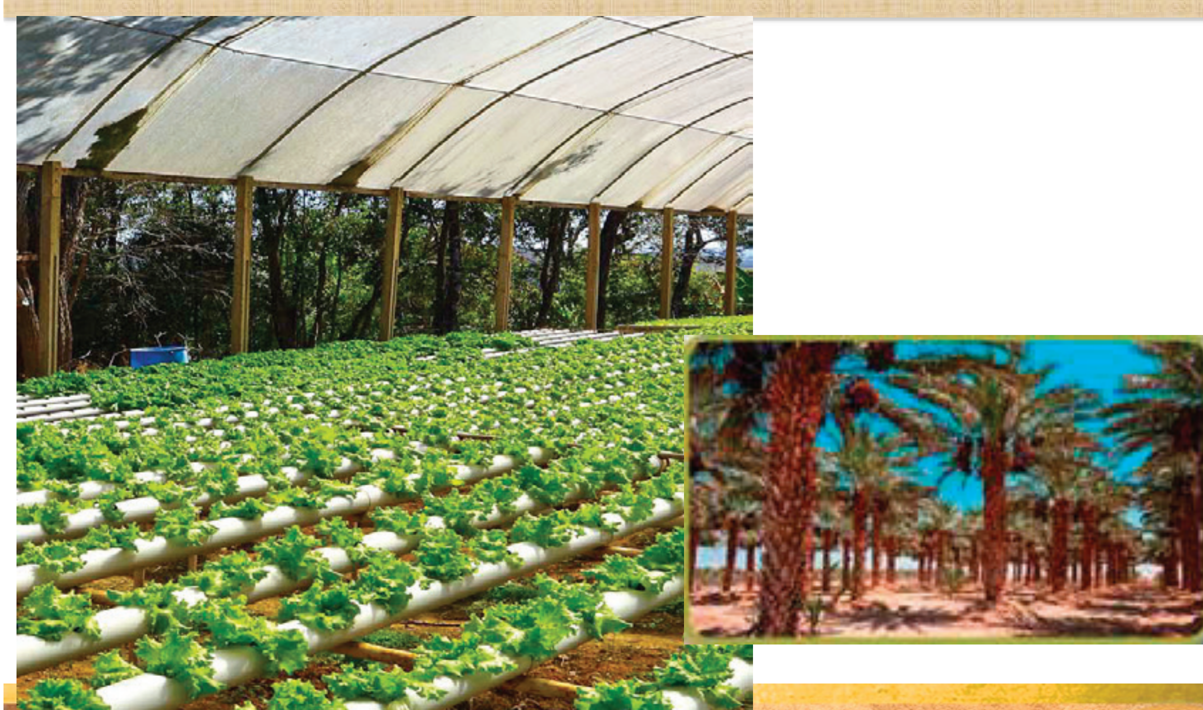
Hydroponics and drip irrigation in Saudi Arabia



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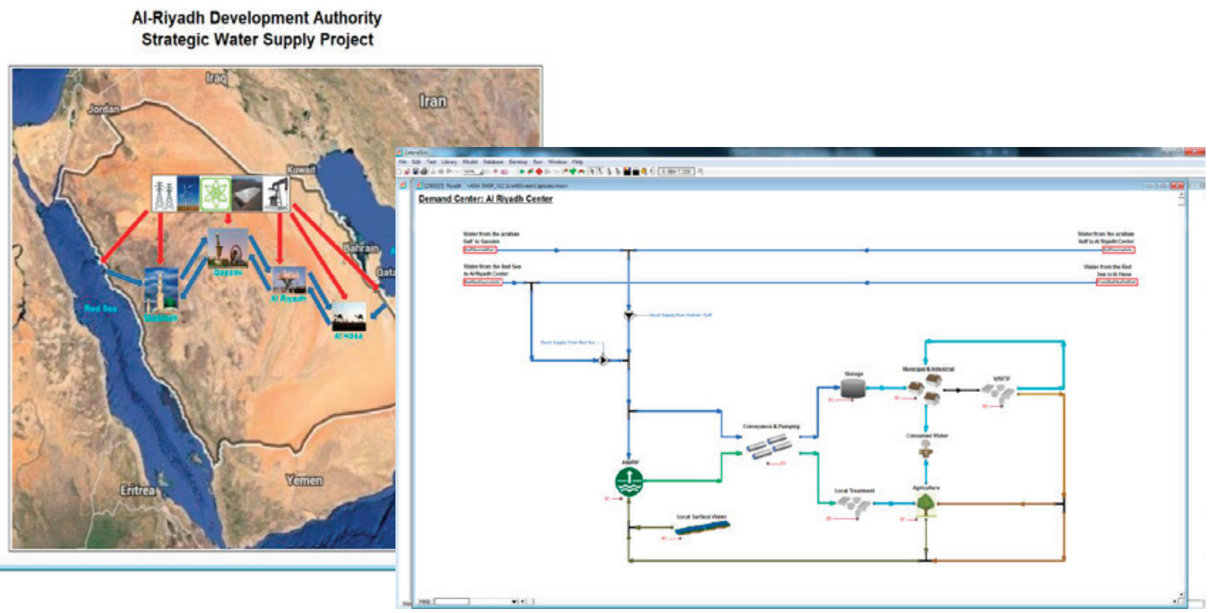
Dynamic Simulation Balancing Energy Water and Agriculture



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Lessons Learned

- Each case has specific needs and different drivers that must be considered
- Dynamic simulation provides a tool to consolidate information for assessment and decisions making
- A wide range of expertise is necessary to integrate technology's involved (water, energy, ag, modeling)
- Today's technologies are effective and can be integrated into a full energy, water, food program
- Costs are high but economically achievable
- Policy and governance must lead to initiate change (e.g., secure loans, subsidies, policy changes, etc.)

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5. Agricultural Water Conservation

To secure water supplies in stressed river basins, especially in the West, water conservation agreements have been gaining attention over the last decade. In 2008, the Western Governors' Association in their publication, Water Needs and Strategies for a Sustainable Future: Next Steps, identified that "…states, working with interested stakeholders, should identify innovative ways to allow water transfers from agriculture to urban use while avoiding or mitigating damages to agricultural economies and environmental values." In Southern California, municipalities partner with irrigation districts and pay for agricultural water conservations to use the conserved water. The conservation methods typically practiced are enhancements in irrigation delivery system, on-farm irrigation efficiency improvements, land fallowing programs, and environmental conservation [1].

Among different water conservation methods, fallowing agreements have largely been practiced in Southern California [2]. Although there are concerns that these types of agreements may ultimately result in redirecting agricultural water to the other users, in several cases, the parties have successfully become to an agreement to leave agricultural lands for fallowing and transfer the corresponding water to the municipal sector. Examples include the consensus between the Imperial Irrigation District and San Diego County Water Authority in 2003, where they agreed to transfer 200,000 acre-feet of water per year from the irrigation district for a 45-year period subject to be renewed for another 35-year period. The district must fallow agricultural lands for the first 15 years and then implement efficiency-based conservation practices [3]. Another example is the agreement between the Palo Verde Irrigation District and the Metropolitan Water District in 2004. They agreed to transfer 25,000 to 118,000 AF/year from agricultural water to urban Southern California for 35 years. This water is saved by fallowing 7% to 28% of each agricultural land [4, 5]. Yuma Mesa Irrigation and Drainage District and the Central Arizona Groundwater Replenishment District (CAGRD) have also signed a 3-year pilot agreement, effective as of January 2014, to save about 9,000 acre-feet per year water, through fallowing 1,500 acres of agricultural lands. This water will initially be used to conserve water in the Colorado River system to be maintained in Lake Mead. It is also seen as a supply acquisition strategy for groundwater replenishment by CAGRD [2]. However, while planning for agricultural water conservations, it is important to assure that these practices will not reduce crop yield, as food deficit is going to be a problem for the growing population.

For more information:

http://cwi.colostate.edu/publications/sr/22.pdf

https://wrrc.arizona.edu/arizona-land-fallowing

http://agwaterconservation.colostate.edu/

6. Constructed Treatment Wetlands

As natural water filtration systems wetlands play an important role in removing water pollutants, such as nutrients and sediments. The pollutant removal capability of wetlands would save a considerable amount of energy that would otherwise be used to treat water.

Wetlands can also help flood control and groundwater recharge. The "no net loss" wetland policy in the United States requires rebuilt of wetland destroyed for development in the same size and watershed. However, artificial wetlands require more energy.

Link(s) for more information:

http://water.epa.gov/type/wetlands/restore/cwetlands.cfm

http://www.epa.gov/owow/wetlands/pdf/ConstructedW.pdf

http://water.epa.gov/type/wetlands/constructed/upload/guiding-principles.pdf

7. Critical Infrastructure Partnership Advisory Council

The U.S. Department of Homeland Security (DHS) is responsible to protect the Nation's diverse and complex critical infrastructure. In 2006, DHS issued the National Infrastructure Protection Plan (NIPP), which was updated in 2009, as a unifying framework to integrate efforts that improve the protection of the Nation's critical infrastructure. In February 2013, Presidential Policy Directive 21: Critical Infrastructure Security and Resilience (PPD-21) was declared as: "proactive and coordinated efforts are necessary to strengthen and maintain secure, functioning, and resilient critical infrastructure—including assets, networks, and systems—that are vital to public confidence and the Nation's safety, prosperity, and well-being." NIPP is currently under revision as part of implementation of PPD-21.

The Critical Infrastructure Partnership Advisory Council (CIPAC), established by the DHS Secretary, and national critical infrastructure partnership structures aim to enable the collaboration and trusted information sharing required to enhance the protection of the Nation's critical infrastructure. CIPAC is an advisory council which promotes coordinating, communicating, and sharing effective practices across critical infrastructure sectors, jurisdictions, or specifically defined geographical areas. It values the private-sector participation in the critical infrastructure mission as an essential planning strategy. As an effective entity that has increasingly enabled cross-government and public-private partnerships, CIPAC's general achievements include [6]:

- Member institutions increased from 962 in 2012 to 1,130 in 2013.
- In 2012, 60 working groups held a total of 199 meetings and in the first half of 2013, 42 working groups held a total of 100 meetings under CIPAC. These meetings aimed for information sharing, training and exercises, research and development, program evaluation, strategic planning, risk management, and sector-specific metrics development.
- For the third year in a row, through the Regional Partnership Engagement effort, CIPAC convened more than 300 participants, representing 257 critical infrastructure owners and operators from almost all sectors. The participants discussed steps that DHS can take to better satisfy owner/operator security and resilience goals and to strengthen the value of the public-private partnership.

For more information:

http://www.dhs.gov/sites/default/files/publications/CIPAC_2013_annual_report.pdf

8. Defining, Measuring, and Improving Corn Sustainability

Presented by Jon Holzfaster, Farmer, National Corn Growers Association

Field to Market is a diverse alliance working to create opportunities across the agricultural supply chain for continuous improvements in productivity, environmental quality, and human well-being. The group provides collaborative leadership that is engaged in industry-wide dialogue, grounded in science, and open to the full range of technology choices. As part of the national Field to Market sustainability initiative, the National Corn Growers Association and its partners are working to define, measure and promote sustainability overall – including water use.

In Field to Market's first report, released early in 2009, they looked at environmental resource indicators in five areas including: water use and quality, land use and biodiversity, soil loss, energy use and climate change. This report helped establish trend in corn's impacts over the past 20 years and established a baseline for future work. In 2012, a second report was released that updated the timeframe for the measurement and included socioeconomic indicators as well. According to this report, irrigation water used per-bushel has decreased by 53% from 1980 to 2011. Volume per irrigated acre also decreased 28% during this period. Average per-acre water use (per irrigated acre) was 12.0 acre inches in 2011 compared with 16.8 acre inches in 1980.

In 2012, corn growers experienced the worst drought in years, a drought that cut four billion bushels from overall production. In spite of this, production per-acre overall was phenomenal in the states most impacted by drought. Conservation practices, precision farming and better hybrids and biotech all played a role and will continue to do so in the future.

http://www.fieldtomarket.org/news/2012/field-to-market-releases-national-report-on-agricultural-sustainability/

http://www.fieldtomarket.org/report/national-2/PNT_SummaryReport_A17.pdf

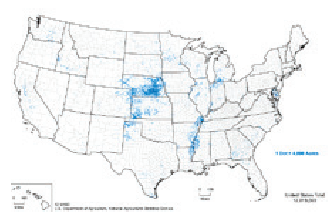
NCGA

Defining, Measuring and Improving Corn Sustainability

Jon Holzfaster, June 2014

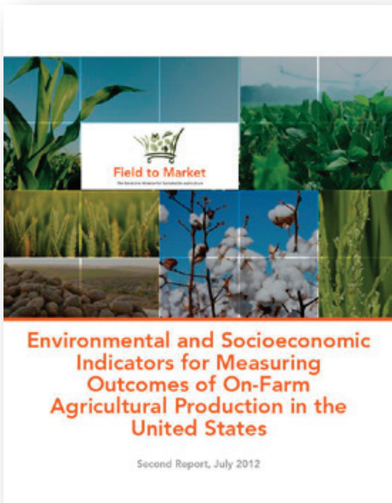
Irrigation and Corn

- Less than 15% of corn acres are irrigated.
- Irrigated corn accounts for less than 20% of total irrigated cropland acres in the United States.



- Through evapotranspiration, corn returns more water to atmosphere than is used in irrigation.

Field to Market 2012 Report

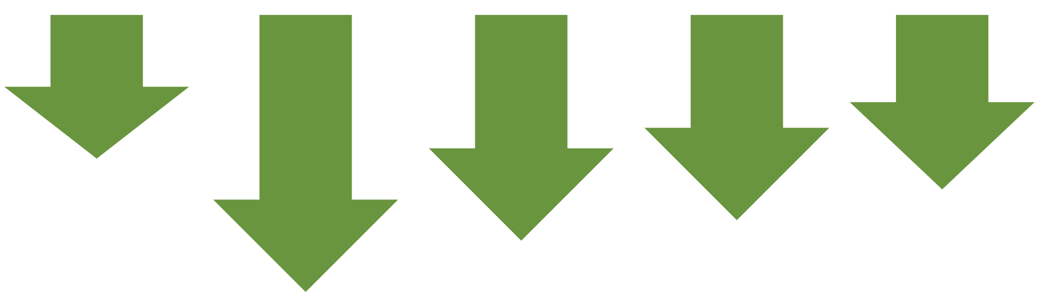


- Looked at five environmental indicators from 1980-2011
- Including irrigation
- Added specific socioeconomic indicators for the first time also

NCGA

Corn's Impacts, 1980-2011

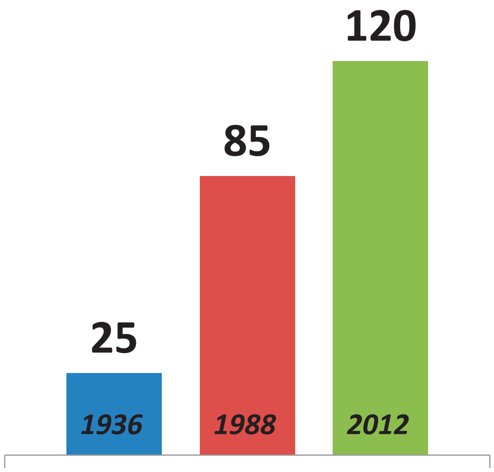
Land Use	Soil Loss	Irrigation	Energy	Climate
Amount of land to produce one bushel of corn	Soil loss per bushel, above a tolerable level	Irrigation water use per bushel	Energy used to produce one bushel	GHG emissions per bushel



30%	67%	53%	43%	36%

NCGA

Corn Growing in Times of Drought



Bushels per Acre During Similar Drought Years

In 2012, several factors helped corn farmers harvest more corn per acre compared to other bad drought years. Examples:

- Practices that are more sustainable, such as conservation tillage
- Mapping technology so farmers can meet their fields' specific challenges better
- Stronger plants due to better hybrids and biotechnology

NCGA

Improving Ethanol Production

	2012 Corn Ethanol	2008 Corn Ethanol
Yield (gallons/bushel)	**2.82**	**2.78**
Thermal Energy (Btu/gallon, LHV)	**23,862**	**26,206**
Electricity Use (kWh/gallon)	**0.75**	**0.73**
DDG Yield (dry basis) including corn oil (lbs/bu)	**15.73**	**15.81**
Corn Oil Separated (lbs/bushel)	**0.53**	**0.11**
Water Use (gallon/gallon)	**2.70**	**2.72**

NCGA

9. Energy Conservation

Energy conservation can be effectively practiced in water supply and treatment. Due to their high energy demand, enhancing and updating the technology of pumps is one of the most straightforward energy conservation options [7, 8]. In early '90s, it was estimated that 880 million kWh (30% of total use) can be saved in treatment plants by load shifting, variable frequency drives, high-efficiency motors and pumps, equipment modifications, and process optimization [7]. The energy crises in 2000 and 2001 forced a number of California water agencies to join an energy and conservation campaign. In one year, they reduced their energy use by up to 15% by employing some techniques such as: adjusting operation schedules, increasing water storage, utilizing generators, optimizing cogeneration and installing efficient water system equipment, variable frequency drives, and advanced equipment controls [7].

A range of approaches for energy savings are also emerging in the water sector. These include [9]:

- A holistic water and energy management approach to: develop local water sources instead of transferring water great distances; use advanced transport and treatment management systems; employ energy efficient water system products (e.g. premium efficiency pumps and motor systems, new types of low pressure membrane filtration, more energy efficient ultra-violet disinfection technology, advanced aeration equipment, and energy recovery systems for desalination)
- Research and development on innovative and energy efficient water treatment technologies such as: membranes to desalt at much lower pressures, with higher yields; ultraviolet disinfection with less energy demand; real-time monitoring systems for raw water quality to control and optimize instantaneous treatment process; and decentralized treatment systems to improve the water and energy use efficiency
- Behavioral changes through the incorporation of sustainability considerations and new design, management and operational philosophies
- Identify and address energy implications of water policy decisions through better coordination among resource management agencies
- Using lessons learned from other industries, such as the oil industry, in terms of exploring alternative ways of operating

For more information:

http://www.energy.ca.gov/2005publications/CEC-700-2005-011/CEC-700-2005-011-SF.PDF

http://www.gao.gov/new.items/d11225.pdf

http://www.johnsonfdn.org/sites/default/files/conferences/whitepapers/10/05/13/Johnson_Foundation_Environmental_Forum_Examining_U.S._Freshwater_Systems_and_Services_Nov16.pdf

10. Recycled Water

Water recycling has numerous benefits. It can create dependable, locally-controlled water supply, decrease the diversion of water from sensitive ecosystems, decrease wastewater discharges, reduce pollutions, enhance wetlands and riparian habitats, and save energy [10]. As the leader of other countries in terms of volume of recycled water, United States reuses 7% to 8% of its treated municipal effluent [11]. Some countries, however, have set vigorous targets to reuse their treated effluents. For example, Australia has planned to increase its water reuse to 30% by 2015. Israel currently reuses 70 percent of its municipal wastewater effluent [11]. Water reuse is rapidly growing in California [12], especially for large users in industry (refineries, agriculture), commercial irrigation facilities (golf courses), groundwater recharge, and landscaping [13]. With current recycling rate of about 500,000 AFY, the 2020 and 2030 targets of using recycled water are 1.5 and 2.5 million AFY, respectively [14]. To meet these goals, numerous projects are being funded at the federal (Bureau of Reclamation), state ($1.25 billion through the Safe, Clean and Reliable Drinking Water Act of 2010) and local (Metropolitan Water District and others) levels. The State Water Resources Control Board issued a mandate to increase wastewater reuse levels from 2009 by 200,000 AFY in 2020 and by an additional 300,000 AFY in 2030.

For more information:

http://water.epa.gov/infrastructure/drinkingwater/pws/

http://www.epa.gov/region9/water/recycling/brochure.pdf

http://www.water.ca.gov/groundwater/casgem/

http://water.epa.gov/infrastructure/drinkingwater/pws/

11. Recycling Materials

In 2009, 34% of waste generated in the United States was recovered. It included recycling 25% of all electronics at the end of their useful lives, 25% of all produced glass, 7.1% of all plastics, 28% of all plastic bottles, and 66.2% of all steel containers produced. With the highest recycling rate, more than 50% of the steel produced in this country over the past 50 years has been recycled [15]. In addition, in 2010, 58.1% of all aluminum beverage cans and 63.5% of U.S. papers (89% increase since 1990) were recycled [15].

Recycling aluminum also creates 97% less water pollution than making new metal from ore [16]. The energy that is saved by not producing one aluminum can be used to recycle twenty cans. In 2010, an energy equivalent of 17 million barrels of crude oil was saved in the U.S. just from recycling cans [15]. Forty percent less energy is consumed by producing recycled paper rather than producing new paper, and 84% energy can be saved by manufacturing recycled PET instead of making it from raw material. Recycling steel may also consume 60% to 74% less energy than producing it from virgin materials [15].

For more information:

http://www.kab.org/site/PageServer?pagename=recycling_facts_and_stats

http://www.cancentral.com/funFacts.cfm

12. Research Implications for Decision Making at the Energy-Water Nexus

Presented by Kristen Averyt, Associate Director for Science, Cooperative Institute for Research in Environmental Sciences; Former Director of the Western Water Assessment, University of Colorado at Boulder

Electricity sector is responsible for about 35% of total US GHG emissions, 41% of total withdrawals, and 5% of total consumptive use. On the other hand, water sector accounts for approximately 13% of the US electricity supply. Main water challenges of the energy sector include insufficient water availability, too warm incoming and outgoing water. While the West is currently experiencing water stress due to lifecycle energy intensity of water, exacerbated situations are projected in the future (2041-2060) and water stress will spatially be expanded to the Midwest and to some extent to the East. As for the future, projected changes in water stress will simply be as a function of climate driven changes to water supplies. As populations grow and environmental requirements become more stringent, demand for electricity at drinking water and wastewater utility plants is expected to grow by approximately 20%. It is critical to assure the water security of energy generation due to climate change and population growth. During planning, not just short-term, but long-term water availability for energy generation should be taken into account. Other main concerns that need to be addressed include:

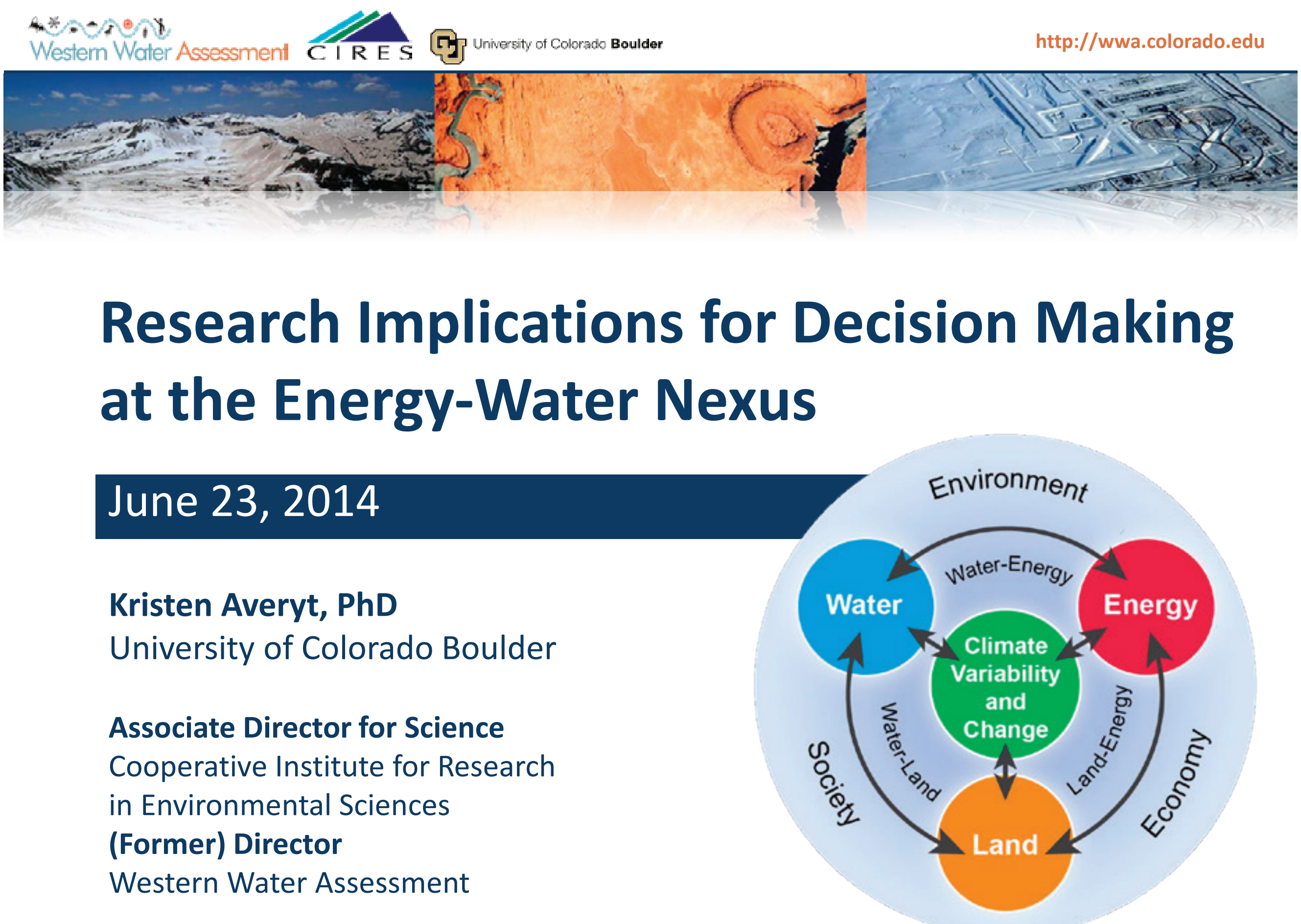
- Are power plants resilient to future extreme weather?
- Will there be enough power to get clean water where it needs to be when it needs to be there?
- Do we have enough data with acceptable quality?

