Water Demand Forecasting Research

ASU Water Demand Workshop

April 2013

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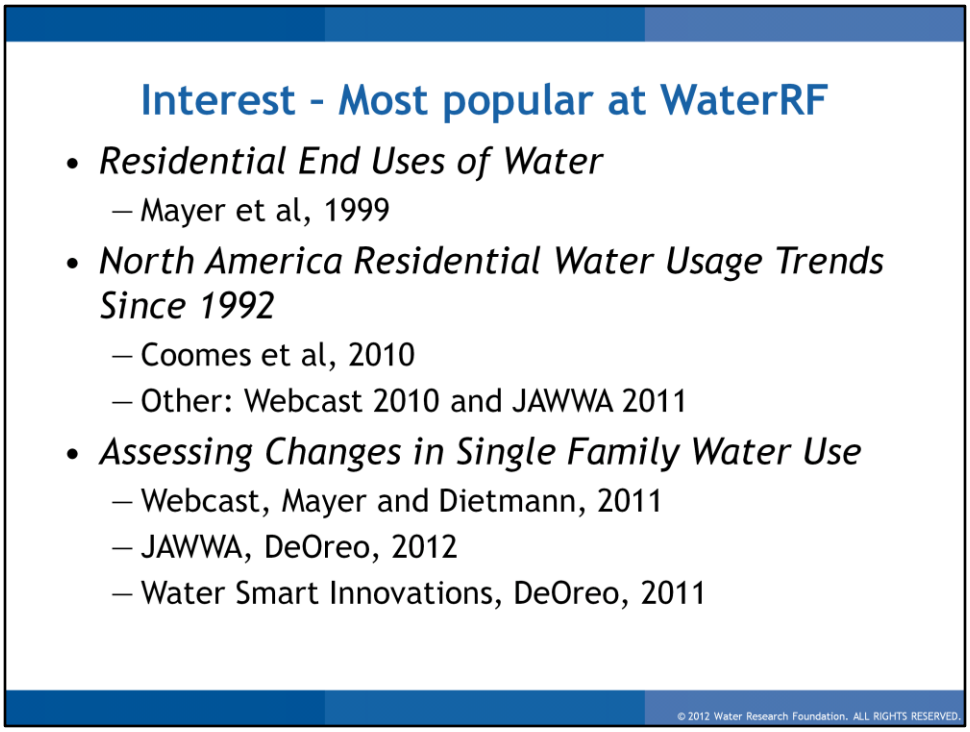
advancing the science of water

Agenda

- Interest by water community
- Utility initiatives
- Recent research and reports
- WaterRF Focus Area