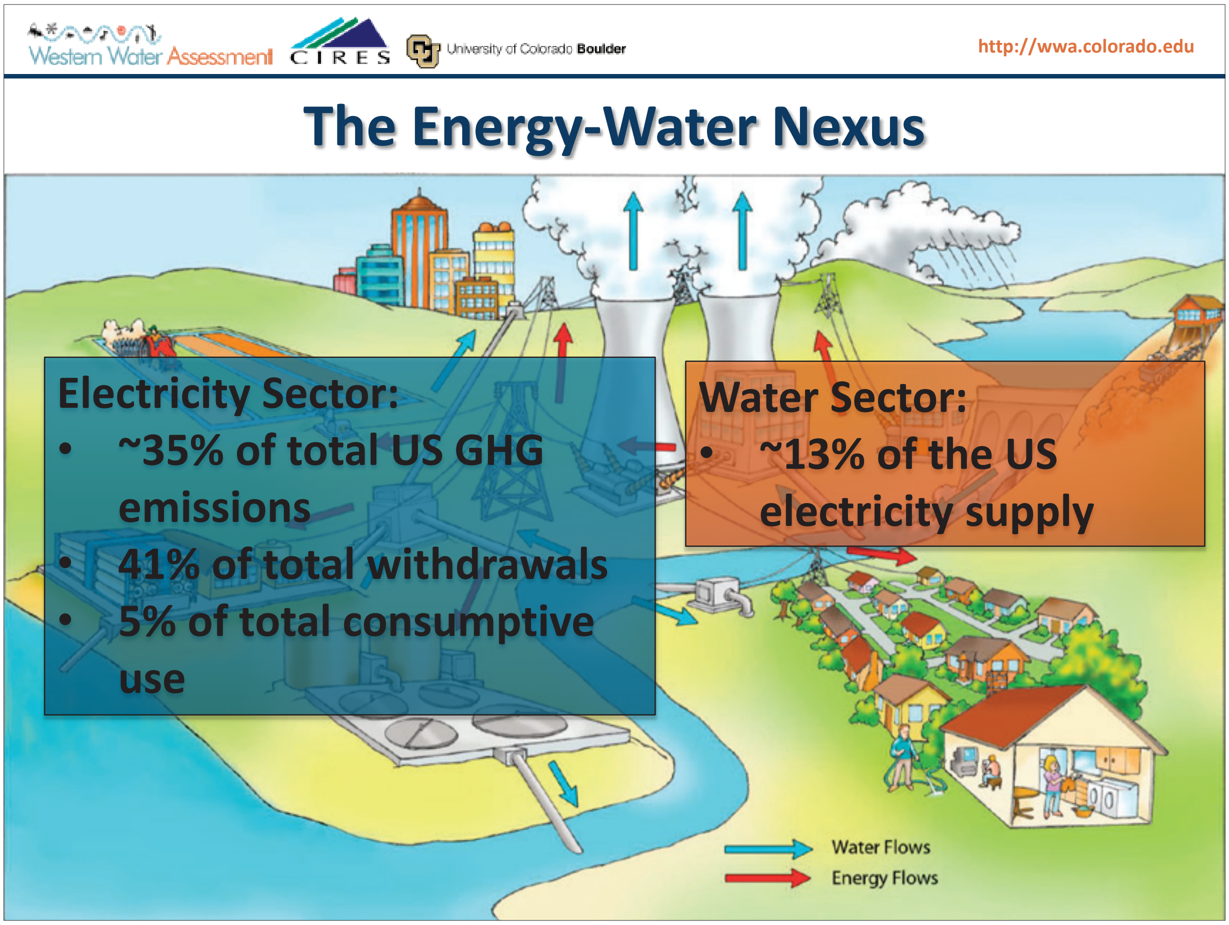
For more information:

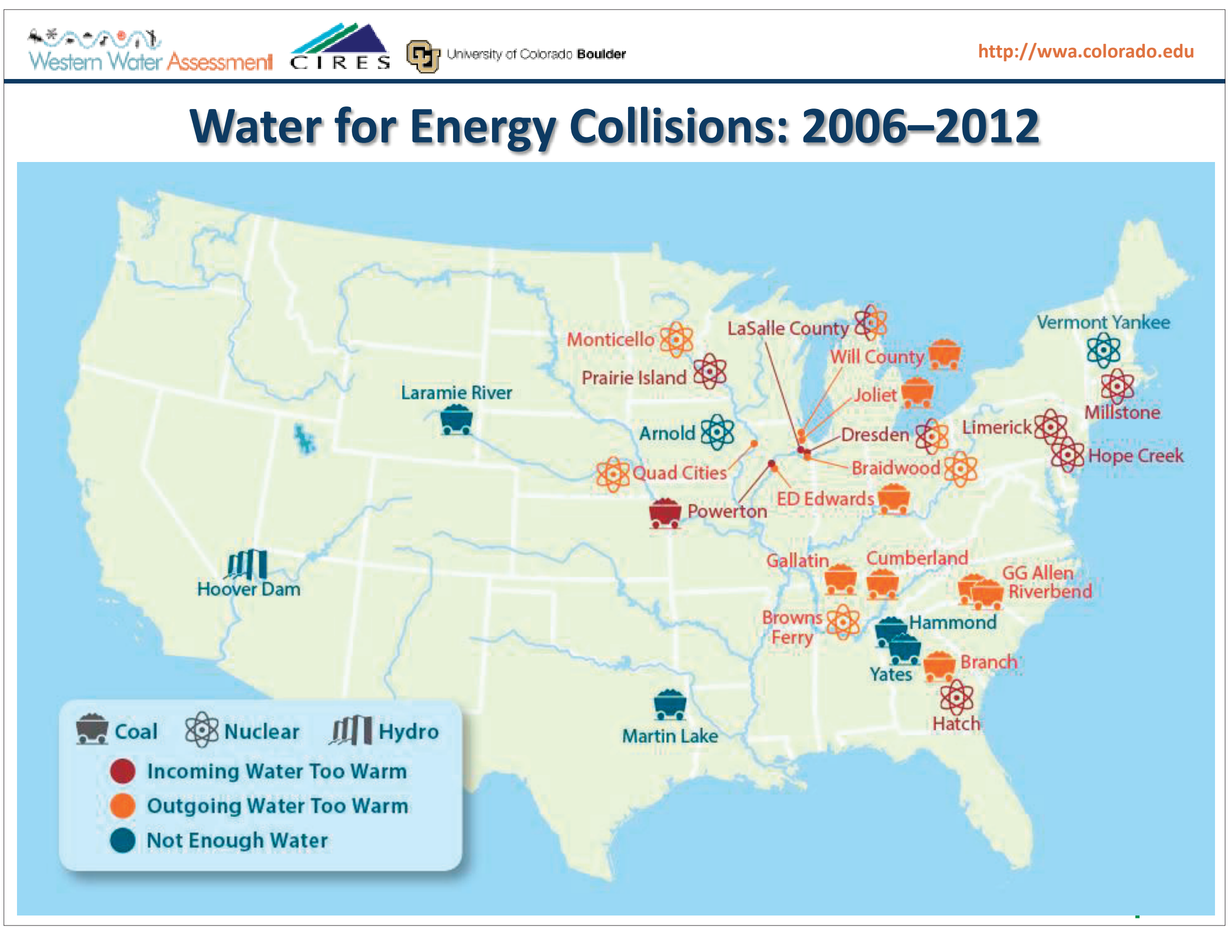
http://iopscience.iop.org/1748-9326/8/3/035046/pdf/1748-9326_8_3_035046.pdf

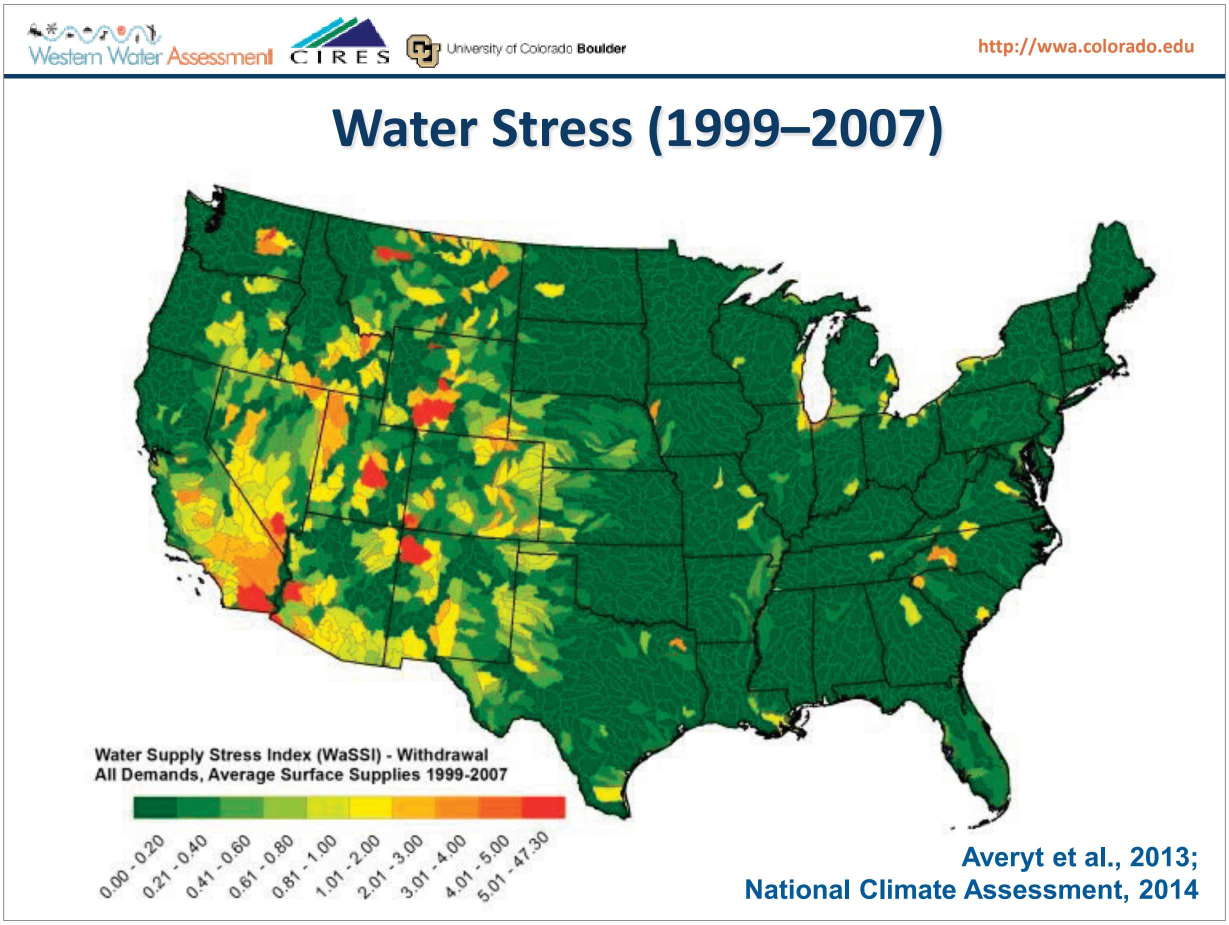
http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-21185.pdf

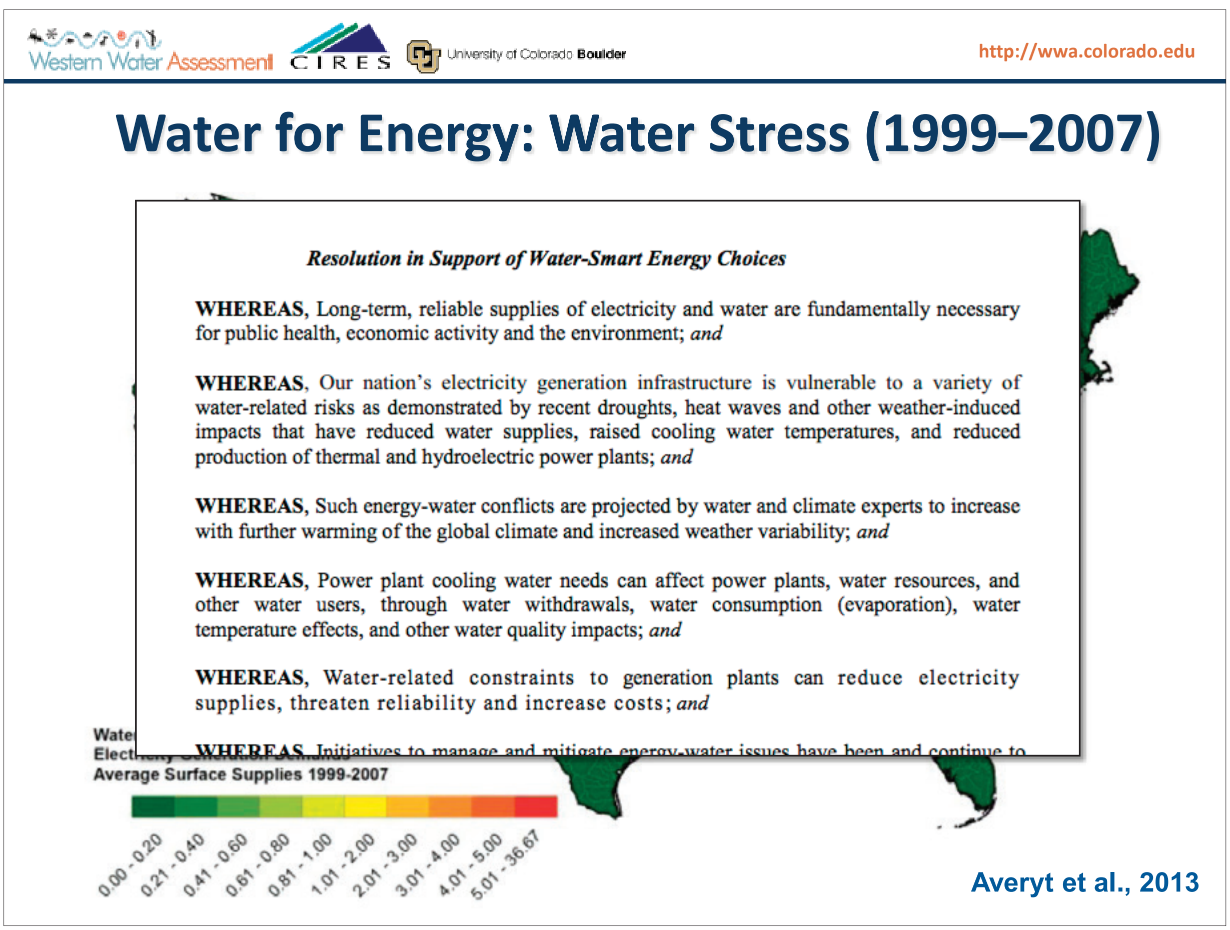
http://iopscience.iop.org/1748-9326/8/1/015001/pdf/1748-9326_8_1_015001.pdf




Western Water Assessment
CIRES
University of Colorado Boulder
http://wwa.colorado.edu
The Energy-Water Nexus
Electricity Sector:
• ~35% of total US GHG emissions
• 41% of total withdrawals
• 5% of total consumptive use
Water Sector:
• ~13% of the US electricity supply
Water Flows
Energy Flows


Western Water Assessment
CIRES
University of Colorado Boulder
http://wwa.colorado.edu
Water for Energy Collisions: 2006–2012
Monticello
LaSalle County
Will County
Vermont Yankee
Prairie Island
Joliet
Millstone
Laramie River
Arnold
Dresden
Limerick
Hope Creek
Quad Cities
Braidwood
Powerton
ED Edwards
Gallatin
Cumberland
GG Allen
Riverbend
Hoover Dam
Browns Ferry
Hammond
Yates
Branch
Hatch
Martin Lake
Coal
Nuclear
Hydro
Incoming Water Too Warm
Outgoing Water Too Warm
Not Enough Water





Resolution in Support of Water-Smart Energy Choices

WHEREAS, Long-term, reliable supplies of electricity and water are fundamentally necessary for public health, economic activity and the environment; *and*

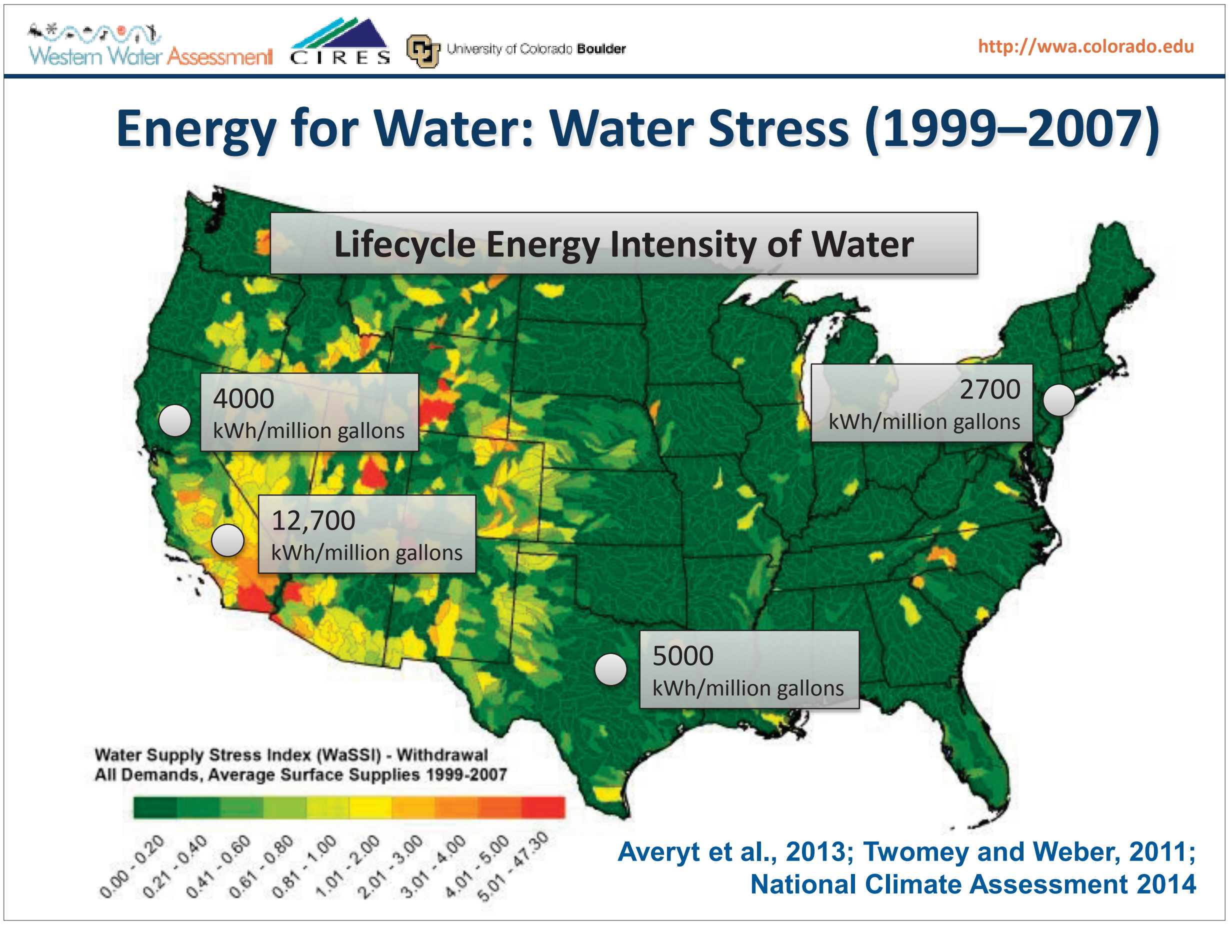
WHEREAS, Our nation's electricity generation infrastructure is vulnerable to a variety of water-related risks as demonstrated by recent droughts, heat waves and other weather-induced impacts that have reduced water supplies, raised cooling water temperatures, and reduced production of thermal and hydroelectric power plants; *and*

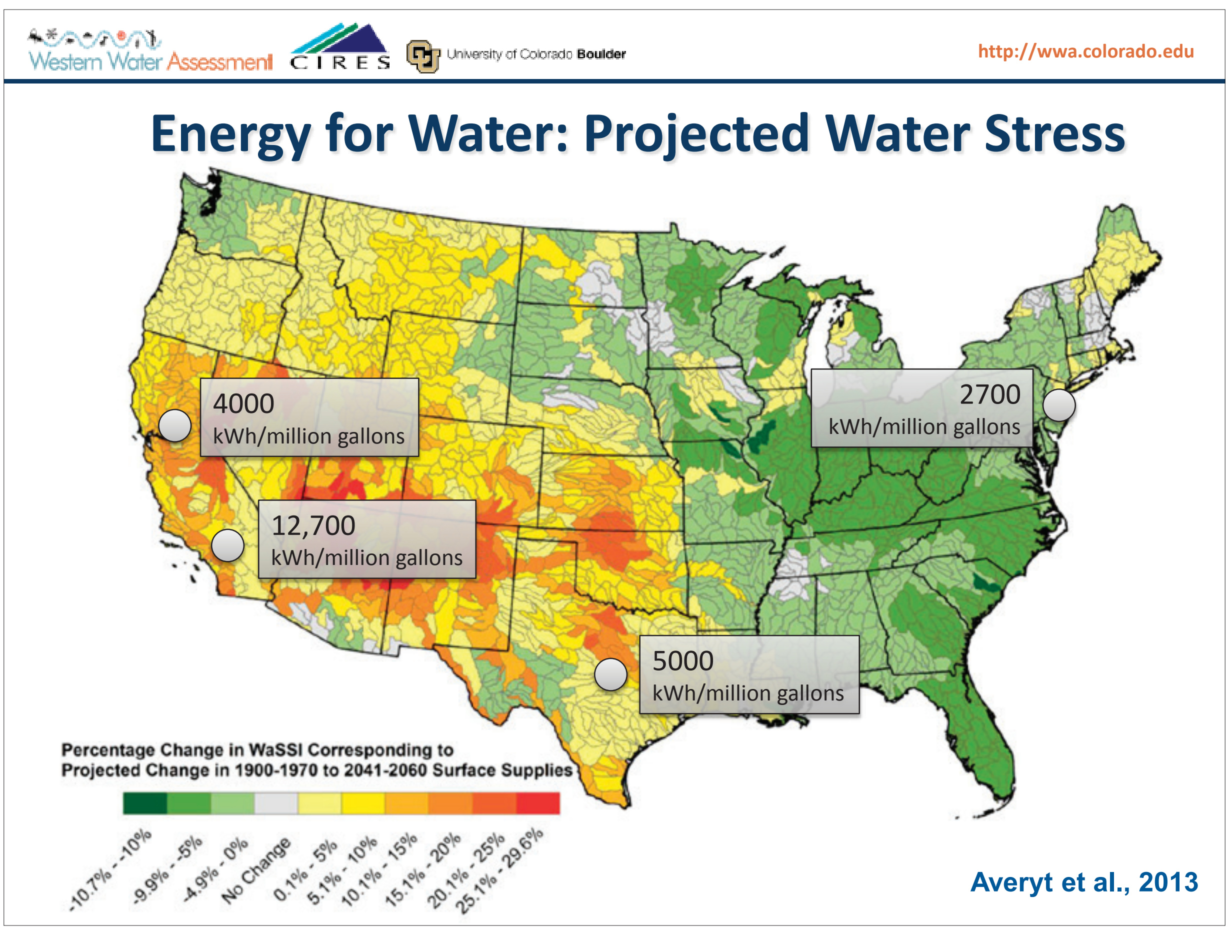
WHEREAS, Such energy-water conflicts are projected by water and climate experts to increase with further warming of the global climate and increased weather variability; *and*

WHEREAS, Power plant cooling water needs can affect power plants, water resources, and other water users, through water withdrawals, water consumption (evaporation), water temperature effects, and other water quality impacts; *and*

WHEREAS, Water-related constraints to generation plants can reduce electricity supplies, threaten reliability and increase costs; *and*

WHEREAS, Initiatives to manage and mitigate energy-water issues have been and continue to

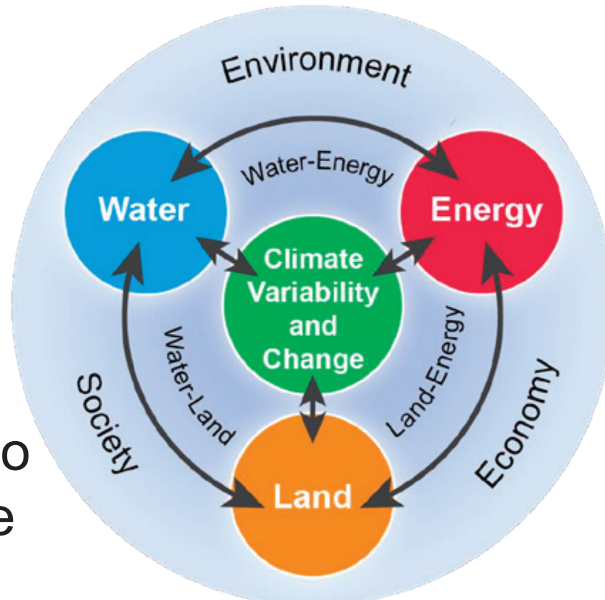

Western Water Assessment
CIRES
University of Colorado Boulder
http://wwa.colorado.edu
Energy for Water: Water Stress (1999–2007)
Lifecycle Energy Intensity of Water
4000
kWh/million gallons
12,700
kWh/million gallons
2700
kWh/million gallons
5000
kWh/million gallons
Water Supply Stress Index (WaSSI) - Withdrawal
All Demands, Average Surface Supplies 1999-2007
0.00 - 0.20
0.21 - 0.40
0.41 - 0.60
0.61 - 0.80
0.81 - 1.00
1.01 - 2.00
2.01 - 3.00
3.01 - 4.00
4.01 - 5.00
5.01 - 47.30
Averyt et al., 2013; Twomey and Weber, 2011;
National Climate Assessment 2014


Western Water Assessment
CIRES
University of Colorado Boulder
http://wwa.colorado.edu
Energy for Water: Projected Water Stress
4000
kWh/million gallons
12,700
kWh/million gallons
2700
kWh/million gallons
5000
kWh/million gallons
Percentage Change in WaSSI Corresponding to
Projected Change in 1900-1970 to 2041-2060 Surface Supplies
-10.7% - -10%
-9.9% - -5%
-4.9% - 0%
No Change
0.1% - 5%
5.1% - 10%
10.1% - 15%
15.1% - 20%
20.1% - 25%
25.1% - 29.6%
Averyt et al., 2013

Western Water Assessment CIRES University of Colorado Boulder http://wwa.colorado.edu

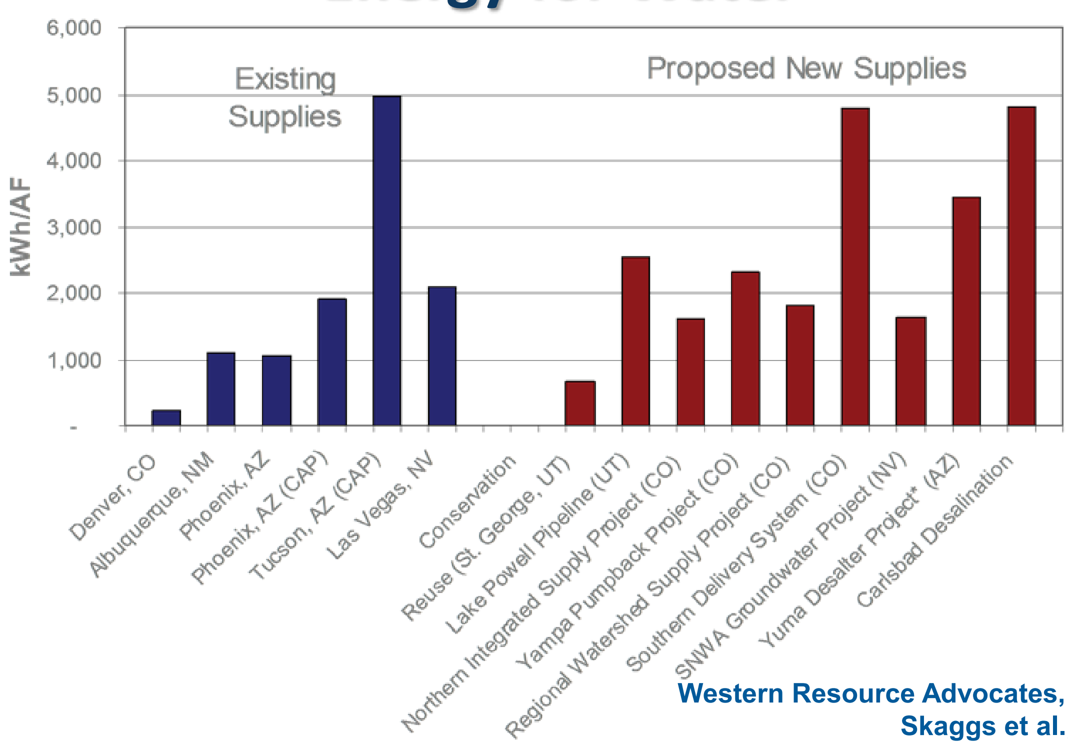
Are power plants resilient to future extreme weather?

Will there be enough power to get clean water where it needs to be when it needs to be there?



Western Water Assessment CIRES University of Colorado Boulder http://wwa.colorado.edu

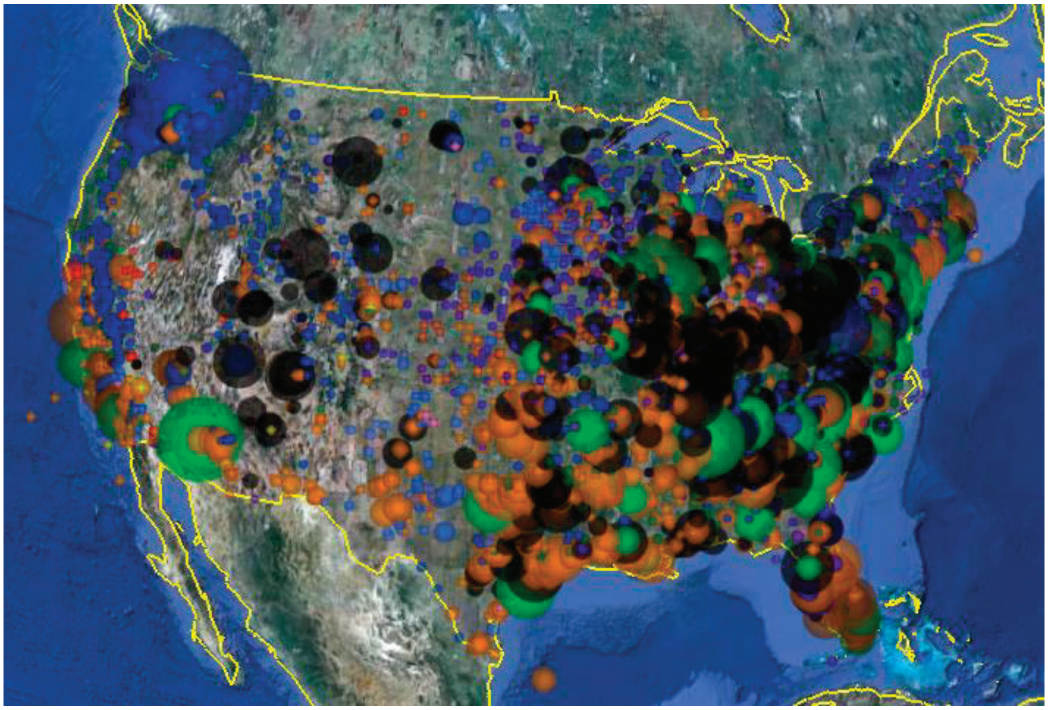
Energy for Water



Western Resource Advocates, 2011; Skaggs et al., 2012

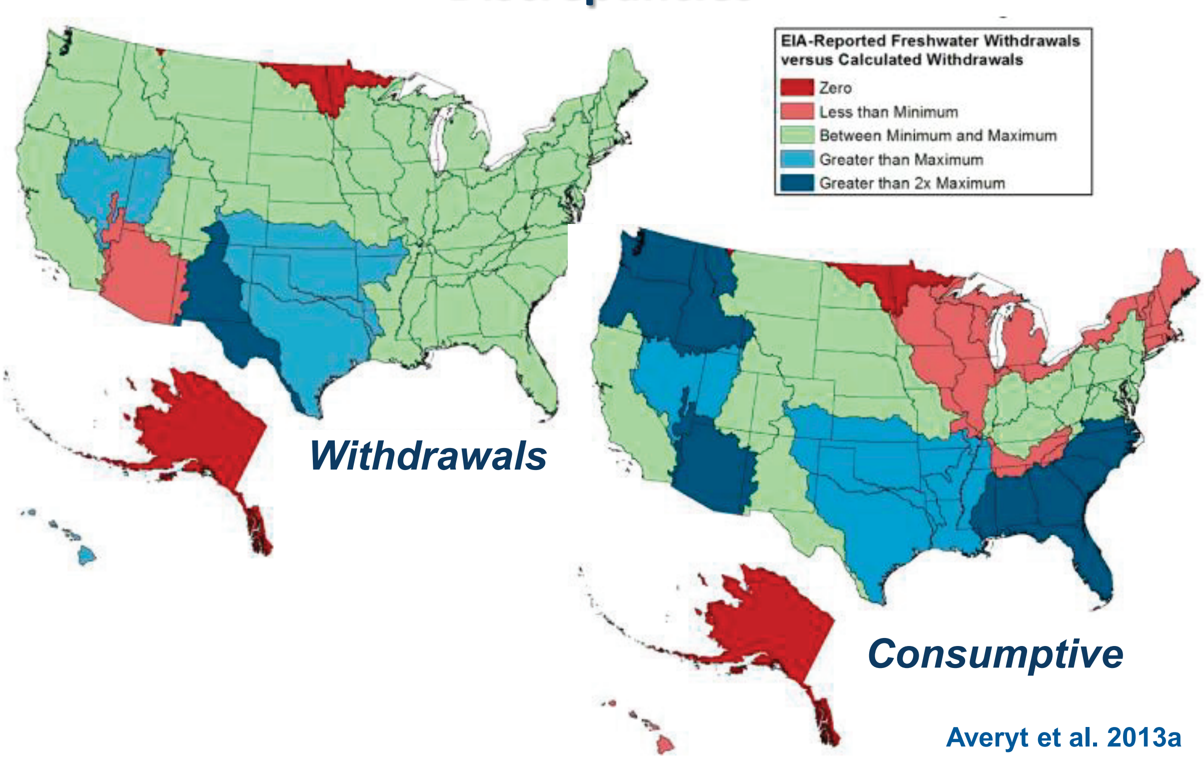
Western Water Assessment CIRES University of Colorado Boulder http://wwa.colorado.edu

Water for Energy: Poor…no, TERRIBLE data



Western Water Assessment CIRES University of Colorado Boulder http://wwa.colorado.edu

Discrepancies



Averyt et al. 2013a

13. Green Infrastructure

Natural ecosystems have the capability of cleaning water without using any energy. These systems can be seen as an energy-efficient treatment option. For this purpose, protected areas need to be maintained and used to help avoid significant costs and associated energy demands of traditional treatment works [17, 18]. New York City (Catskills region), San Francisco (Hetch Hetchy) and Portland, Oregon (Bull Run) currently take advantage of these systems and rely on watershed protection and management for their potable supply treatment [13, 19].

For more information:

http://water.epa.gov/type/wetlands/methods_index.cfm

http://waterinthewest.stanford.edu/sites/default/files/Water-Energy_Lit_Review.pdf

http://www.ncbi.nlm.nih.gov/pubmed/17195871

http://pubs.acs.org/doi/abs/10.1021/es071594%2B

14. The NEXUS and the Inland Navigation System

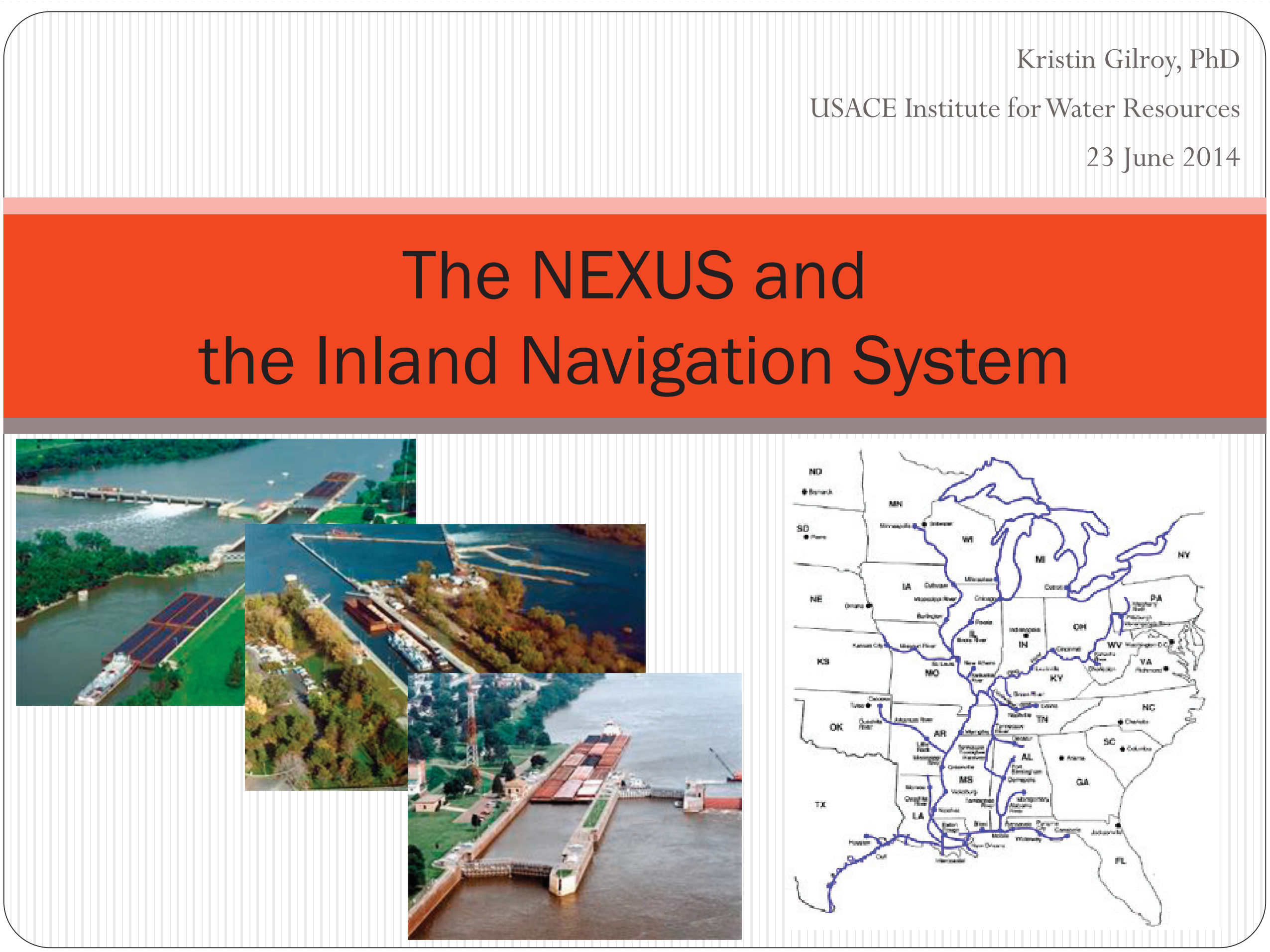
Presented by Kristin Gilroy, Institute for Water Resources, US Army Corps of Engineers

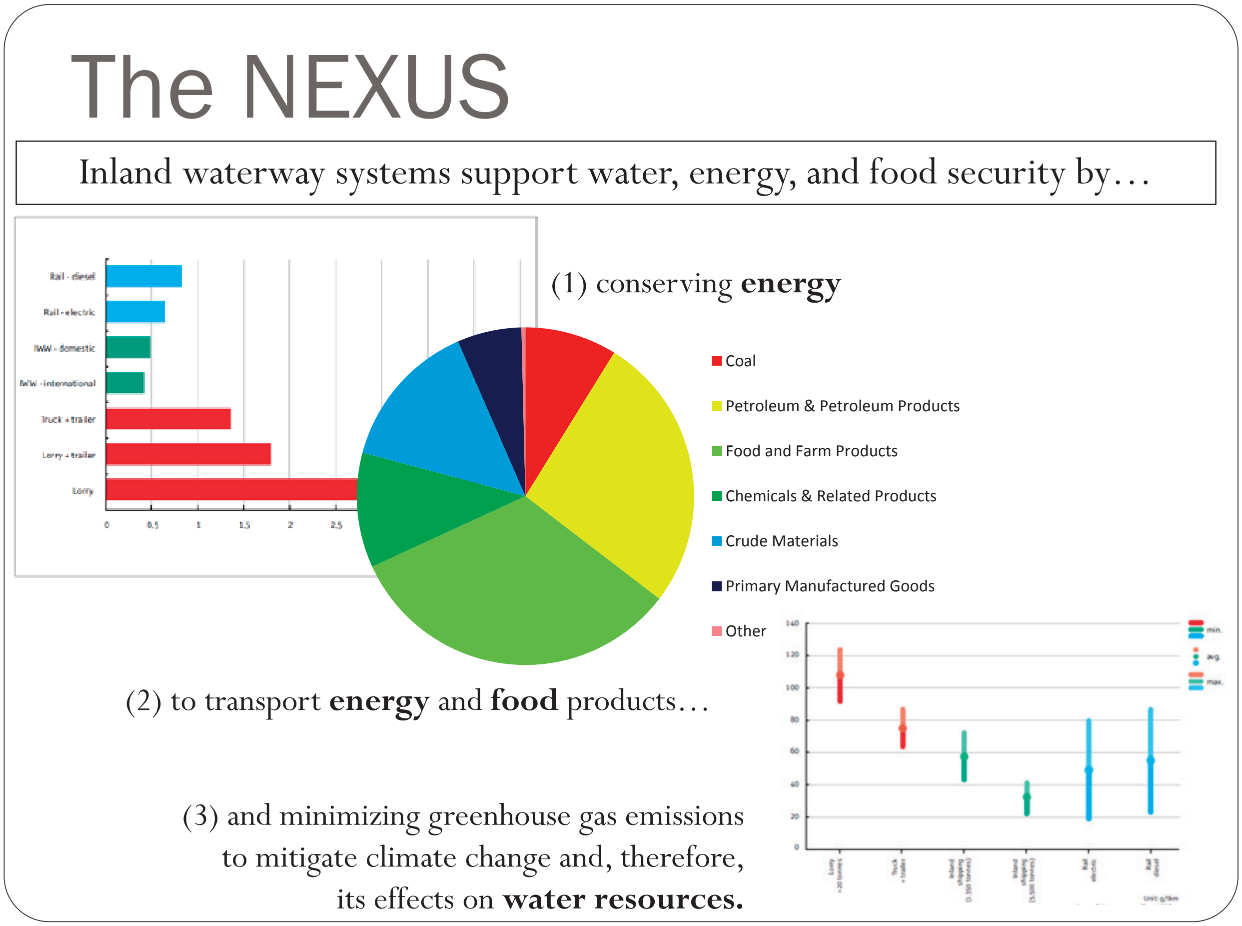
Inland waterway systems support water, energy, and food security by conserving energy during food and energy transportation and therefore by minimizing greenhouse gas emissions. Floods, droughts, and infrastructure failures threaten the function of these systems, which may result in consequences such as stockpiled products, ceased operations, switched to overland mode, and altered production to shippers as well as delay costs, lost revenue, and logistical expenses to carriers. Appropriate uses of governance, technology, and financing methods are required to operate and maintain a reliable navigation system.

Proper governance should balance uses between navigation, water supply, hydropwer, flood risk management, and the environment across states and countries. International Joint Commission makes decisions on applications for projects, such as dams and diversions that affect the natural level and flow of water across the boundary. Changing water levels can affect drinking water intakes, commercial shipping, hydroelectric power generation, agriculture, shoreline property, recreation, fisheries, wildlife, wetlands and other interests. Technology can be used for planning. Decision-making support tools can be developed to plan operations and maintenance, e.g. operating reservoirs in series to meet multi-objectives. In addition, technology can be used to enhance equipment, e.g. sliding gates to minimize unplanned outages, etc. Financing influences the reliability of infrastructure component. The challenge associated with financing is to come up with a way to manage system of deteriorating infrastructure without increasing the budget. Some solutions could be to develop watershed-based budgeting plans, and to share risks and revenues with private sector along the inland waterways system, would likely still require an increase in taxes to create revenue for private sector.

For more information:

http://www.corpsnets.us/docs/other/05-NETS-R-12.pdf



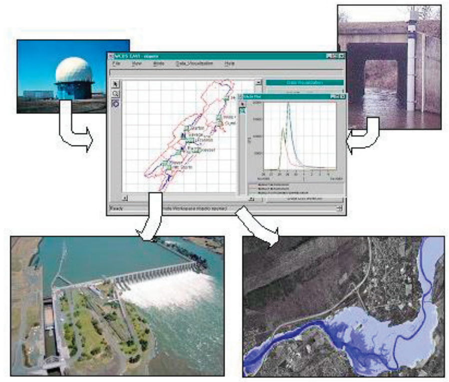

The NEXUS
Inland waterway systems support water, energy, and food security by…
(1) conserving **energy**
Rail - diesel
Rail - electric
IWW - domestic
IWW - international
Truck + trailer
Lorry + trailer
Lorry
Coal
Petroleum & Petroleum Products
Food and Farm Products
Chemicals & Related Products
Crude Materials
Primary Manufactured Goods
Other
(2) to transport **energy** and **food** products…
(3) and minimizing greenhouse gas emissions to mitigate climate change and, therefore, its effects on **water resources.**

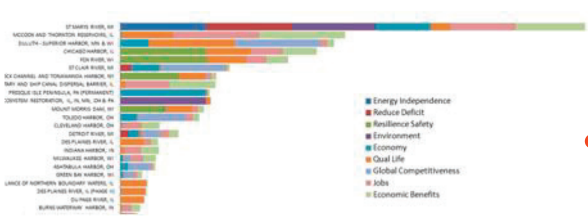

2008 Closure of Upper Mississippi River
Upper Mississippi River System
MINNESOTA
MISSOURI
Major flood event caused closures from June 14- July 5
Communication between **public and private sector**
were essential to minimize effects
Threats to the success of the system:
Floods, Droughts , and Infrastructure Reliability (i.e., failures)
We need to combine appropriate use of **governance**, **technology,** and **financing methods** to **operate** and **maintain** a reliable system


Governance
Interstate
Mississippi River Basin Commission formed in 1879
Congress charged the MRC with the mission to develop plans to improve the condition of the Mississippi River, foster navigation, promote commerce, and prevent destructive floods
Today's mission is to lead sustainable management and development of water related resources for the nation's benefit and the people's well-being
International
Boundary Waters Treaty (1909)
Provides general principles for preventing and resolving transboundary water issues
International Joint Commission (1912)
Regulate shared water uses
Investigate transboundary issues & recommend solutions
2007 IJC Great Lakes Study
To update 30-yr old regulation plan for outflows to meet all water use objectives
http://www.mvd.usace.army.mil/About/MississippiRiverCommission(MRC).aspx
http://ijc.org/en_/IJC_History

Technology

- Systems modeling through Corps Water Management System (CWMS)
- World Association for Waterborne Transport Infrastructure (PIANC)



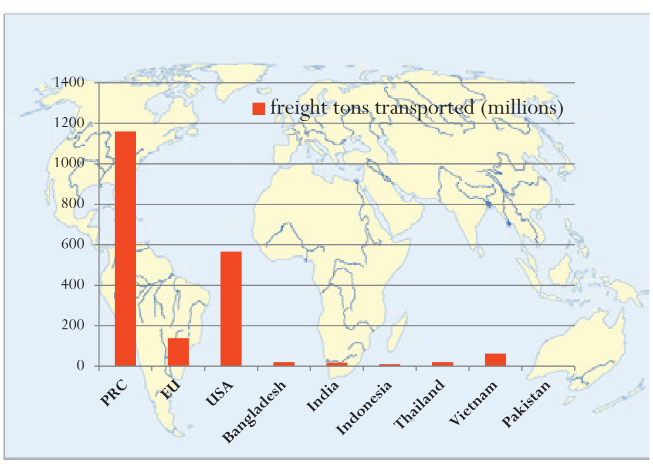


Financing

- Challenge: How to manage system of deteriorating infrastructure without increasing the budget?
- Potential Solutions
  - Public-Private Partnerships
  - Watershed based budgeting

International Applications

Inland waterways are under utilized in many developing countries, which constrains economic growth



The United States can assist through

- Governance
  - Mekong River Basin and Mississippi River Basin Commission Agreement
  - Shared Vision Planning Case Studies
- Technology
  - Systems modeling software and training
  - Promote involvement in PIANC
- Financing
  - Watershed based budgeting

15. Thermoelectricity Generation

Open-loop cooling facilities use substantially more water than close-loop or dry cooling facilities. In 1972, the Federal Water Pollution Control Act and Section 316(a) of the Clean Water Act, which regulate intake structures and thermal pollution discharges, established restrictions on open-loop cooling systems. It resulted in a declining trend in the construction of open-loop cooling power plants and only 10 of these plants have been built since 1980 [20]. Closed-loop cooling plants, with less water requirements, lower discharges, and less vulnerability to water shortages, have been the main substitute of open-loop system since then. Hybrid cooling technology, which uses both wet and dry cooling components that can be used either separately or simultaneously is in its early phases of development. These systems may reduce water requirements of wet systems by up to 80%, while they do not have the disadvantages of dry cooling systems. Therefore hybrid cooling technology can be seen as a promising way to secure energy generation in the future while imposing less stress on water resources.

For more information:

http://www.sandia.gov/energy-water/docs/121-RptToCongress-EWwEIAcomments-FINAL.pdf

16. Infrastructure Sustainability Policy

To promote sustainable infrastructure within the water sector, the U.S. EPA has issued its Clean Water and Drinking Water Infrastructure Sustainability Policy [21]. Guided by this policy, EPA has developed the Water Infrastructure: Moving toward Sustainability program, which provides technical support and financial resources to states to increase water and energy efficiency in water, wastewater, and stormwater infrastructure. The agency works with partners across the water sector and a broad group of stakeholders to help implement practices on three levels [22]:

- Sustainable Water Infrastructure: To sustain infrastructure that is used for the collection and distribution systems, and treatment plants in water-related services
- Sustainable Water Sector Systems: To sustain any aspect of the utilities and systems that provide water-related services
- Sustainable Communities: To promote the role of water services in extending the broader goals of the community

EPA has identified the following four key areas of action to assure sustainability of water infrastructure: asset management, water and energy efficiency, infrastructure financing and the price of water services, as well as alternative technologies and assessment. To promote and maintain sustainable water systems, EPA has two management frameworks: Effective Utility Management Initiative and the Safe Drinking Water Act's Capacity Development Program. In addition, to advance community sustainability, EPA is collaborating with the states of New York, Maryland, and California to identify ways in which projects that promote smart growth and other sustainable practices can be incentivized [22].

For more information:

http://water.epa.gov/infrastructure/sustain/Clean-Water-and-Drinking-Water-Infrastructure-Sustainability-Policy.cfm

http://water.epa.gov/infrastructure/sustain/

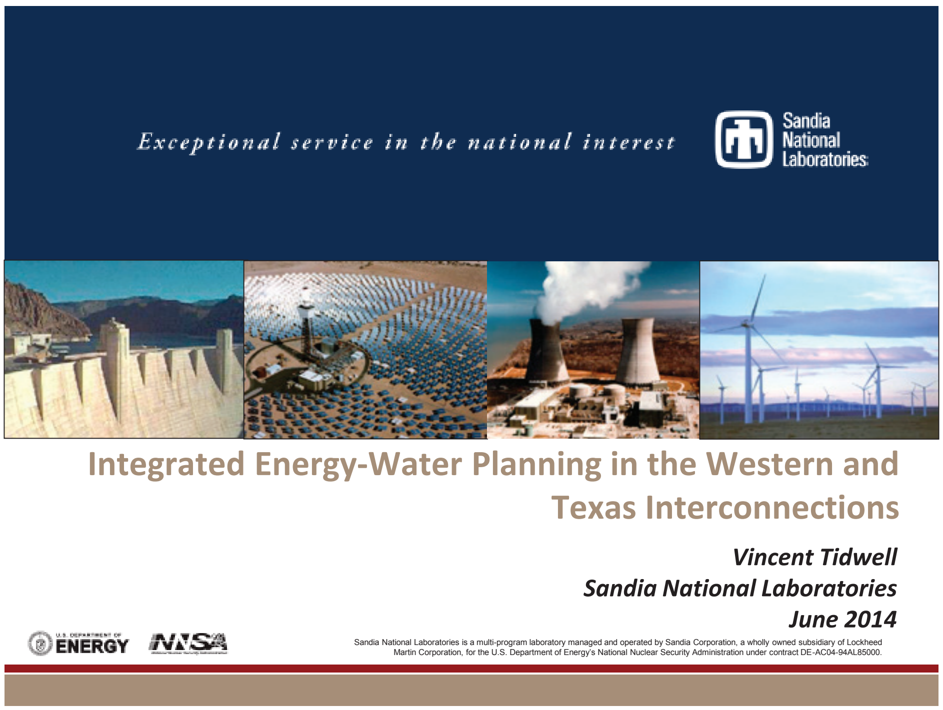
17. Integrated Energy-Water Planning in the Western and Texas Interconnections

Presented by Vincent Tidwell, Sandia National Laboratories

While long-term regional electricity transmission planning has traditionally focused on cost, infrastructure utilization, and reliability, issues concerning the availability of water represent an emerging issue. Thermoelectric expansion must be considered in the context of competing demands from other water use sectors balanced with fresh and non-fresh water supplies subject to climate variability. An integrated Energy-Water Decision Support System (DSS) is being developed that will enable planners in the Western and Texas Interconnections to analyze the potential implications of water availability and cost for long-range transmission planning. The project brings together electric transmission planners (Western Electricity Coordinating Council and Electric Reliability Council of Texas) with western water planners (Western Governors' Association and the Western States Water Council).

For more information:

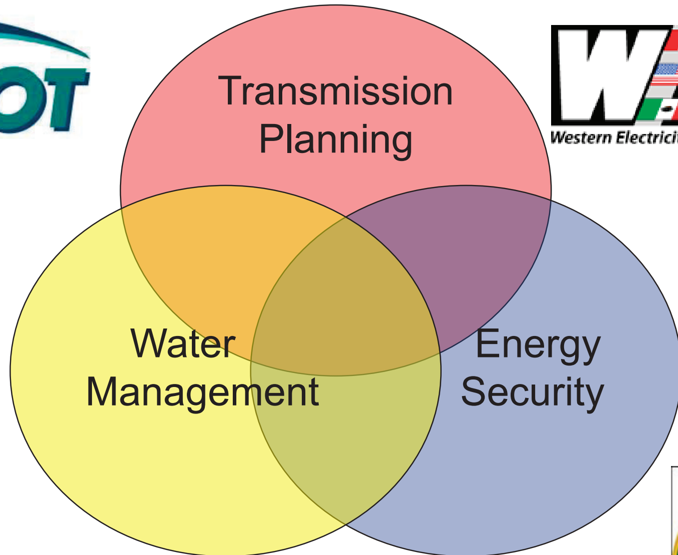
http://energy.sandia.gov/?page_id=1741



Integrated Planning

ERCOT

WECC
Western Electricity Coordinating Council



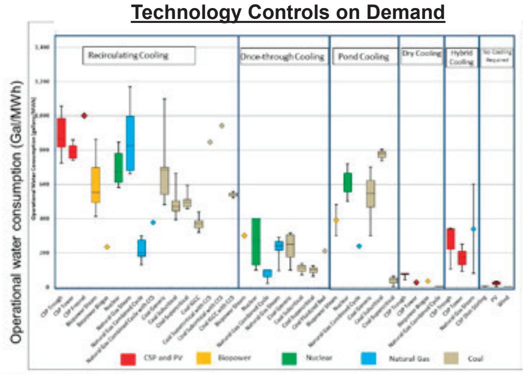
Western Governors' Association
Serving the Governors of 19 States and 3 US-Flag Pacific Islands

WSWC
Western States Water Council

Department of Energy · United States of America

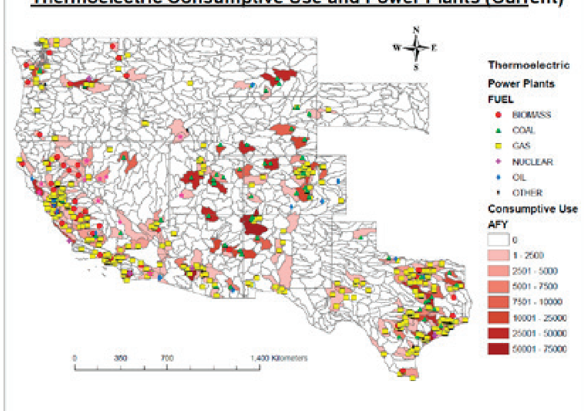
Mapping Thermoelectric Water Demand

Technology Controls on Demand

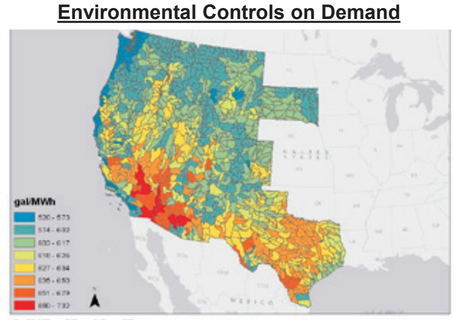


Source: Macknick et al. 2011

Thermoelectric Consumptive Use and Power Plants (Current)



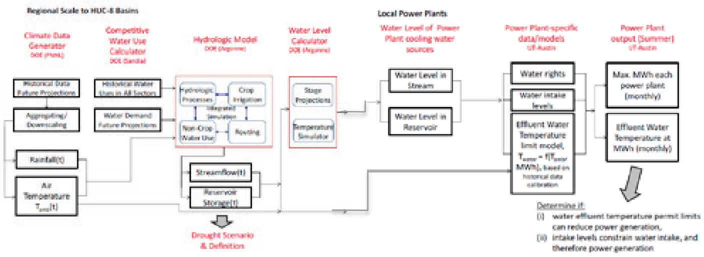
Environmental Controls on Demand



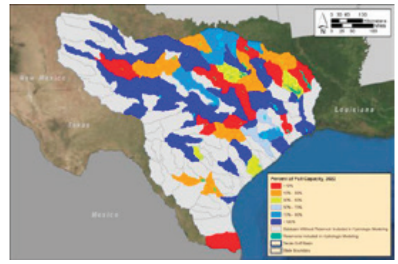
NREL 2012

Climate Impact on Existing Plants

Climate Modeling Scheme

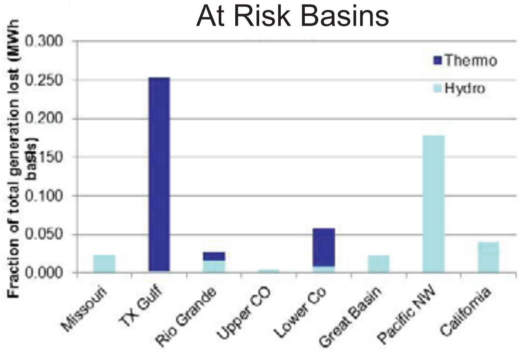


Water Availability Impact



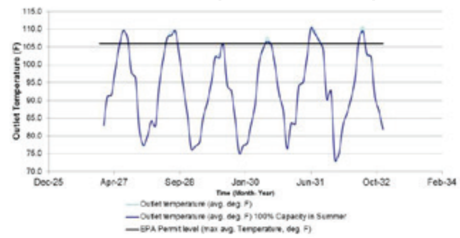
ANL 2013

At Risk Basins



ANL 2012

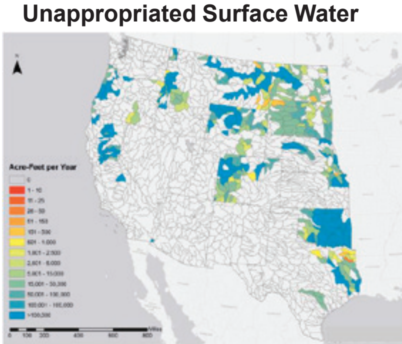
Water Temperature Impact



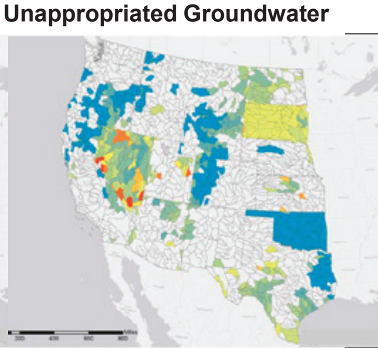
ANL 2013

Water Availability

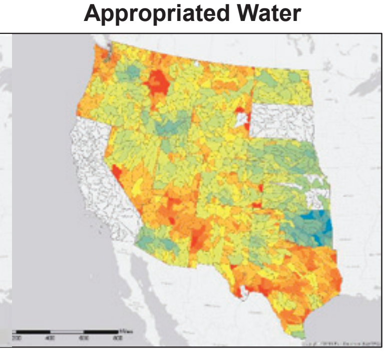
Unappropriated Surface Water



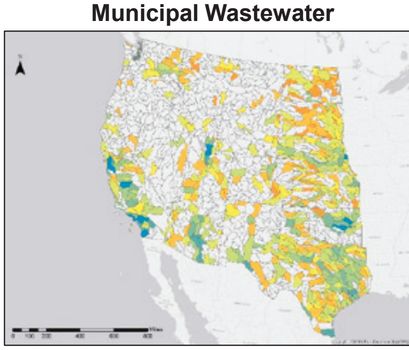
Unappropriated Groundwater



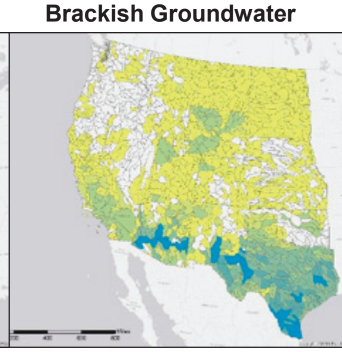
Appropriated Water



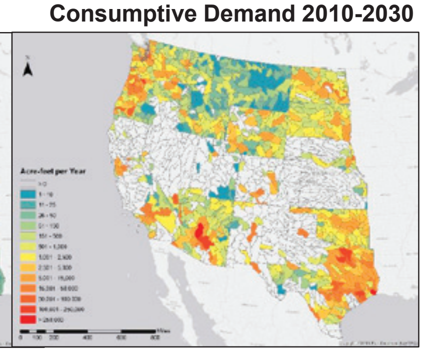
Municipal Wastewater



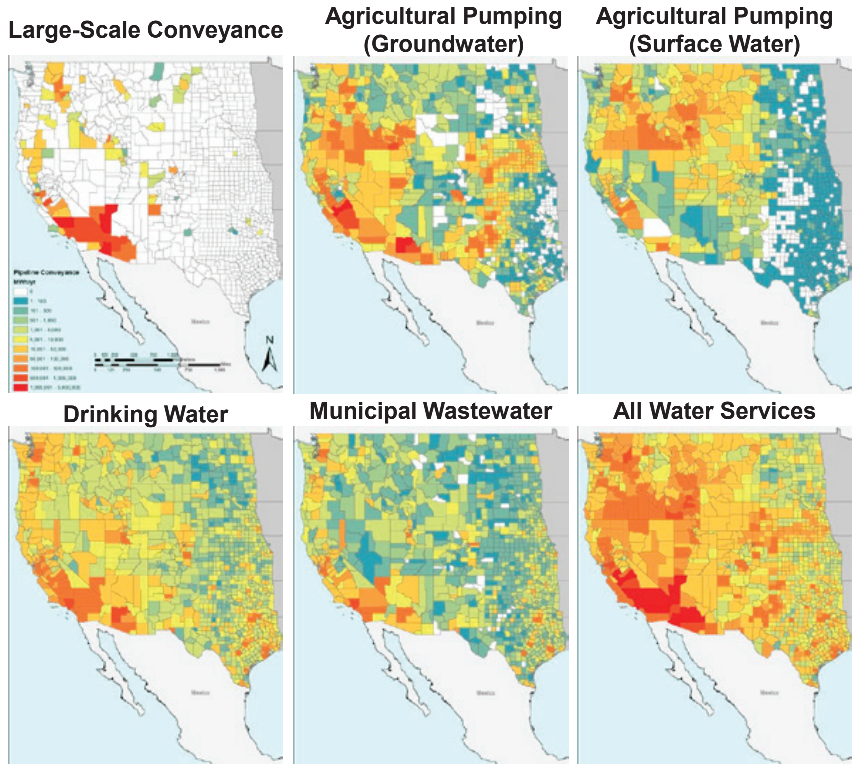
Brackish Groundwater



Consumptive Demand 2010-2030



Energy for Water Services



Perspectives

- Did approaching the case from the perspective of water, energy and food together as a nexus affect the results? Yes, results forthcoming.
- What are the main lessons learned from the case, with emphasis on the nexus approach? Big need to change planning culture and communication.
- Did these lessons learned identify important gaps in governance, public/private partnerships, data, financing, or infrastructure/technology? Gaps in appreciation of competing sector and communication.
- What does the business sector you represent contribute to the Water Energy Food Nexus approach? What can be transferred globally? Improved understanding, data, modeling tools and technology.
- Are there other examples in your sector of wider adoption of best practices to advance water, energy, and food security? What can be done to encourage wider adoption? DOE Water Energy Tech Team (WETT) along with interagency cooperation.

18. Catawba-Wateree River Basin Water Supply Master Plan

Presented by Jeff Lineberger, Director - Water Strategy and Hydro Licensing, Duke Energy

Communities along the hardest working river in the Carolinas have an approaching problem. Without significant effort to manage water consumption and improve supplies, this generation could see a time when there will not be enough water flowing in the Catawba-Wateree River to support more people moving into the heart of North or South Carolina, new industry and jobs, more electricity production and maintenance of the quality of life we currently enjoy.

The non-profit Catawba-Wateree Water Management Group has worked with stakeholders for more than four years to address this complex issue. Through much collaboration, they have designed a basin-wide Water Supply Master Plan that can help ensure the region's shared water supply will fully support growing needs into the next century.

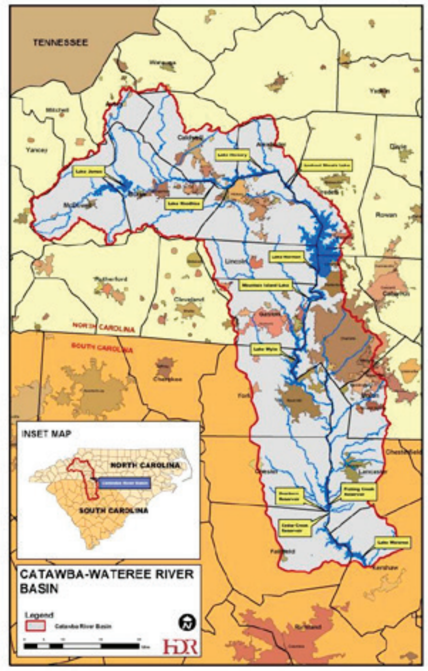
The Water Supply Master Plan is the most significant water supply management and planning endeavor undertaken in the Catawba-Wateree River Basin since original construction of the eleven-reservoir system by Duke Energy in the 1900s. The Water Supply Master Plan includes:

- Input and guidance from a 19-member public stakeholder team representing environmental interests, lake users, various local governments and state agencies
- Updated long-term water use projections in the Basin (to the Year 2065) and an updated, complex water quantity model
- Evaluation of numerous options to extend the available water supply
- New long-term Basin-wide strategies to increase the Basin's water yield by more than 200 million gallons per day, ensuring sustainable water supplies through 2100, decades beyond current expectations.

http://www.catawbawatereewmg.org/

Catawba-Wateree (CW) River Basin

- 11 interconnected reservoirs licensed by the Federal Energy Regulatory Commission (FERC)
  - Completed 1904-1963 (spanning 225 river miles)
  - 79,895 surface acres, 1,795 miles shoreline
- Modest water availability
  - Avg. inflow – 5,806 cubic feet per second (cfs)
  - Avg. annual precipitation – 46 inches
  - **Usable Storage = 776,747 acre-feet = 252 billion gallons ≈ 7% of annual basin precipitation**
- **Duke Energy electric generation – 8,591 MW (25% of our Carolinas' generation)**
  - 13 conventional hydro stations (845 MW)
  - 2 nuclear stations (4,516 MW)
  - 2 coal-fired stations (3,230 MW)
- Most densely populated river basin in NC
- **Reservoirs serve as the drinking water source for 18 public water systems (2 million customers)**
- Several large industrial water intakes
- 2 states, 17 counties, 30+ municipalities
- Over 25,000 lake neighbors
- Over 10 million recreation visits per year



2

Water Supply Master Plan

- **Extends water yield by 200+ million gallons per day (mgd) = 50 years**
  - Instead of reaching *modeled water yield* in 2050, we'd reach it in 2100
  - Sustains future basin growth potential
- Improves drought resiliency for vulnerable water intakes
- Prepares us for future climate change and population growth
- Promotes cooperation between water users and stakeholders in the river basin
- Balance of strategies (supply, demand, drought response) for enhancing water supply

3

Key Elements Driving the Master Plan

- **Cooperation**
  - 70-Party Comprehensive Relicensing Agreement (2006)
  - CW Drought Management Advisory Group (CW-DMAG) (2006)
  - CW Water Management Group (CWWMG) (2007)

- **Conflict**
  - Growth and competing uses
  - Water withdrawal fee proposal (2005)
  - SC 401 Water Quality Certification (2009)
  - SC v. NC Supreme Court Case Settlement Agreement (2010)
  - Business impacts
- **Climate**
  - Drought of Record (1998 - 2002)
  - New Drought of Record (2007 – 2009)
- **CWWMG and CW-DMAG Approach – Shared Resource = Shared Responsibility**
  - Plan and manage like it's "our water resource"
  - If one Large Water Intake Owner fails, we all fail

4

Lessons Learned

- **Get the science and engineering right**
  - Good modeling tools with good data are essential to good decisions
  - Know the state of the local practice versus what others are doing
  - Focus on implementable solutions
  - Consider the long-term
- **Social and political factors are also very important**
  - Diversity of planners
  - Water use priority setting is inevitable during severe droughts
  - Careful not to under-estimate level of effort for broad, effective communications
  - Health of the waterway and quality of life must balance economic development
- **All users / uses aren't equally capable of water conservation (every day) or water use restrictions (drought)**
  - Individual utility investments can benefit entire basin
- **Gaps**
  1) Funding to Develop Plan – filled by NC, SC and Duke Energy Foundation
  2) Implementation Funding and Staff – TBD
  3) Data – sedimentation impacts, tributary flows, water use
  4) Governance Mosaic – Riparian (NC), Regulated Riparian (SC), Advisory (CWWMG, River Basin Advisory Commission, others)

5

Energy and Water Sectors

- **Global Transfers**
  1) Both sectors contribute essential services
     - Electricity / drinking water
     - Public health and safety
  2) Managers of multi-use reservoirs need broad perspective
     - We serve the same public
     - Shared resource = shared responsibility
  3) Science + engineering is only half of the job
  4) Difficult to focus the public on long range (50+ years) plans

- **Wider Adoption - Joint Integrated Resource Planning (IRP)???**
  - IRP (20-yr look ahead) required of electric public utilities
  - Public water systems
    - Individual plans
    - Local Water Supply Plans (NC), Permitting Limits (SC)
  - Is more formal joint planning in our future?

- **More info – www.catawbawatereewmg.org**

6

19. Case study illustrating water energy food nexus

Presented by Larry MacDonnell

Substantial quantities of water are produced as a byproduct of oil and gas development. Most of that water is unusable for other purposes because of its poor quality; thus, it is either reinjected or contained in pits and evaporated. The large volumes of water generated as a byproduct of coal bed natural gas development, however, often are of a quality suitable for other use such as for irrigation. Nevertheless, states decided not to require its use. Consequently, large volumes of usable water either were simply discharged into surface water systems or were contained and evaporated. Despite the view that water is scarce in states such as Colorado, New Mexico, and Wyoming, it has proved to be uneconomic to find uses and cheaper simply to discharge or evaporate it. In this case the importance of energy production clearly outweighed our interest in careful use of our limited water resources.

For more information:

http://energy.usgs.gov/EnvironmentalAspectsEnvironmentalAspectsofEnergyProductionandUse/ProducedWaters.aspx#3822110-overview

http://capitolwords.org/date/2007/04/18/S4672-4_more-water-more-energy-less-waste-act/

https://www.govtrack.us/congress/bills/110/s1116#summary

CBM produced water management as a case study illustrating water energy food nexus

Larry MacDonnell

Nexus Dialogue Workshop – June 23, 2014

Golden, Co

Produced water as a byproduct of oil and gas production

- Large volumes of water are produced in association with oil and gas production (15 to 20 billion barrels (bbl; 1 bbl = 42 U.S. gallons) generated each year in the United States; equivalent to a volume of 1.7 to 2.3 billion gallons per day. Argonne, Produced Water Volumes and Management Practices (2009))
- A "waste" product; management and disposal a major concern
- Very little applied to beneficial use, such as irrigation

Coalbed Methane Production

- Began in the 1990s
- Peaked in 2008
- Virtually all production from Colorado, New Mexico, and Wyoming

Produced water in Powder River Basin in Wyoming

- According to 2009 report:

since 1987, 4.784 billion bbl of water have been produced from coal beds [more than 600,000 acre-feet]. Approximately 54% has been discharged to ephemeral and perennial streams, 35% has been managed using off-channel pits, 5% has been reused for irrigation projects, 3% has been managed through injection, and 3% has been treated and then discharged into streams.

Argonne, Produced Water Volumes and Management Practices

Why so little beneficial use of all this water?

- In some cases, water quality is a concern

- But, according to a National Academy of Sciences panel:

"Even where CBM produced water is intentionally put to beneficial use, the cost of implementation of such use almost universally exceeds any realized economic gain in the current regulatory and economic climate."

Management and Effects of Coalbed Methane Produced Water in the United States (2010)

Policy Choices

- Promotion of energy development outweighs concerns about making beneficial use of water

- Without regulation requiring beneficial use of produced water, not economic

- Tells us something about the relative economic value of water

20. Xcel Energy Water-Energy-Food Nexus Case Study

Presented by Richard Belt, Senior Water Resources Analyst, Xcel Energy

Xcel Energy partners with agricultural communities to buy their recharge credits and contracts long-term with them to use a portion of their excess water. The water right remains under the agricultural community's own enterprises. Using agricultural water for energy generation is especially more beneficial during a drought, when there is not enough water for agricultural production. If there is a power blackout, all sectors may remain out of water as well. Xcel Energy pays substantial amount of money to agricultural community to use their water, because power plants need substantially less water. One criticism is that these water transactions have high costs, but they are easily affordable for energy companies. Xcel Energy also trades with municipalities. It has the right to some high quality water sources, which are good for domestic use. The company trades this water with lower quality water from municipalities, which is good for energy production, so water treatment costs are reduced. This trade also reduces some capital costs for both parties. In the case when the government is involved in energy supply (as in some countries), if trades help the utility to make all the water needs, it creates a great Public-Private Partnership lesson. In addition, some water conservation practices at Xcel Energy include: using recycled effluent at some plants, installing a hybrid cooling plant at Pueblo, and using their wastewater to spray emission flows. From this company's experiences, they have the following key conclusions:

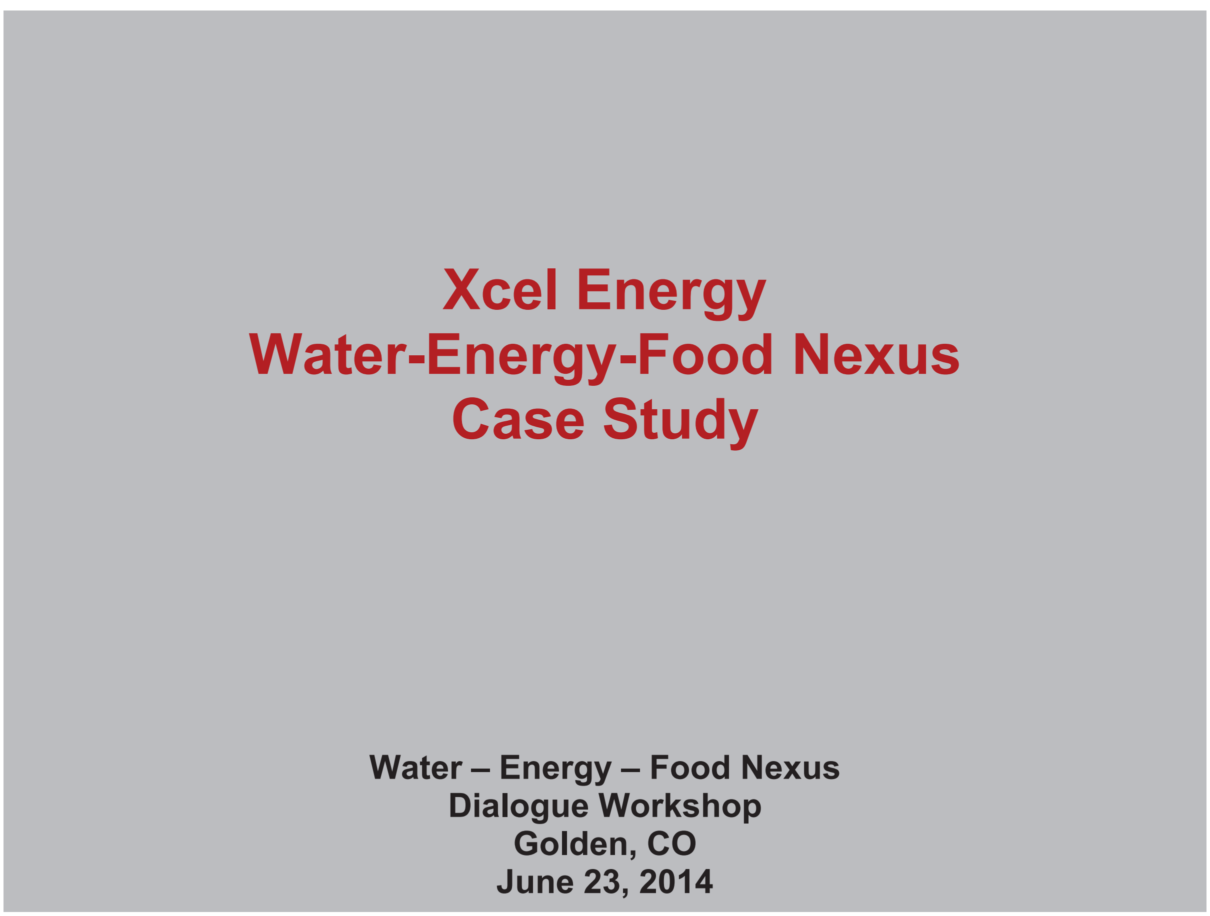
- Private water markets work
- Natural "nexus" partnerships may be location-based, quality-based, or drought-based
- All water issues have a local scale
- When developing arrangements, core needs should be addressed
- Water supply flexibility and diversity enable partnerships

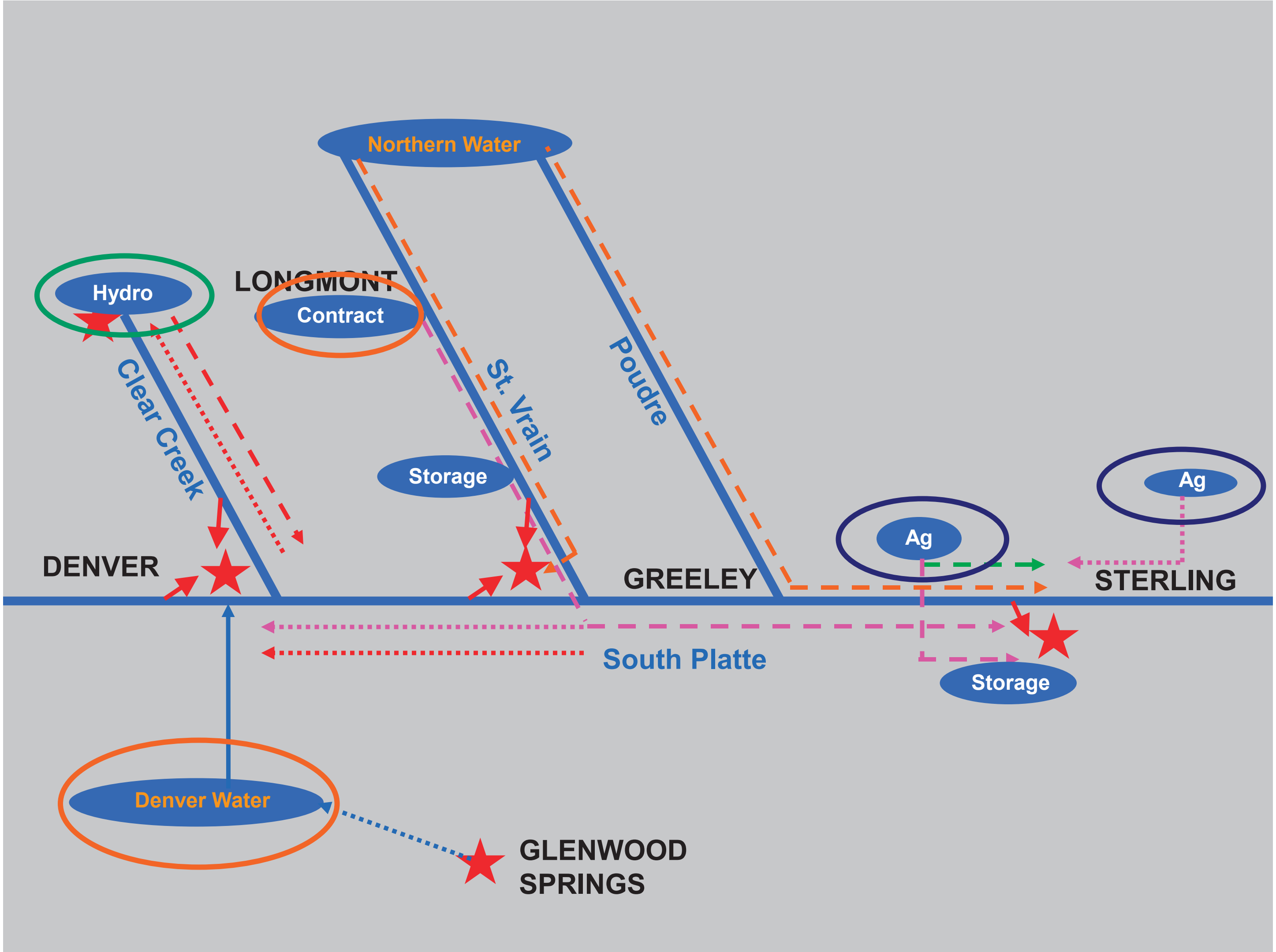
For more information:

http://www.xcelenergy.com/staticfiles/xe/Corporate/CRR2012/environment/water-management/conservation.html

http://www.xcelenergy.com/staticfiles/xe/Corporate/CRR2012/environment/water-management/supply.html

https://www.xcelenergy.com/staticfiles/xe/Corporate/CRR2013/environment/water-management.html





Nexus-related partnerships

- Traditional multiple use
  - Environmental/recreational
  - Hydropower
  - Municipal
  - Thermoelectric
- Trades
  - Appropriate water quality for use
  - Avoided capital expense – for both parties
- Interruptible supplies
  - Source of agriculture revenue
  - Drought resilience
  - Timing to minimize impact

Lessons

- Private water markets work
- Natural “nexus” partnerships
  - Location-based
  - Quality-based
  - Drought-based
- All water issues are local
- Develop arrangements that address core needs
- Water supply flexibility and diversity enable partnerships

Knowledge gaps

- How does it work?
  - Structure
  - Operation
  - Administration
- Which partners?
  - Need
  - Fit
- When? (Key consideration)
  - When should it start?
  - Should it end? When?

Industry “best” practices

- Water supply diversity and flexibility
- Repowering/combined cycle gas generation
- Renewables
- Demand-side management
- Technology
  - Alternative water supplies
  - Alternative cooling technology
  - Emission controls
- Good water stewardship practices

21. CALFED Bay-Delta Program

Presented by Masih Akhbari, Research Assistant and Program Aide, Colorado Water Institute, Colorado State University

California has been dealing with serious conflicts over its water resources management for decades. Debates over whether or not to transfer water from the Delta region to users elsewhere, and how to transport the water, have been the root causes of the conflicts in this state [23]. The conflicts became more complex after more limitations were imposed to the supplying system due to new environmental regulations enacted to protect the region's ecosystem.

To find a solution, a variety of innovative ideas have been developed. However, they lacked an overall framework. California Bay-Delta Program (CALFED) was initiated in 1995 as the most comprehensive effort to resolve water resources conflicts in the region and to address three main areas: ecosystem health, water quality, and water supply reliability. The "problem area" was defined as the Delta, and the "solution area" as all areas hydraulically connected to the Delta or relying on its water supplies, mainly Sacramento and San Joaquin Rivers [24]. CALFED intended to respond to the conflicts through a series of agreements and revisions that have involved federal and state legislation, and stakeholder accords [25]. Early in the program, the CALFED agencies decided the program needed to engage the public, particularly from identified interest groups or NGOs. One of the best and earliest achievements of CALFED was public awareness and their participation in water conservation activities [23]. CALFED has not been able to eliminate the zero-sum aspect of the game through collaborations, negotiations, and collective decision-making by stakeholders [23]. A review by the Little Hoover Commission found CALFED to be "costly, underperforming, unfocused, and unaccountable" [26]. Elimination of the strong support from the political leadership in Washington and Sacramento, after President Bush was elected, caused the situation at CALFED to begin a slow decline [27]. New leadership who was less supportive of CALFED, creation of the California Bay-Delta Authority (CBDA) without enough authority, and depletion in external funding secured earlier from Congress and the state taxpayers were other reasons for the decline of CALFED [28].

Based on the CALFED program experience, it can be concluded that an agreement may be reached by involving all key stakeholders, increasing public awareness, and providing guaranteed political and financial support. If you create an initiative that requires government funding, and if it is withdrawn without a successful governance structure in place, then the activity will not succeed.

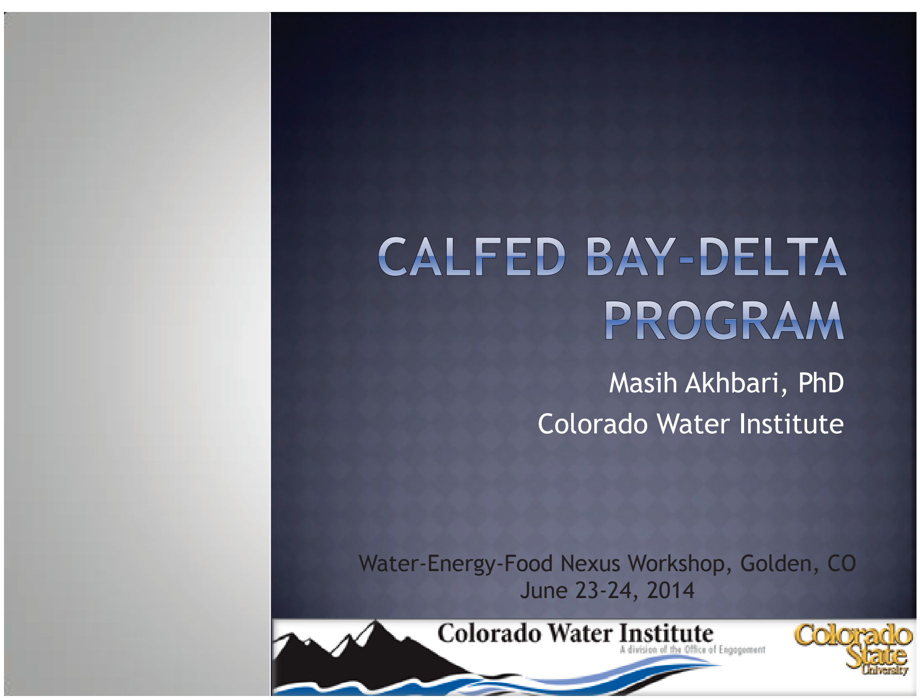
For more information:

http://calwater.ca.gov/content/Documents/library/309.pdf

http://www.bvsde.paho.org/bvsacd/encuen/calfed.pdf

http://www.sciencedirect.com/science/article/pii/S1462901109000963

http://www.lhc.ca.gov/studies/195/report195.html



This case focuses on a decision about balancing water for food, cities, energy, and environment

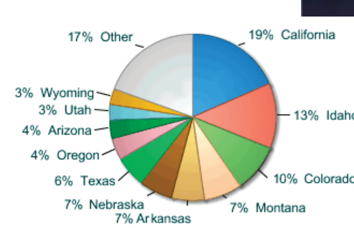
The case emerged due to gridlock reaching back many years about water allocation among the sectors for:

- Environmental purposes in the Bay-Delta area
- Supply irrigation water for agricultural activities
- Supply urban demands (in both Northern and Southern California)
- Hydropower generation in Northern California

- Most fertile soils in the United States
- Significant agricultural activities (Central Valley)
- Several hundred aquatic species
  - More than a hundred are threatened or endangered

WATER AND ENERGY USE

- 14.2% of total irrigated acres in the U.S.
- Produces half of the nation's fruits and vegetables
- The largest surface-water withdrawals
- The highest increase in total freshwater withdrawal by 2050



Source: Kenny, J.F., et al. 2009, *Estimated use of water in the United States in 2005*. USGS Report

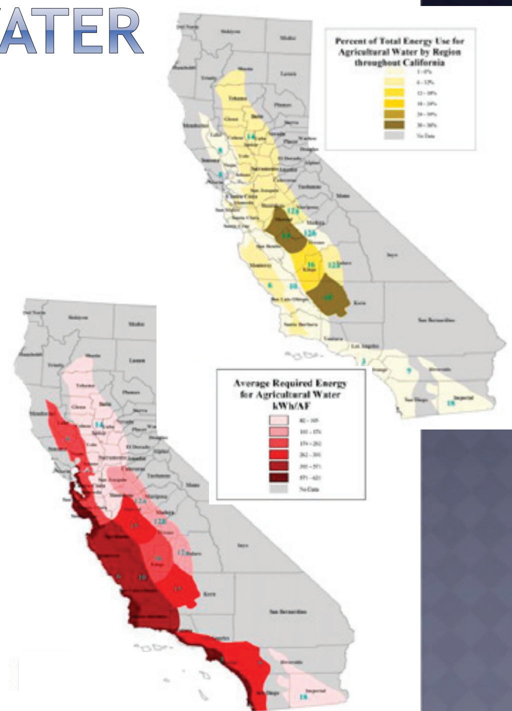
- About 2/3 of precipitation falls in the North
- ~75% of Californians live in the South
- Federal, state, and local project supply ag water
- To meet water demands in Southern California, water is pumped and transferred through the 3,000 miles of pipelines, tunnels and canals

Water transfers to agricultural lands and southern residents is highly energy-intensive

http://aquadoc.typepad.com/waterwired/2009/04/the-baydelta-imbroglio.html

ENERGY USE FOR WATER

- Groundwater supplies ~30 to 46% of the State's water
- Water sector accounts for an estimated use of ~6.9% of the state's electricity and 20% of the state's total energy use
  - Settlement patterns, topography, and climate patterns



Source: Burt, et al. 2003, *California Agricultural Water Electrical Energy Requirements*, ITRC Report No. R 03-006

CALFED BAY-DELTA PROGRAM

The main subject of conflicts among stakeholders in California has been the limited supply of water.

The most comprehensive effort to resolve the conflicts was the CALFED Program

- Initiated in 1995
- CALFED Policy Group: 25 federal and state agencies

Intended to respond to the conflicts through a series of agreements and revisions that have involved federal and state legislation, and stakeholder accords

Addressing three main problem areas in the Bay-Delta:

- Water supply reliability
- Water quality
- Ecosystem health in the Delta

CALFED'S EFFECTIVENESS

- CALFED was successful in the first decade of its implementation and it gained an advanced scientific understanding of the Delta
- One of the best and earliest achievements of CALFED was public awareness and their participation into water conservation activities
- CALFED failed to:
  - reverse the decline of the Delta ecosystem
  - improve the reliability of water supply
  - adopt new paradigms of governance
- CALFED had no power to restrict diversions, set water quality standards, levy charges, or make infrastructure investments

> **"Costly, Underperforming, Unfocused,**
> **and Unaccountable"**
>
> Little Hoover Commission

DRIVERS OF FAILURE

- Elimination of the strong support from the political leadership in Washington and Sacramento
- Creation of the California Bay-Delta Authority without enough authority
- Depletion in external funding secured earlier from Congress and the state taxpayers
- Fundamental opposition of interests
- Significant disagreements about the property rights

LESSONS LEARNED

Identify feasible, transparent, and coherent solutions, which can lead to agreement among the competing parties

- Involve all key stakeholders in planning and decision-making processes
- Increase public awareness about the consequences of non-cooperation
- Provide guaranteed political and financial support
  - The Bay-Delta region has been selected as one of the Critical Conservation Areas and will receive increased attention and be financially supported by the Regional Conservation Partnership Program recently launched by the USDA

If you create an initiative that requires government funding, and if it is withdrawn without a successful governance structure in place, then the activity will not succeed.

22. Geysers Geothermal Power Plant Municipal Waste Water Recharge

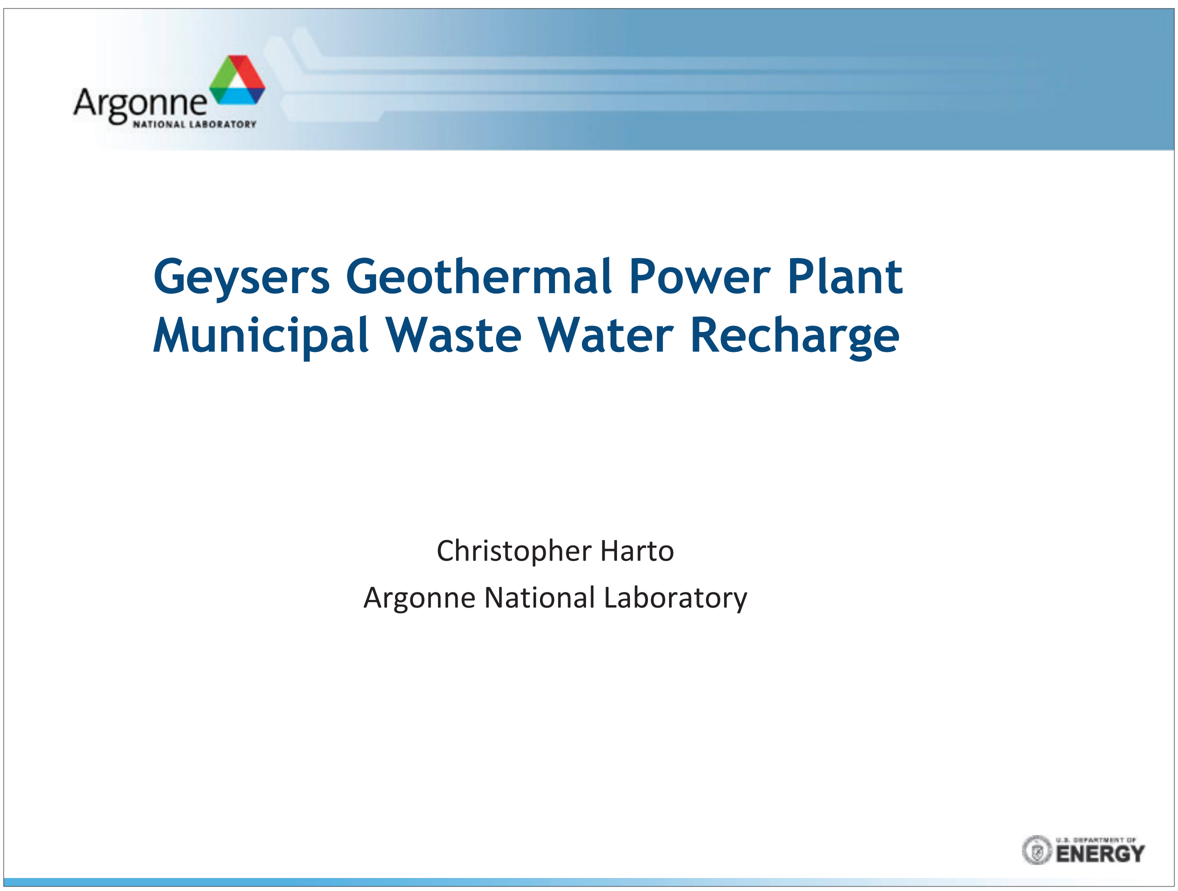
Presented by Chris Harto, Energy/Environmental Systems Policy Analyst, Natural Resource Economics and Systems Analysis Team, Argonne National Laboratory

Geothermal power plants utilize condensed geothermal steam for cooling. The majority of these plants are located in water stressed regions. Total water consumption of these plants will potentially increase due to growth in geothermal development by 2030. In Northern California, high value irrigated agricultural activities (mostly vineyards) limit increased water supply to energy companies. Failure in water supply results in reduced power production. To avoid this problem, Argonne National Laboratory has come up with the idea of using wastewater for cooling. They have built two large scale wastewater injection projects totaling 20 million gallons of waste water a day. These projects have improved local water quality, as low quality wastewater is consumed in the geothermal power plants and freshwater is remained in the reservoirs. Although successful, it is challenges to implement this method in other locations since in many areas municipal waste water effluent is discharged into the local watershed and provides in stream flow and may be used by downstream users; pipeline projects can be costly and sometimes challenging to implement. The alternative opportunity is to use brackish or saline groundwater for supplementary injection in many geothermal systems.

Link(s) for more information:

http://www.geysers.com/numbers.aspx

http://www.watereducation.org/userfiles/Brostrom_Peter.pdf



The Geysers Geothermal Field

- 75 miles north of SF CA in Sonoma and Lake Counties
- 15 power plants with a total 725 MW capacity
- Field covers 45 square miles

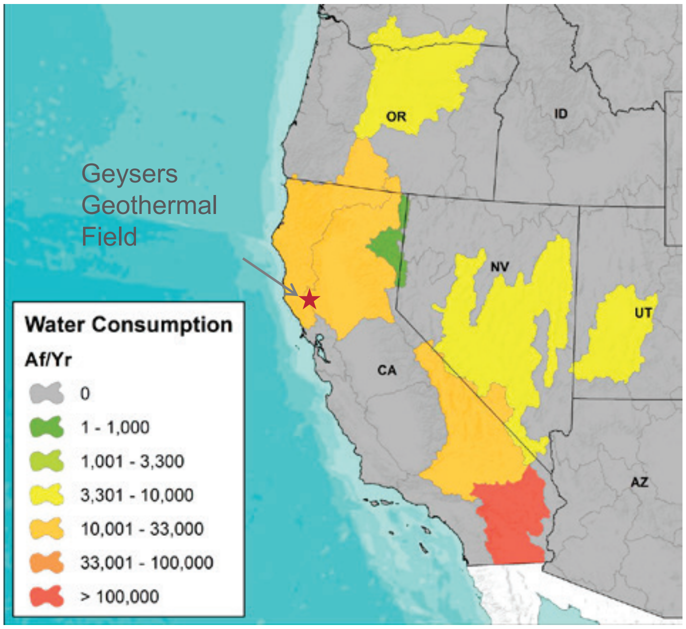
- Power plants utilize condensed geothermal steam for cooling
- Over time this results in reduced power production due to reservoir drawdown

- Two municipal waste water pipelines have been built to provided water to recharge the reservoir and increase/maintain power production

http://www.geysers.com/numbers.aspx

2

Potential Increase in Water Consumption from Growth in Geothermal Development by 2030



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Water Recharge Pipelines

- Two large scale wastewater injection projects have been built totaling 20 million gallons of waste water a day
- Southeast Geysers Effluent Pipeline
  - Completed in 1997
  - 29 mile pipeline (later extended to 40 miles)
  - 9 million gallons per day of secondary treated wastewater
  - First project of it's kind in the world
  - Resulted in 70MW increase in power output
  - Project improved local water quality
- Santa Rosa Geysers Recharge Project
  - Completed in 2003
  - 42 mile pipeline
  - 11 million gallons per day of tertiary treated wastewater
  - Cost over $200M and took 10 years from planning to completion
  - Resulted in 100 MW increase in power output

4

Impact on Local Wine Growers

- California produces around 90% of the wine produced in the US with a retail value of $23B
- Napa, Sonoma, and Napa counties surrounding the Geysers Geothermal Field contain the largest concentrations of wineries in the state
- The majority of Vineyards in CA are irrigated
  - 1.7M acre-ft/year for irrigation[1]
- Advantages of Project to Local Agriculture:
  - Preserves existing surface and groundwater sources
  - Reduced pollutant discharges to surface water bodies

[1] http://www.watereducation.org/userfiles/Brostrom_Peter.pdf

5

Challenges, Alternatives, and Additional Examples from the Energy Sector

- Challenges in Implementation in other Locations
  - In many areas municipal waste water effluent is discharged into the local watershed and provides in stream flow and may be used by downstream users
  - Pipeline projects can be costly and sometimes challenging to implement, so it may not be the optimum use of resources in all cases

- Alternative Opportunities
  - Brackish or saline groundwater may be able to be used for supplementary injection in many geothermal systems

- Additional Examples from the Energy Sector
  - Palo Verde Nuclear Plant, 3.3 MW, Outside of Phoenix, AZ uses reclaimed waste water
  - Growing use of recycled flowback and produced water from oil and gas production for hydraulic fracturing of new wells

6

23. Opportunities at the California Water-Energy Nexus

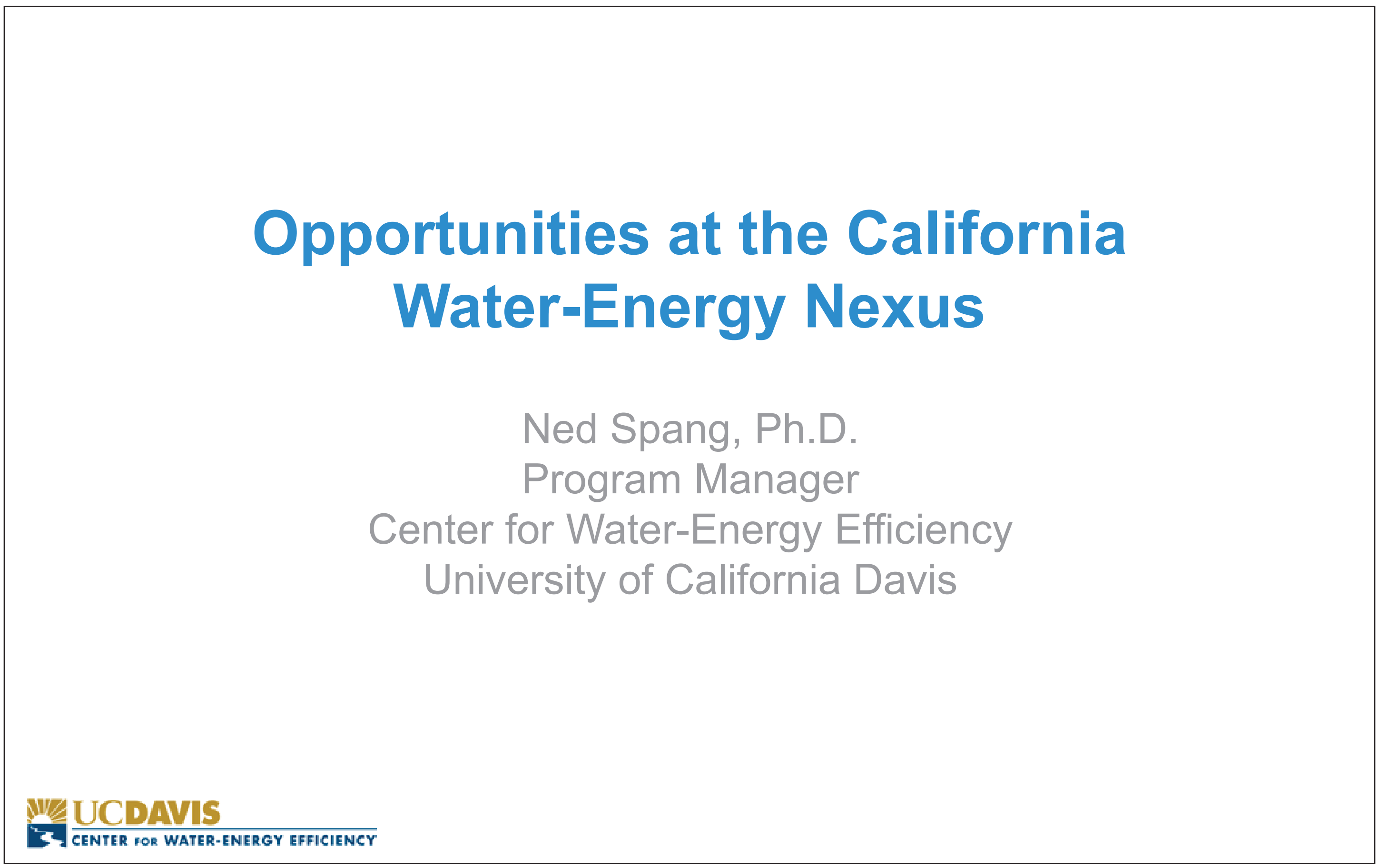
Presented by Ned Spang, Program Manager, Center for Water-Energy Efficiency, UC-Davis

Using East Bay Municipal Utility District in Northern California as a case study, researchers at the Center for Water-Energy Efficiency (CWEE) at UC Davis developed a methodology for calculating at a high resolution the energy intensity of water treated and delivered to customers of a major metropolitan water district. This method extends previous efforts by using highly granular data, including hourly data from supervisory control and data acquisition (SCADA) system components, to produce a system-based understanding of the delivered water's energy intensity. We found significant variations in the energy intensity of delivered potable water within the service territory due to seasonal and topographic effects. This method enhances our understanding of the energy inputs for potable water systems and can be applied to the entire water life cycle. A nuanced understanding of water's energy intensity in an urban setting enables more intelligent, targeted water conservation efforts to secure both water and energy savings that take seasonal, distance, and elevation effects into account.

For more information:

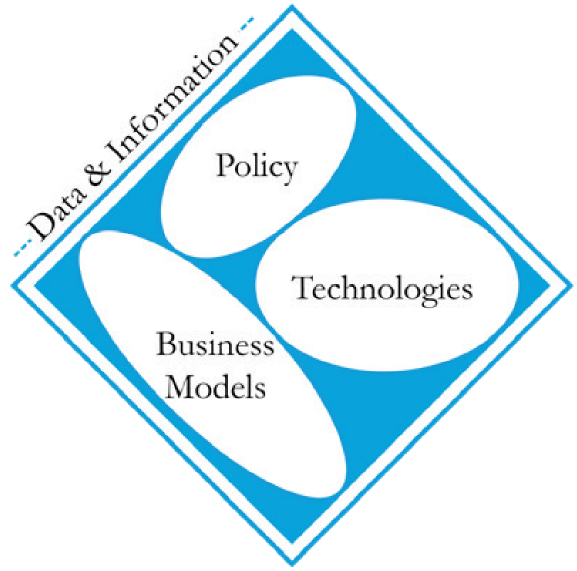
http://cwee.ucdavis.edu/projects/accounting-for-waters-energy-intensity

http://www.etccca.com/sites/default/files/reports/ET12PGE5411_Embedded%20Energy%20in%20Water_0.pdf



The Information Bottleneck

- California' active water-energy agenda
  - AB 32
  - CPUC Guidance
  - WET-CAT
- But limited by availability of actionable data



Saving Energy with Water

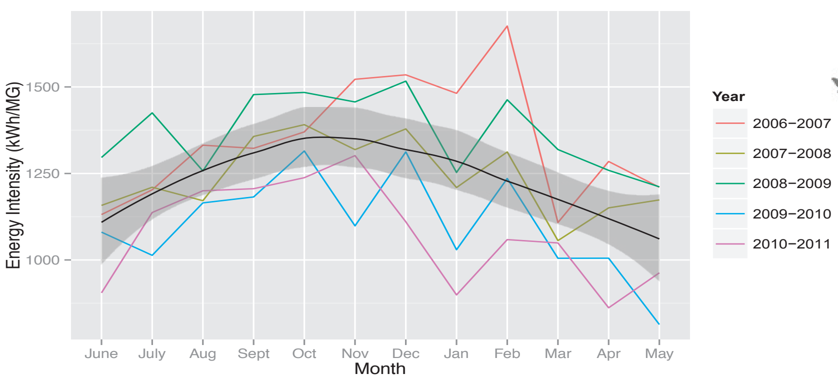
Energy Efficiency of Water System

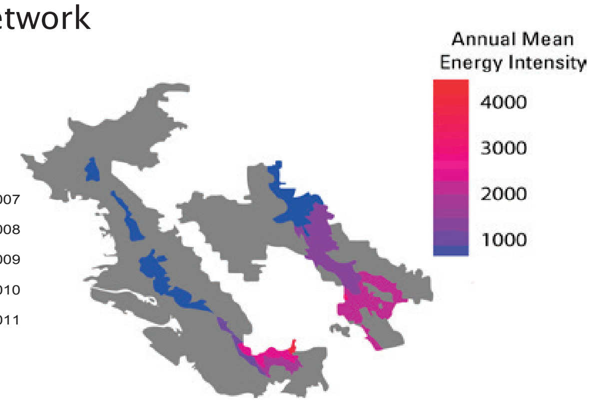
Energy Savings through Water Efficiency

UC DAVIS CENTER FOR WATER-ENERGY EFFICIENCY

Case Study: East Bay MUD

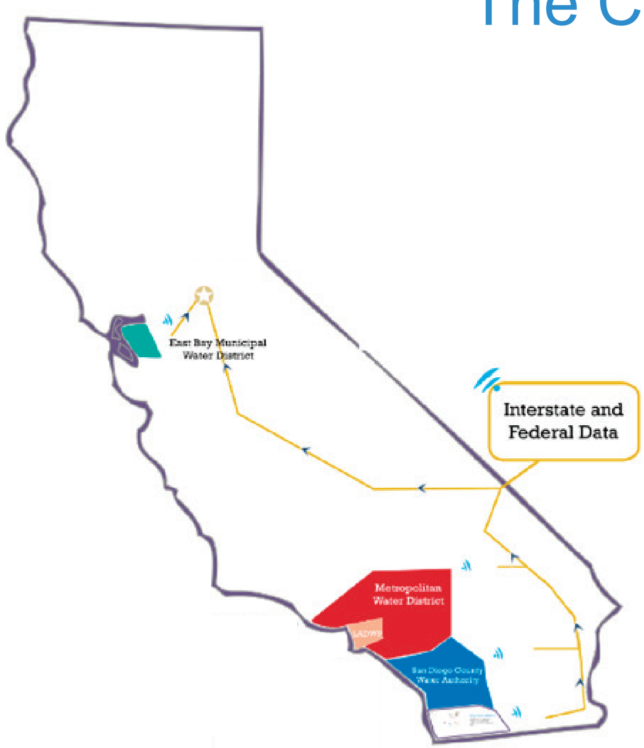
- Results:
  - 10-12% monthly variation around the annual mean
  - >12X difference across the distribution network

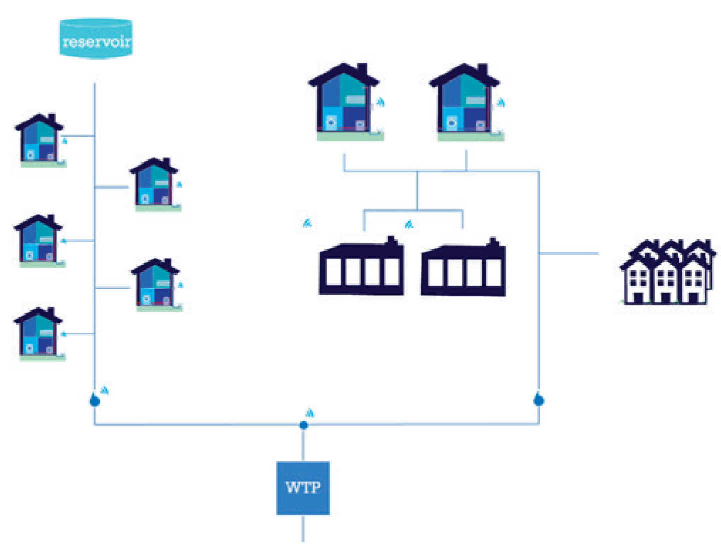




UCDAVIS CENTER FOR WATER-ENERGY EFFICIENCY

The Complexity

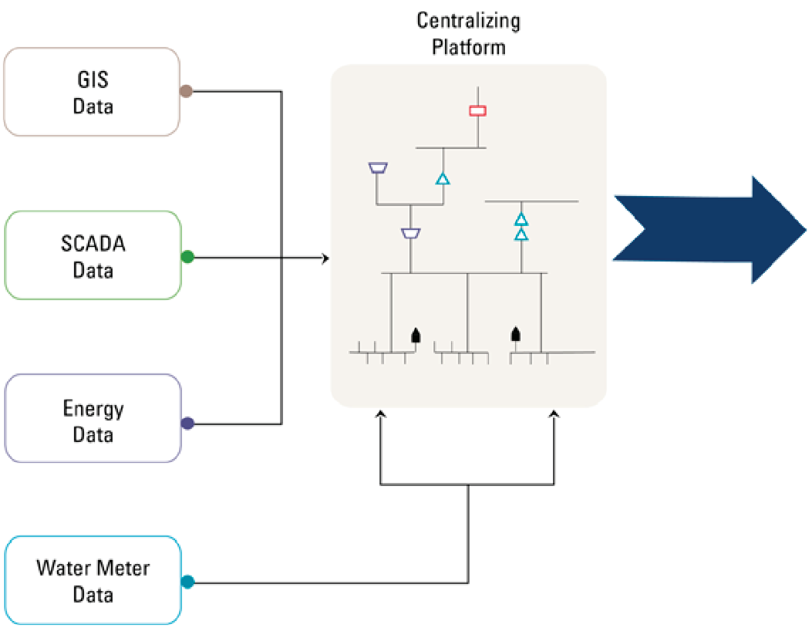




- Multiple scales
- Multiple and overlapping jurisdictions

UCDAVIS CENTER FOR WATER-ENERGY EFFICIENCY

Opportunities



ANALYTICS

Water Benefits

- Water Use Benchmarking
- Targeted Conservation
- Leak Loss Detection
- Monitoring and Verification

Energy Benefits

- Energy Savings
- Demand Response
- Peak Shaving/Shifting
- Energy Storage
- Monitoring and Verification

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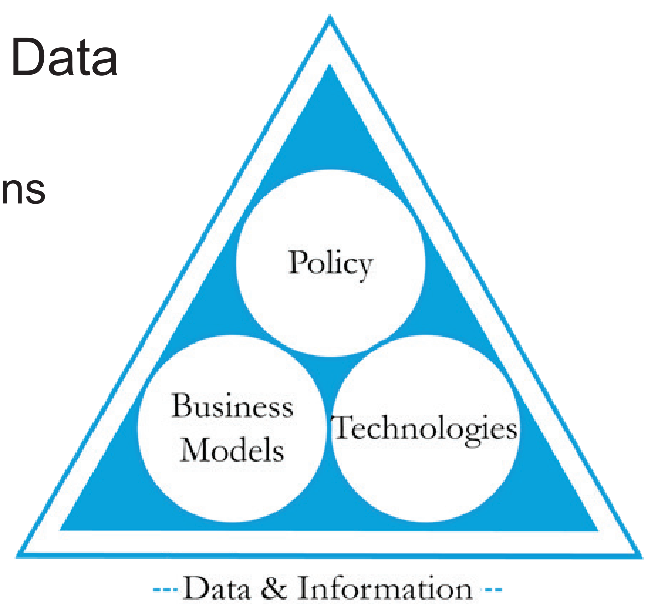
Next Steps

- Aligning Water and Energy Data
  - Common data platform
  - Security and privacy provisions
  - Suite of analytics
  - Funding (e.g., PGC)
  - Stakeholder engagement
- Drive Innovation in Policy, Technology, and Business Models



24. Southern California Ag-Urban Transfer

Presented by Michael Cohen, Senior Research Associate, Pacific Institute

The 2003 water conservation and transfer agreement between California's Imperial Irrigation District (IID) and San Diego County Water Authority (SDCWA) is the largest agriculture to urban water transfer in the U.S. The transfer agreement calls for an annual increase in the volume of water effectively moved from the Imperial Valley to San Diego, from 10,000 acre-feet (AF) in 2003 to almost 200,000 AF in 2020, and 200,000 AF per year from 2023 to 2047, with a provision for a 30 year extension. Through the year 2017, the transfer agreement and supporting authorization require the delivery of 'mitigation water' to the Salton Sea, to offset the direct impacts of decreased inflows due to the transfer. The delivery of the mitigation water ceases at the end of 2017. IID diverts Colorado River water at Imperial Dam. Under the transfer agreement, IID forgoes a prescribed diversion volume, while SDCWA diverts that same volume 142 miles upstream, from Lake Havasu. The transfer agreement has several clear energy implications that have not been studied to date: 1) IID receives Colorado River water via gravity and in fact generates a nominal amount of energy from this water; 2) Colorado River water flowing through Lake Havasu and Parker Dam generates about 70 kWh per AF per year; 3) delivering Colorado River water to SDCWA requires about 1900 kWh/AF/y; 4) SDCWA's other major supply, from California's Bay-Delta via the State Water Project (SWP), requires about 3100 kWh/AF/y to deliver to its service area. To the extent that SDCWA substitutes Colorado River water for its SWP supply, the transfer generates a net energy savings. To the extent that SDCWA is simply augmenting its existing SWP supply, the IID transfer represents additional net energy consumption. Through at least 2017, the transfer agreement also affects crop production, because the transfer agreement requires that IID land be taken out of production to generate water for delivery to SDCWA. Currently, about 30,000 acres of land are taken out of production in IID each year to generate water for transfer. Most of this land would otherwise have been planted in alfalfa, potentially affecting the availability of forage for southern California dairies. After 2017, the fallowing requirement expires, though IID may not be able to generate sufficient water from efficiency and conservation practices by that time and so may need to continue to fallow land. In either case, after 2017 IID is no longer required to deliver mitigation water to the Salton Sea, at which point the Sea will begin to experience profound ecological changes. The IID-SDCWA transfer agreement represents an interesting nexus of water, energy, food, and environmental changes that have not been studied to date.

For more information:

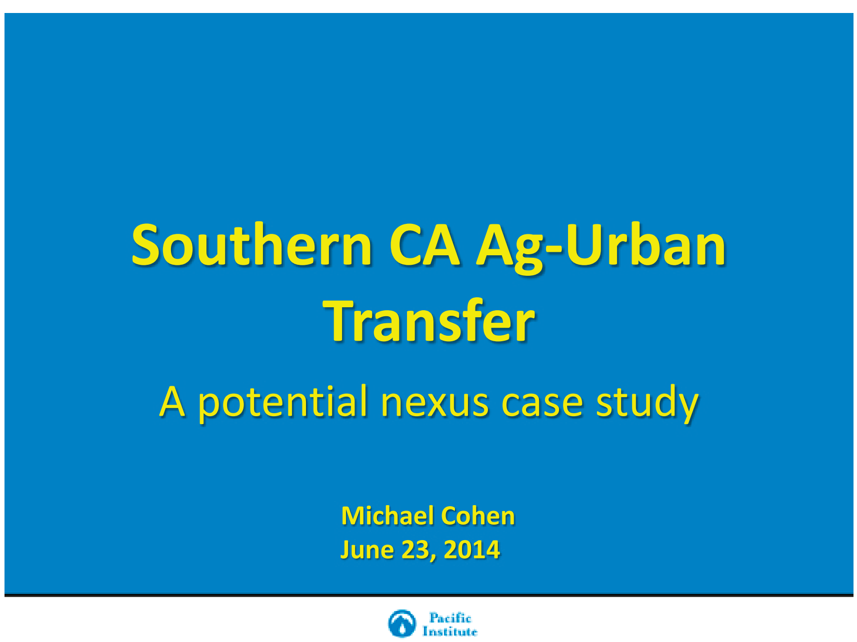
http://www.sdcwa.org/quantification-settlement-agreement

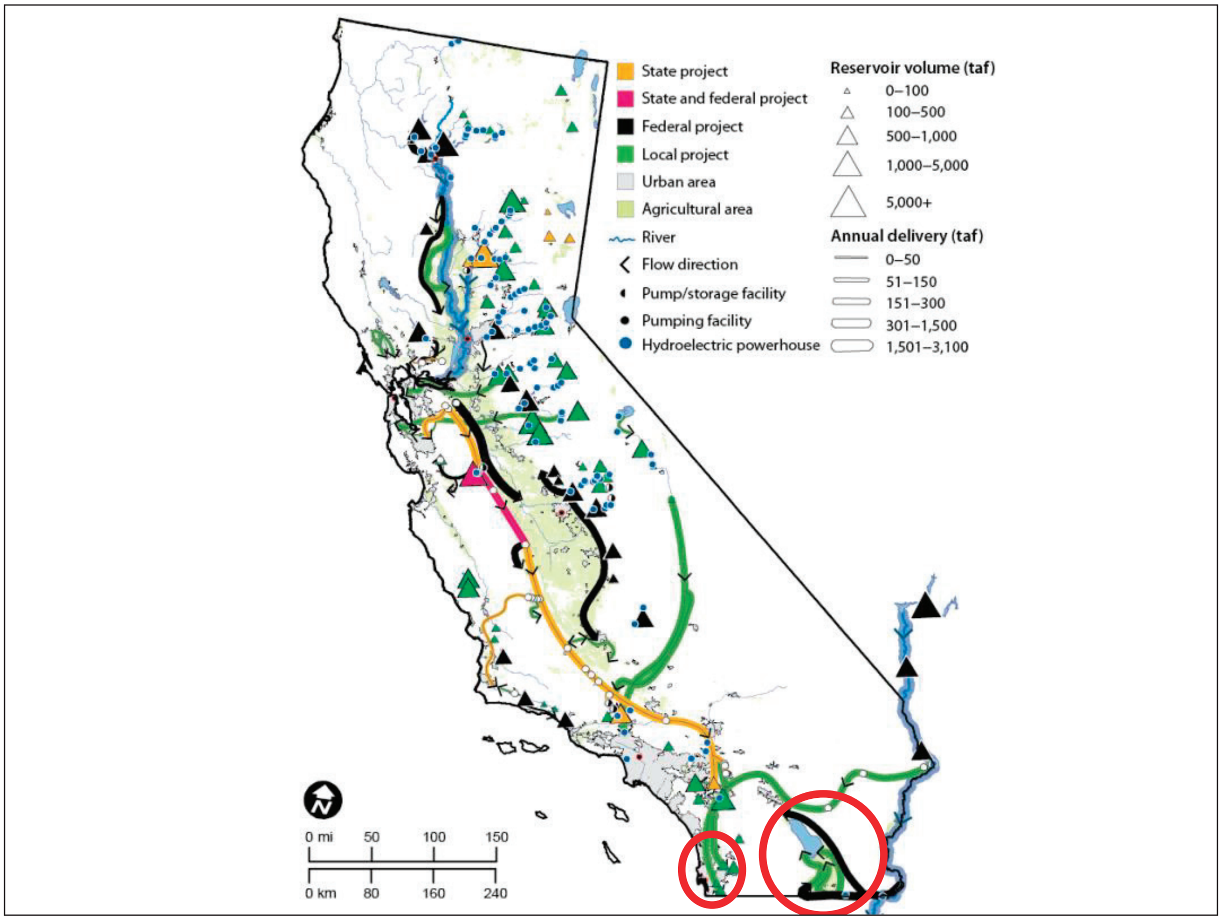
http://www.iid.com/Modules/ShowDocument.aspx?documentid=921

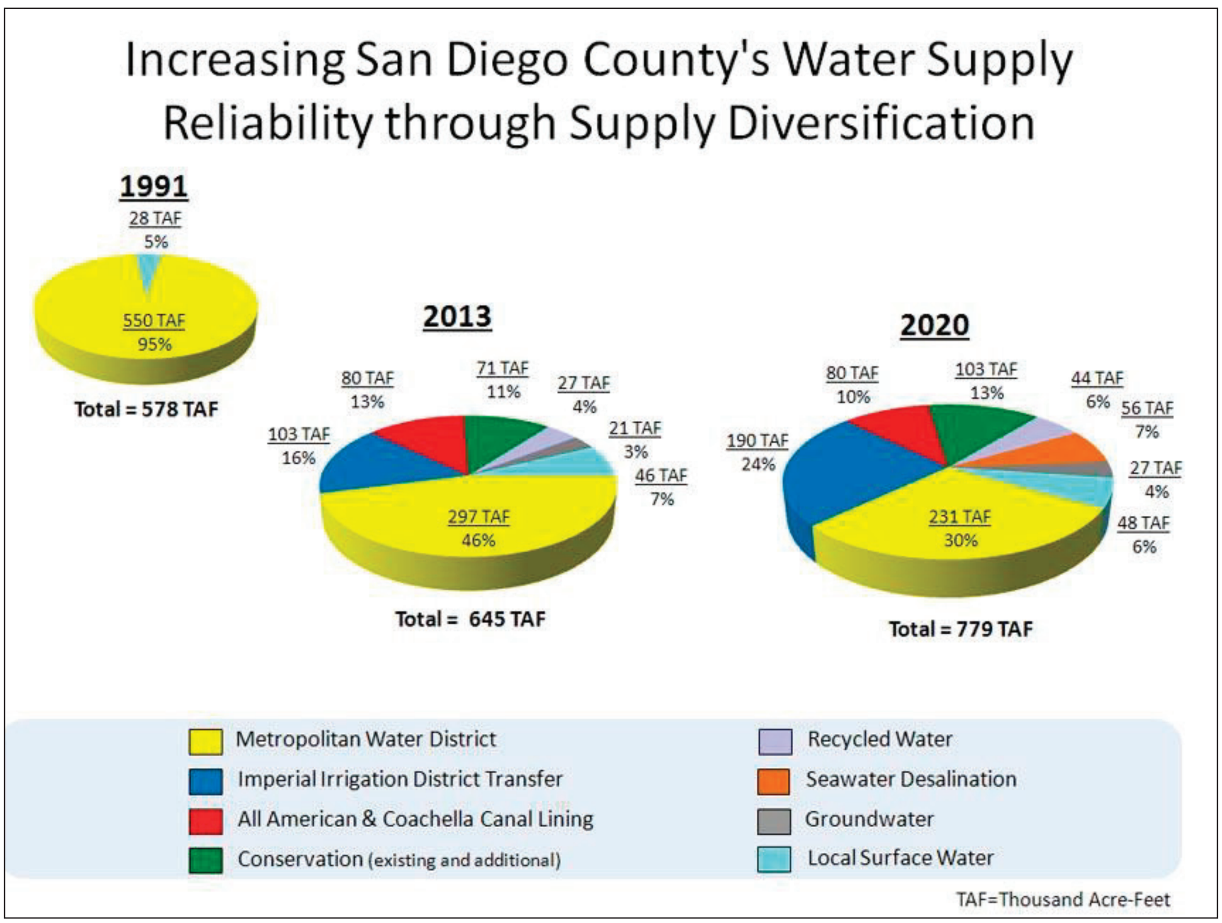
http://www.aquapedia.com/quantification-settlement-agreement/

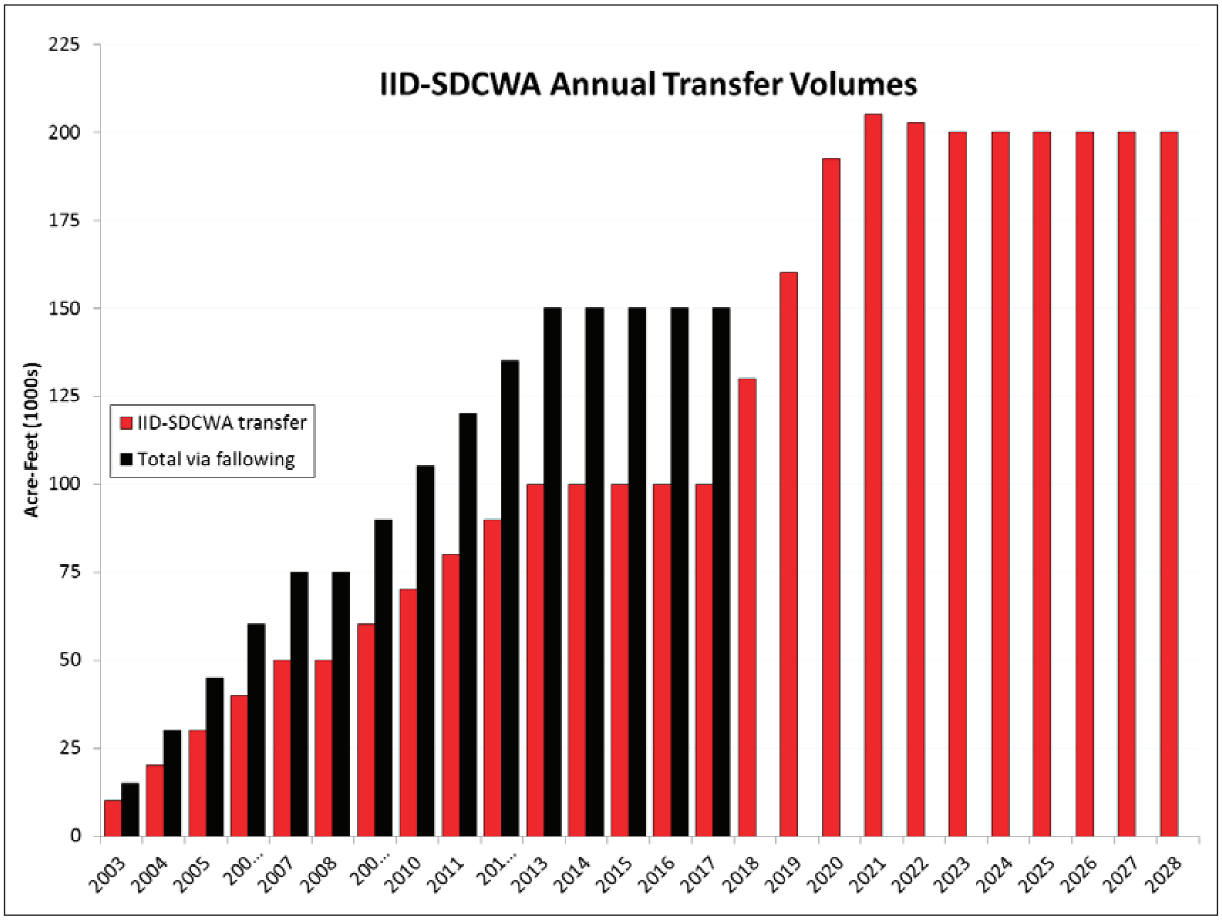
http://www.sdcwa.org/sites/default/files/files/FifthAmendment-iid-sdcwa.PDF

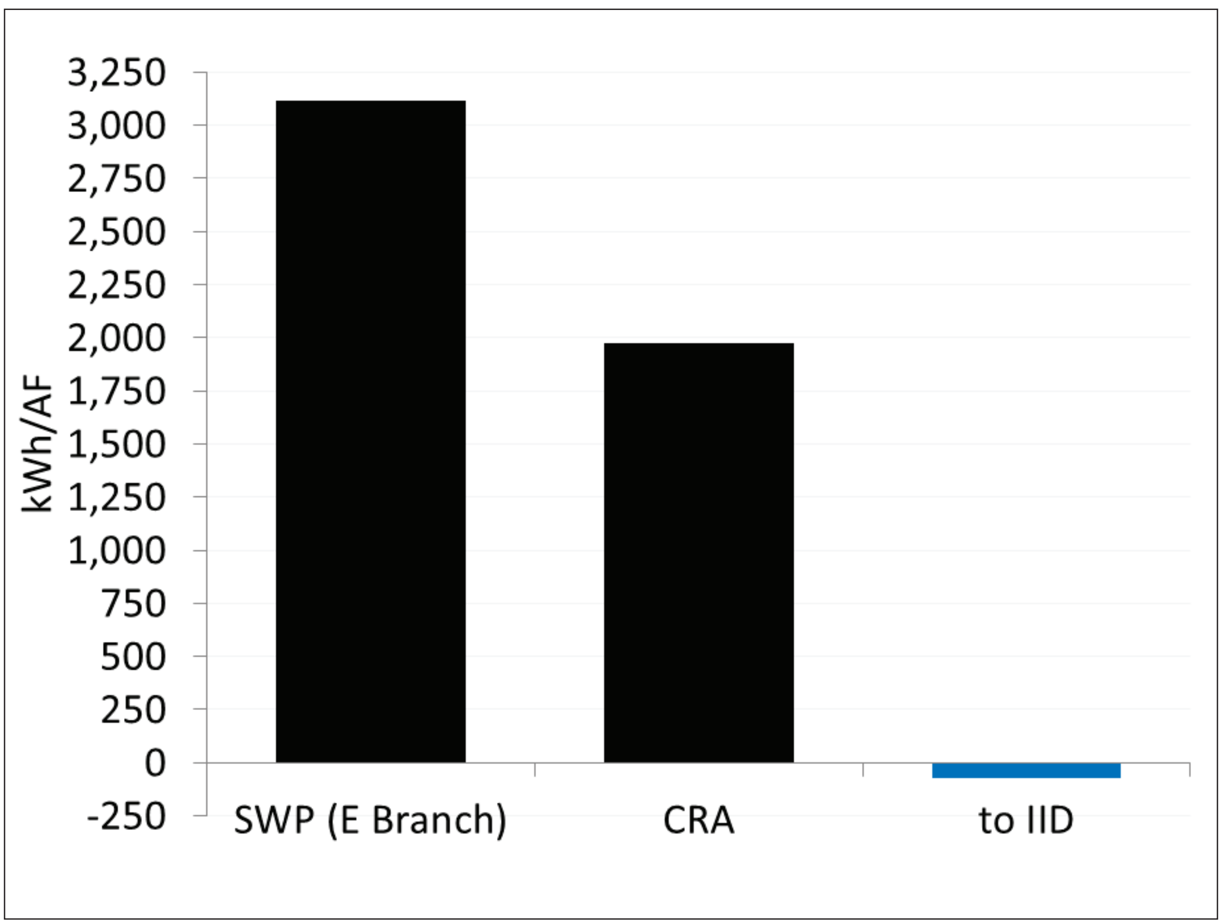
http://www.crb.ca.gov/Board%20Folders/2011/8%20Aug/Tab%205/IID%20Letter.pdf

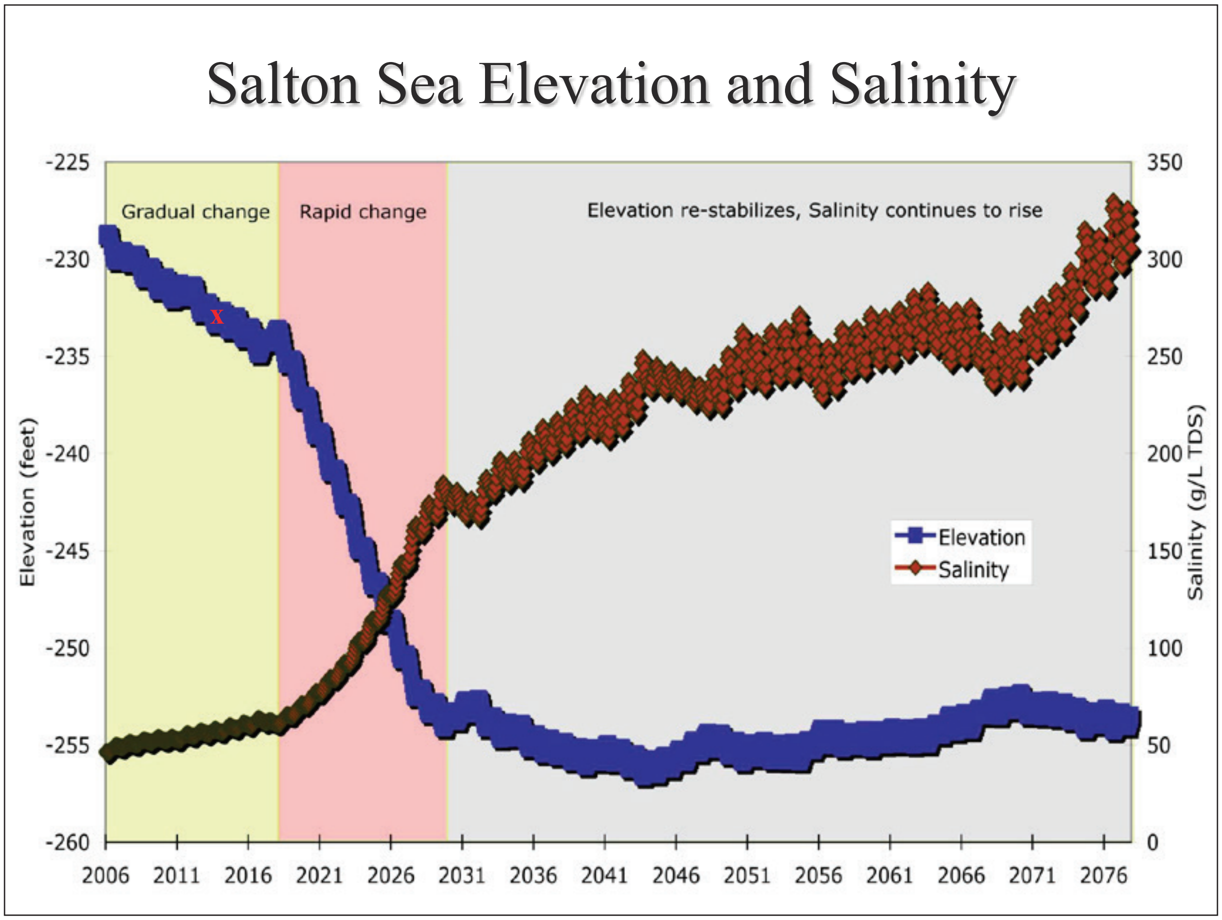



State project
State and federal project
Federal project
Local project
Urban area
Agricultural area
River
Flow direction
Pump/storage facility
Pumping facility
Hydroelectric powerhouse
Reservoir volume (taf)
0–100
100–500
500–1,000
1,000–5,000
5,000+
Annual delivery (taf)
0–50
51–150
151–300
301–1,500
1,501–3,100
0 mi 50 100 150
0 km 80 160 240


Increasing San Diego County's Water Supply Reliability through Supply Diversification
1991
28 TAF
5%
550 TAF
95%
Total = 578 TAF
2013
80 TAF
13%
71 TAF
11%
27 TAF
4%
21 TAF
3%
46 TAF
7%
103 TAF
16%
297 TAF
46%
Total = 645 TAF
2020
80 TAF
10%
103 TAF
13%
44 TAF
6%
56 TAF
7%
27 TAF
4%
48 TAF
6%
190 TAF
24%
231 TAF
30%
Total = 779 TAF
Metropolitan Water District
Imperial Irrigation District Transfer
All American & Coachella Canal Lining
Conservation (existing and additional)
Recycled Water
Seawater Desalination
Groundwater
Local Surface Water
TAF=Thousand Acre-Feet


IID-SDCWA Annual Transfer Volumes
Acre-Feet (1000s)
IID-SDCWA transfer
Total via fallowing
225
200
175
150
125
100
75
50
25
0
2003
2004
2005
200...
2007
2008
200...
2010
2011
201...
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028


kWh/AF
3,250
3,000
2,750
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
250
0
-250
SWP (E Branch)
CRA
to IID



Salton Sea Elevation and Salinity
Gradual change
Rapid change
Elevation re-stabilizes, Salinity continues to rise
Elevation (feet)
Salinity (g/L TDS)
Elevation
Salinity
-225
-230
-235
-240
-245
-250
-255
-260
350
300
250
200
150
100
50
0
2006
2011
2016
2021
2026
2031
2036
2041
2046
2051
2056
2061
2066
2071
2076

25. Navajo Generating Station Case Study

Presented by Stacey Tellenhuisen, Senior Energy/Water Policy Analyst, Western Resource Advocates

Navajo Generating Station (NGS), a 2,250 MW coal plant, provides revenues to Navajo and Hopi Tribes, and contributes to air quality problems. It supplies power demand of the Central Arizona Project (CAP), which delivers Colorado River water to Phoenix, Tucson, Tribal lands, and agricultural lands. Excess power sales contribute to the Lower Colorado River Development Fund. In Feb. 5, 2013, the U.S. Environmental Protection Agency issued a proposed Best Available Retrofit Technology (BART) rule for Navajo Generation Station to reduce emissions of nitrogen oxide (NOx) from the power plant. This rule has the most stringent NOx standard in the U.S. and requires installation of Selective Catalytic Reduction technology, which costs $ 544 million, with the possibility that costs exceed $1.1 billion if additional air filters are required. CAP, along with the other stakeholders, including Gila River Indian Community, the Navajo Nation, Salt River Project, the Environmental Defense Fund, the U.S. Department of the Interior and Western Resource Advocates, developed an alternative "Better than BART" plan for NGS. This proposal addresses EPA's NOx emissions while protecting the future of the NGS. The plan has two alternatives and both reduce NOx emission eve greater than the EPA's proposed rule. Based on this plan:

- 1 Unit (or equivalent) will be retired in 2020;
- Plant owners mitigate economic impacts on local communities
- Department of Interior (DOI): CO_2 Reduction Commitment (3%/year) for its unit, or 11.3 million metric tons by 2035
- DOI: Clean Energy Development Commitment;
- DOI: Evaluate transition from NGS to cleaner sources of energy
- Bureau of Reclamation: mitigate impacts on cost of water

Main takeaways from this study are:

- Are energy utilities reporting – and valuing – water use today?
- Are water utilities considering future energy demands? Their reliance on energy? GHG emissions (and future costs)?
- Are we recognizing the positive trends underway?

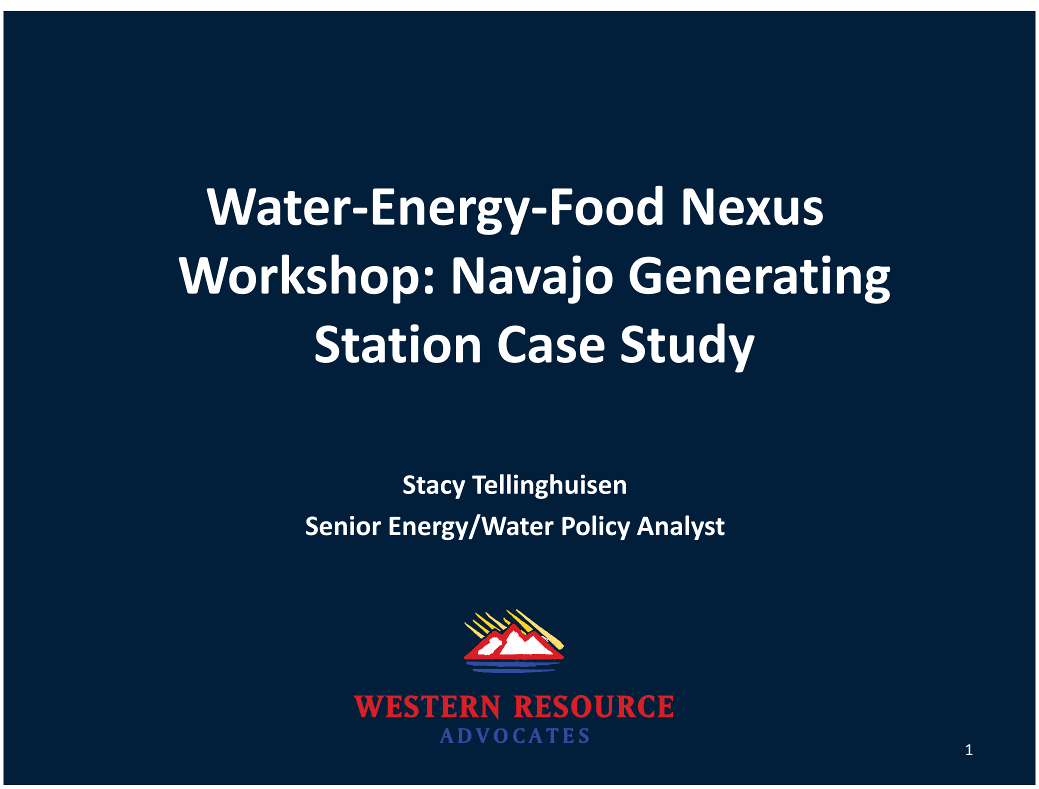
For more information:

http://www.ngspower.com/

http://www.cap-az.com/index.php/public/navajo-generating-station/twg-bart-proposal

http://www.ngspower.com/twg.aspx

http://webcms.pima.gov/UserFiles/Servers/Server_6/File/Government/Drought%20Management/LDIG/Summaries/2013/9.11.13/CAP%20Better%20than%20BART%20handout.LDIG%20091113.pdf



The Challenge

- Navajo Generating Station – 2,250 MW coal plant
- Department of Interior owns ~25% of the plant
- Plant provides revenues to Navajo and Hopi Tribes, and contributes to air quality problems
- Power pumps Central Arizona Project water
- Water is delivered to Phoenix, Tucson, Tribal lands, and agricultural lands
- Excess power sales contribute to the Lower Colorado River Development Fund

Base map source: http://www.ezilon.com/maps/united-states/arizona-geographical-maps.html

Western Resource Advocates

2

The Impetus

- NGS faced pending EPA regulations (regional haze)
- Several plant owners terminating contracts
- President Obama announced climate change action

Base map source: http://www.ezilon.com/maps/united-states/arizona-geographical-maps.html

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3

Solutions

Alternative to BART Agreement

- Better than BART NOx reductions;
- 1 Unit (or equivalent) retired in 2020;
- Plant owners – mitigate economic impacts on local communities
- Department of Interior – CO_2 Reduction Commitment (3%/year) for its unit, or 11.3 million metric tons by 2035
- DOI – Clean Energy Development Commitment;
- DOI – Evaluate transition from NGS to cleaner sources of energy
- Bureau of Reclamation – mitigate impacts on cost of water

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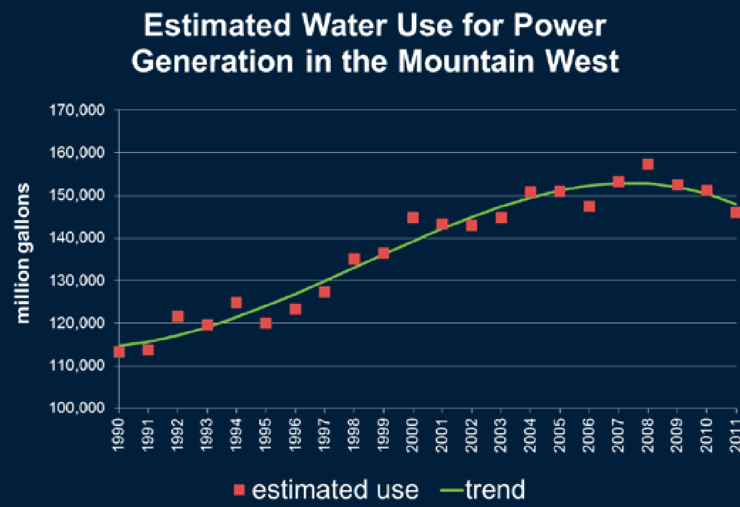
Takeaways

- Stakeholders – and government agencies – have disparate interests and priorities (e.g. water costs, Trust obligations, CO_2 reduction goals, etc.)
- Key #1: breaking the link between energy, water, climate, and money
- Key #2: leadership at Bureau of Reclamation

Western Resource Advocates 5

Takeaways

- Are energy utilities reporting – and valuing – water use today?
- Are water utilities considering future energy demands? Their reliance on energy? GHG emissions (and future costs)?
- Are we recognizing the positive trends underway?



Western Resource Advocates

6

26. Supplying Southern Nevada: Challenges and Solutions

Presented by Zane Marshall, Director, Water & Environmental Resources, Southern Nevada Water Authority

Southern Nevada's population is projected to increase by an annual average of 1.2% through 2050. Nevada's water share from the Colorado River is 0.3 million acre-feet, which is not enough to supply urban water demands in Southern Nevada. To address unique water supply challenges, Southern Nevada Water Authority (SNWA) requires out-of-the-box solutions, including:

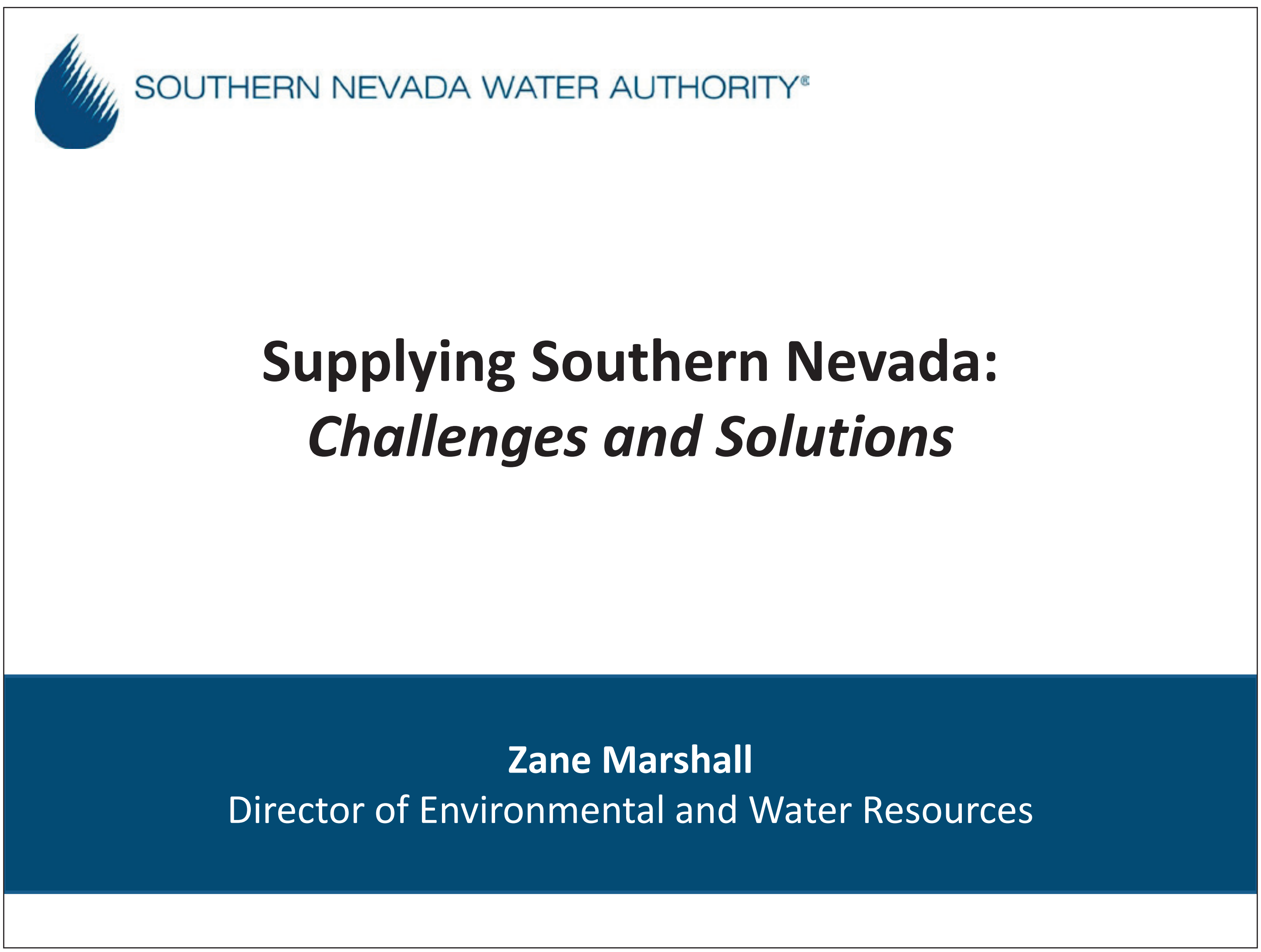
- Aggressive conservation
- Forging partnerships (Regulatory, public, private, NGO)
- Developing flexible water-use agreements
- Seeking alternate supplies

The SNWA has purchased and leased Nevada surface water rights, which were previously used for agriculture, along the Virgin and Muddy Rivers. These water transfer agreements are mutually beneficial for both parties. Resources help diversify resource portfolio and SNWA pays assessments, contributing to long-term stability of the irrigation company. These partnerships with agricultural users can be beneficial without impacts to food production. The agreements also provide environmental benefits to maintain Lake Mead water elevations and to keep water in the tributaries that would have otherwise been used for agriculture. SNWA has also planned for in-state groundwater projects as a water supply separate from the drought-stricken Colorado River. Modification of Nevada's water law allows for Intentionally Created Surplus. These policy changes required significant efforts and a lot of time.

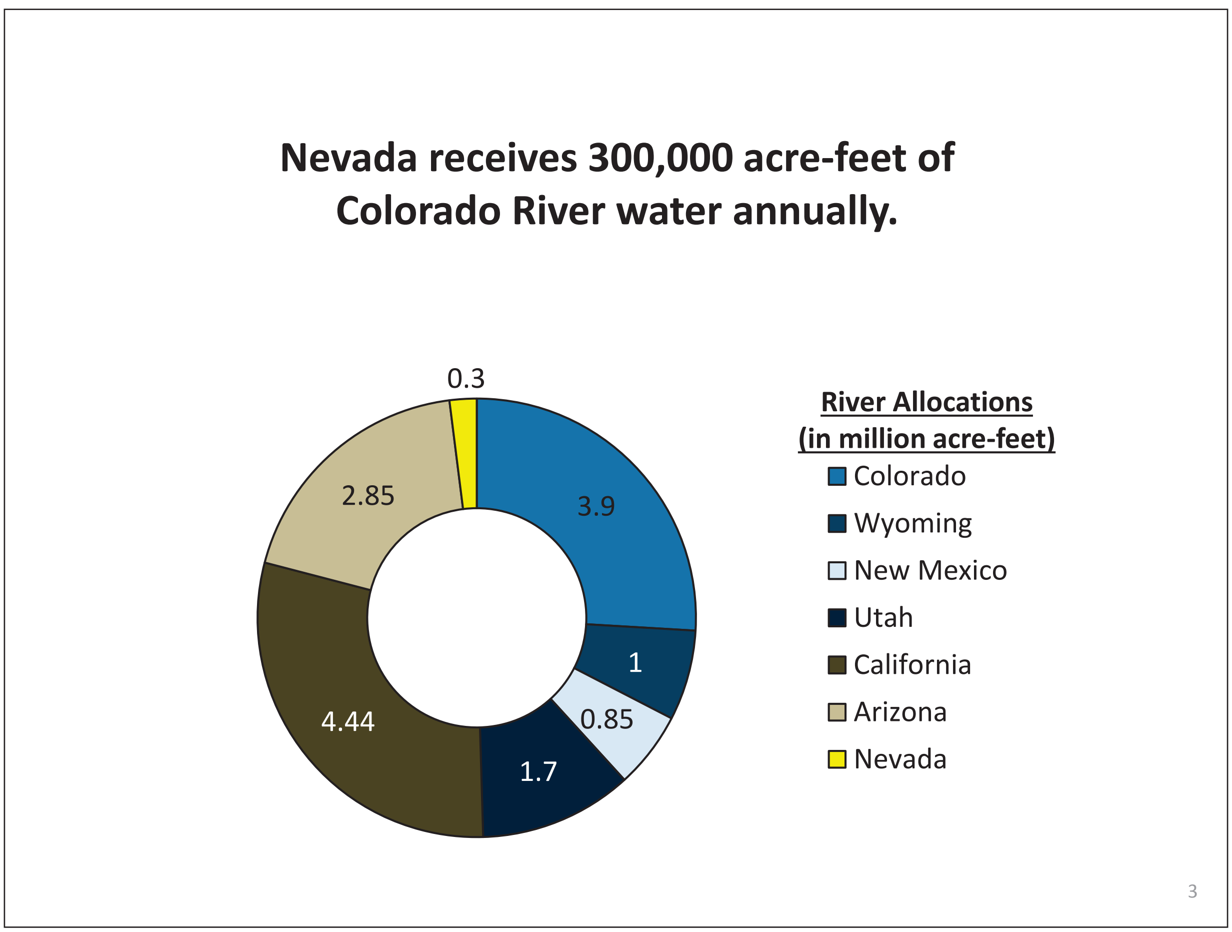
For more information:

http://www.snwa.com/ws/cac_recommendations.html

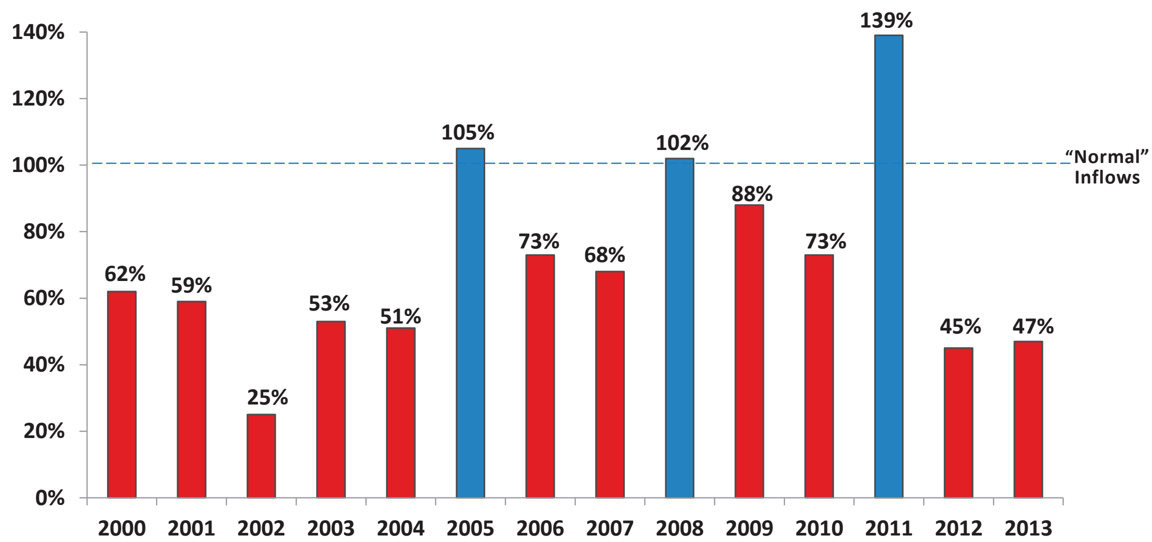
http://www.snwa.com/ws/cac.html




SOUTHERN NEVADA WATER AUTHORITY®
What We Do:
Regional water supply planning
Conservation programming
Water Quality
Facility construction
Operate Major Regional Facilities
2

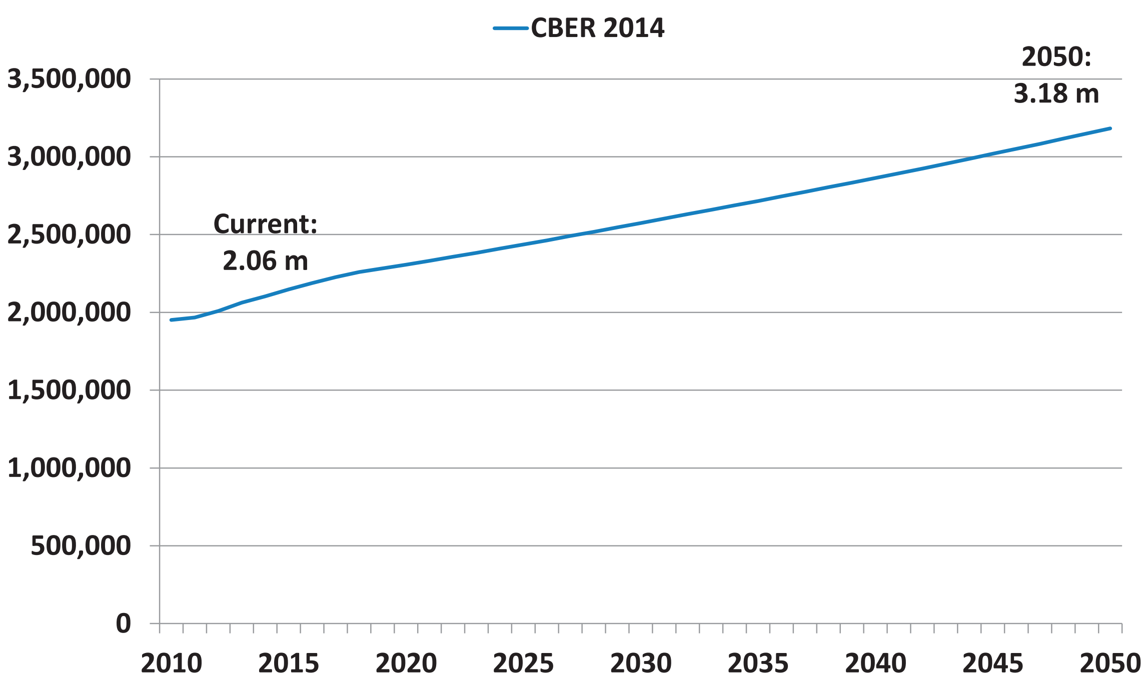

Nevada receives 300,000 acre-feet of Colorado River water annually.
River Allocations (in million acre-feet)
Colorado
Wyoming
New Mexico
Utah
California
Arizona
Nevada
3.9
1
0.85
1.7
4.44
2.85
0.3
3

Lake Powell's annual inflows continue to be below normal.



4

In addition to dwindling supplies, Southern Nevada's population is expected to grow by nearly 1 million residents over the next 35 years.



5

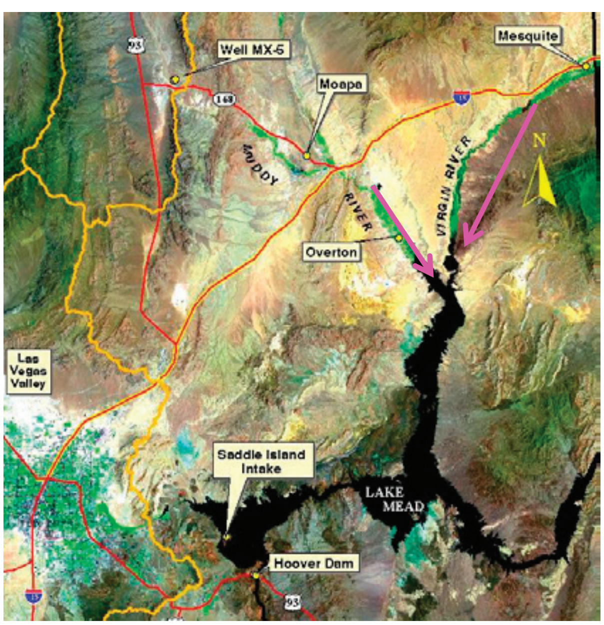
What We're Doing:

Addressing Southern Nevada's unique challenges requires out-of-the-box solutions:

- **Aggressive conservation**
- **Forging partnerships (Regulatory, public, private, NGO)**
- **Developing flexible water-use agreements**
- **Seeking alternate supplies**

6

Water Right Leases/Purchases



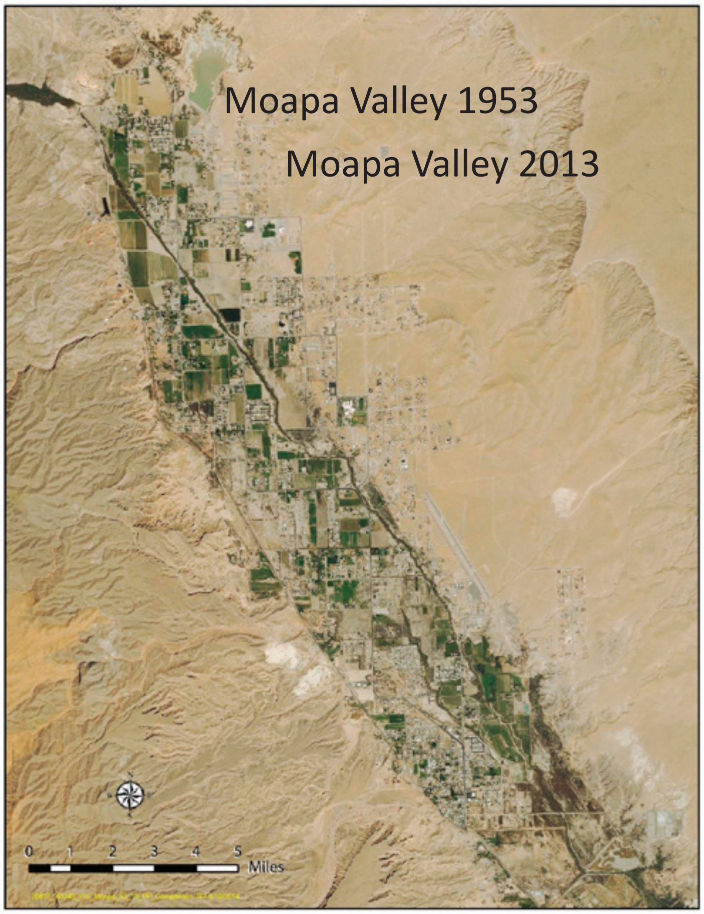
The SNWA has purchased and leased Nevada surface water rights along the Virgin and Muddy Rivers.

Water Rights pre-date Boulder Canyon Project Act: pre-1929.

These water rights were previously used for agriculture (forage crops).

7

7



Agricultural areas experiencing urbanization

Muddy River purchases began in 1997 through Requests-for-Offers

Agreements with Irrigation Companies facilitating leases/ purchases

The agreements have been mutually beneficial for both parties.

Willing Seller

- Individual shareholder's decision
- Irrigation companies agree to not divert SNWA water or leave in ditch; SNWA becomes last turnout

Willing Buyer

- The additional supplies help protect Lake Mead water elevations
- Resources help diversify resource portfolio
- SNWA pays assessments, contributing to long-term stability of the irrigation company

9

SNWA Acquisitions

Own: ~15,000 afy
Lease:

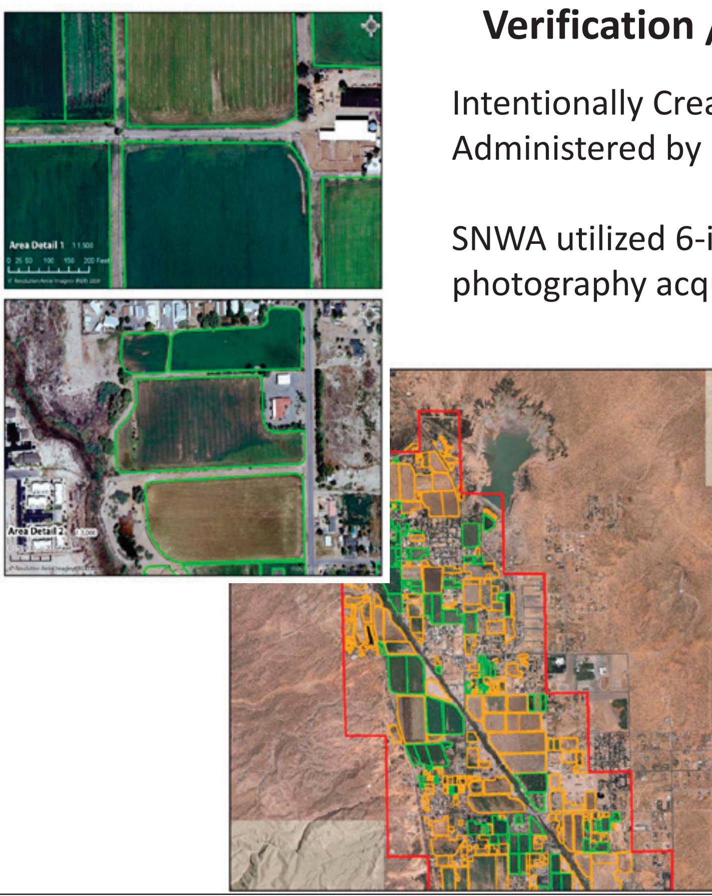
- Long-term ~5,000 afy (>20 years)
- Short-term ~11,000 afy (1 to 3 years)

Acreage represented by owned/leased shares ~ 3,500 arces

- Roughly a third already out of production when acquired
- SNWA does not own land

Leases ranged from $250/af to $130/af as economy and SNWA need for water has changed

Verification / Accounting process



Intentionally Created Surplus
Administered by Bureau of Reclamation

SNWA utilized 6-inch resolution aerial photography acquired 3 times per year

Muddy River:
Total water budget to demonstrate flows to Lake Mead

Virgin River: acreage verification

Checked and Certified by Nevada State Engineer and USBR

Beyond the benefits the leases/purchases affords to the parties, it is also provides environmental benefits:

- Maintains Lake Mead water elevations
- Keeps water in the tributaries that would have otherwise been used for agriculture

12

In-State Groundwater Project

Groundwater Development Project alignment

A water supply separate from the drought-stricken Colorado River is necessary to meet Southern Nevada's long term demands.

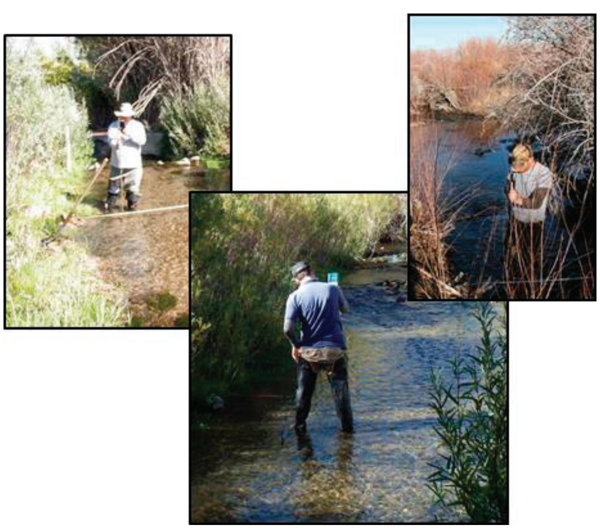
14

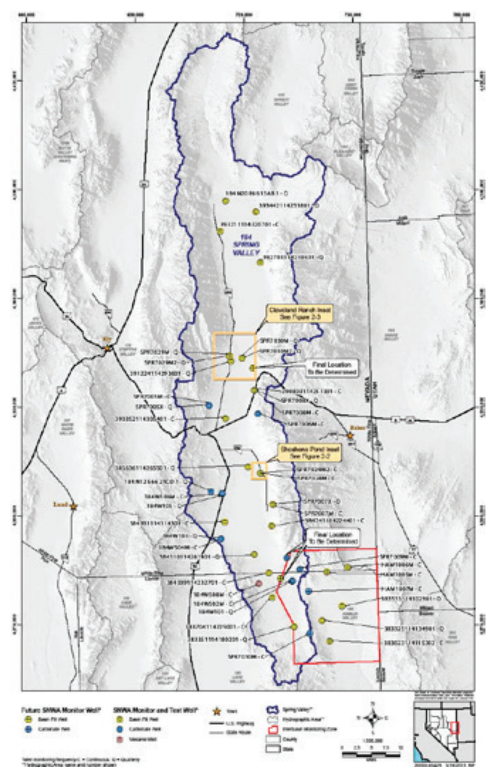
To support future development of the project, the SNWA has purchased several ranches in the project area:

- Support sustainable resource management
- Allows the SNWA to meet state and federal requirements
- Provides access to resources
- Promote community engagement

The properties also support environmental monitoring efforts:

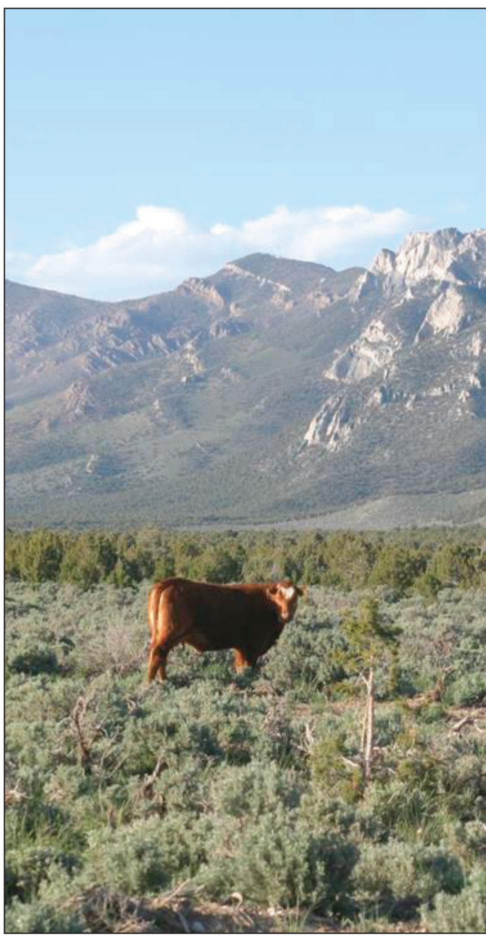
- >200 Hydrologic sites
- 15 Climatological sites
- 44 Biological sites





Safeguards are in place to protect existing water users:

- Nevada water law (prior appropriation)
- Federal stipulations among affected federal agencies
  - Stakeholder-led workgroups and management teams
- Extensive, state-approved monitoring and management plans
- An established history of managing watersheds and sensitive environments (Las Vegas Wash)



Partnerships with agricultural users can be beneficial without impacts to food production:

- **Meets existing and anticipated M&I demands**
- **Beneficial to environment**
- **Flexible in nature**
- **Avoids future conflicts**

27. NEWBA “Grass-Roots” Approach

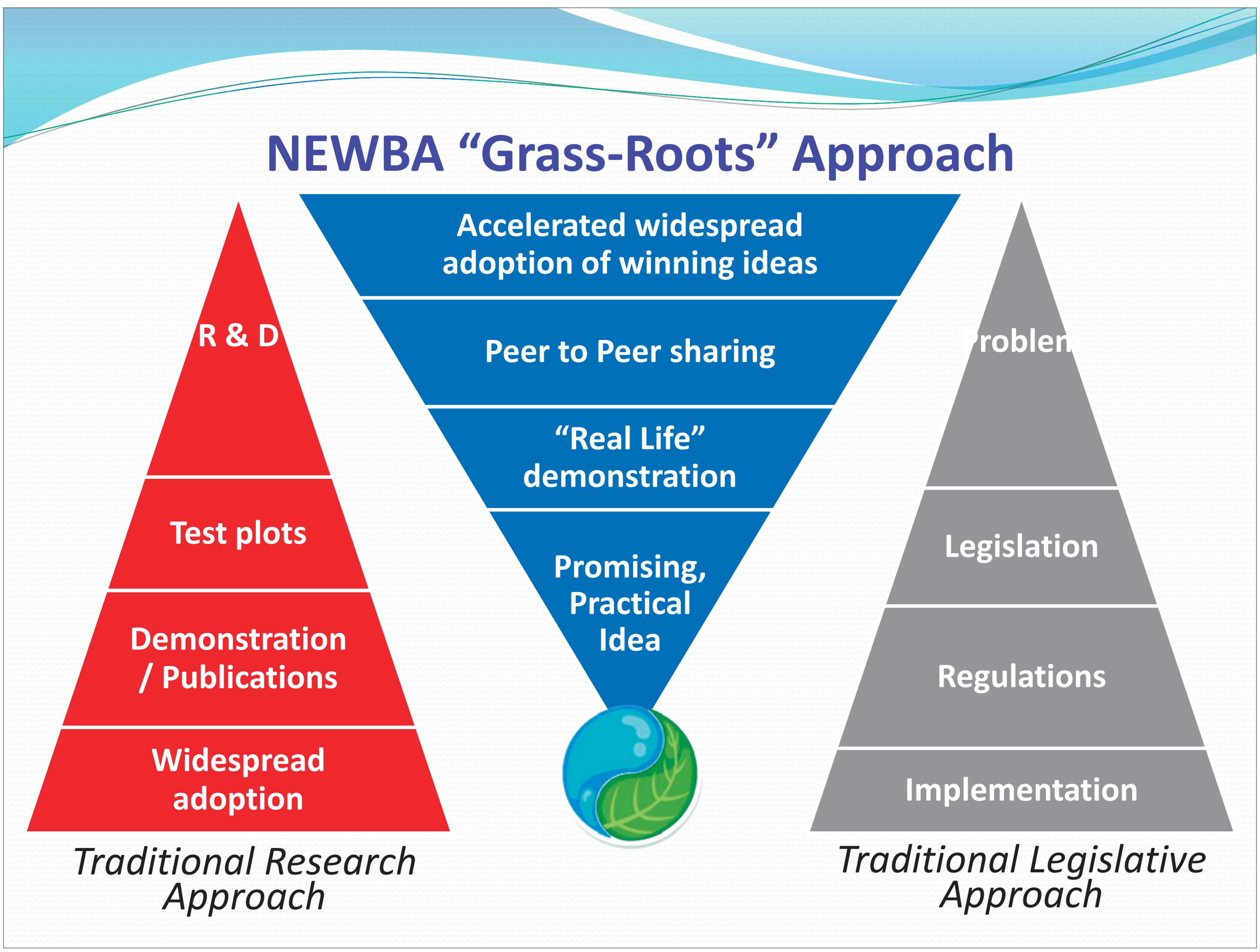
Presented by Laura Chartrand, Water Resources Policy Advisor, Tri-State Generation & Transmission

Traditional research approach would start with research and development, and then continue by test plots, demonstrations/publications, and widespread adoption. Traditional legislative approach, on the other hand, would start with problem identification, and continue with legislation, regulation, and implementation. Nebraska Water Balance Alliance’s (NEWBA) Grassroots Approach, which is believed to be more powerful than the traditional research and legislative approach, starts with specification of promising and practical ideas, and continues with “real life” demonstration to engaging parties, peer to peer sharing, and results in accelerated widespread adoption of winning ideas. This approach was tested in a small scale in Nebraska and was concluded to be very successful. The main lessons learned from this case were summarized as:

- “Real life” studies help shorten learning and adoption curve for new technologies
- Grower concerns with technology must be addressed to gain confidence
- Localized weather is required to make good decisions
- Data must be “real time”
- Telemetry and flow meter must be compatible
- Pressure Gauge readings should be on dashboards
- Residue management is especially important when water is limited

For more information:

http://www.nebraskawaterbalance.com/



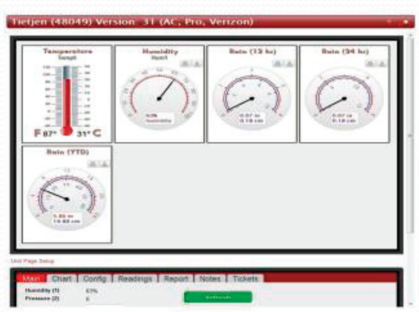
Real Time Management
Water Data

1. Real Time Consumptive Water Use:

- Weather Stations record Evapotranspiration (ET)
- Record planting and emergence dates
- Record daily growth stages

Real Time Management
Water Data

2. Real Time Water Application:



Ag Sense
Crop Link

Ag Sense
Field
Commander

Comparing:
- Flow meter
- Power company energy readings
- Pressure gauges

Cross check for accuracy

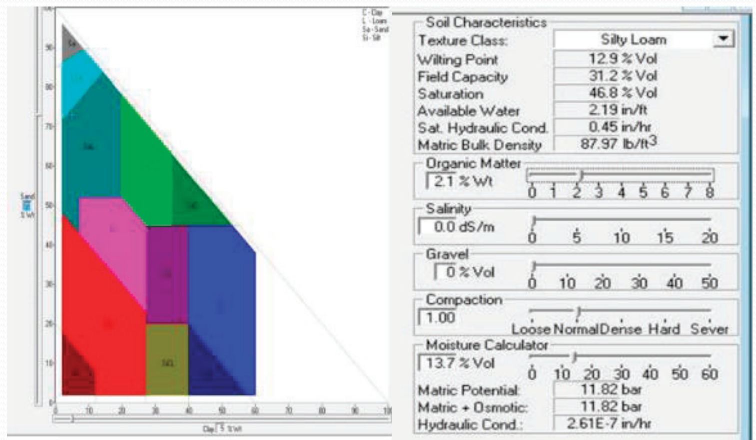
Real Time Management

Water Data

2013

3. Real Time Water Availability in the soil

Soil Texture Triangle



What did we learn?

2012

- **"Real life" studies** help shorten learning and adoption curve for new technologies
- **Grower concerns** with technology must be addressed to gain confidence
- **Localized weather** required for good decisions
- Data must be **"real time"**
- More study of **nitrates** is needed

2013

What did we learn?

- **Telemetry and flow meter** must be compatible
- **Sprinkler package** problems -- greater than anticipated
- **Pressure Gauge** readings should be on **dashboards**.
- **Nitrogen movement** is higher than expected
- **Residue management** is especially important when water is limited

2013

Real Time Management

Team Approach

Tri-State Generation and Transmission Association, Inc. — A Touchstone Energy Cooperative
Dawson Public Power — today's energy. tomorrow's vision.
Midwest Electric Cooperative Corporation — Your Touchstone Energy Partner
Central Nebraska Public Power and Irrigation District
Nebraska Public Power District — Always there when you need us
McCook Public Power Dist.
Wheat Belt Public Power District
southern power district — lighting the way
Roosevelt PPD

McCrometer
21st Century Equipment LLC
earthtec Solutions
AgSense
Simplot Grower Solutions
AquaCheck Soil Moisture Management
Sargent Irrigation
Landmark Implement
Olsen's Agricultural Laboratory, Inc. — www.olsenlab.com
SFP
WinField Solutions

At the Center — University of Nebraska Lincoln

Twin Platte Natural Resources District
Middle Republican NRD
North Platte Natural Resources District
Tri Basin Natural Resources District
Upper Republican Natural Resources District

28. Facing the Challenges: Water-Energy Nexus in Austin, Texas

Austin, located near the center of energy-rich and water-stressed Texas, is one of the fastest growing cities in the U.S., with 80% population growth from 1990 to 2011 [29]. This rapid growth has made it challenging for the public electricity and water suppliers to provide reliable and affordable services while promoting environmental sustainability. However, Austin suppliers have successfully integrated and strategized programs and policies to sustainably meet the public demands. Austin Energy, as the 8th largest public electricity utility in the U.S., serves more than 400,000 customers and Austin Water, as its 5th largest consumer, which uses 210,000 MWh electricity to pump and treat 200 million m3 water and 100 million m3 wastewater [30].

Energy and water conservation initiatives are important aspects of the city. Austin Energy initiated the Green Building Program in 1990. A citizen driven effort terminated a substantial development over a local aquifer the same year. This effort was followed by the adoption of the city's Save Our Springs ordinance in 1992 to ensure sustainable use of water resources [31]. Austin Water and Austin Energy continuously measure the amount of energy used in providing water services, water use in thermoelectric generation, and the average water use in water and energy services to use these data in optimizing water and energy use and keeping costs down.

Austin Energy has conserved 700 MW in demand-side and targeted an additional conservation of 800 MW peak-day demand by 2020. Meanwhile, Austin Water is making comprehensive water conservation efforts, such as a tiered rate structure and weekly watering schedules for landscaped areas, which has reduced peak seasonal demand. In addition, the two utilities collaborate in generating renewable energy and reducing greenhouse gas emissions [31]. Additional demand-side energy savings are practiced in the city by distribution of high-efficiency kitchen and bathroom aerators and showerheads, as well as rebates to buying high-efficiency dishwashers, washing machines, auxiliary water and irrigation system upgrades [32]. In addition, Austin Water employed Green Choice, Austin Energy's 100% wind energy program, in 2011 resulting in an 85% reduction in the water utility's greenhouse gas emissions. The utility has also reduced its surface water withdrawals through its reclaimed water program and supplies low cost water to energy generation facilities operated by Austin Energy and the University of Texas [31].

For more information:

http://www.statesman.com/news/news/local/austin-property-taxes-jump-38-over-past-decade/nRprf/

http://www.yumpu.com/en/document/view/13766054/austin-energy

http://unesdoc.unesco.org/images/0022/002257/225741e.pdf

http://aceee.org/w-e-program/city-austin-multifamily-energy-and-wat

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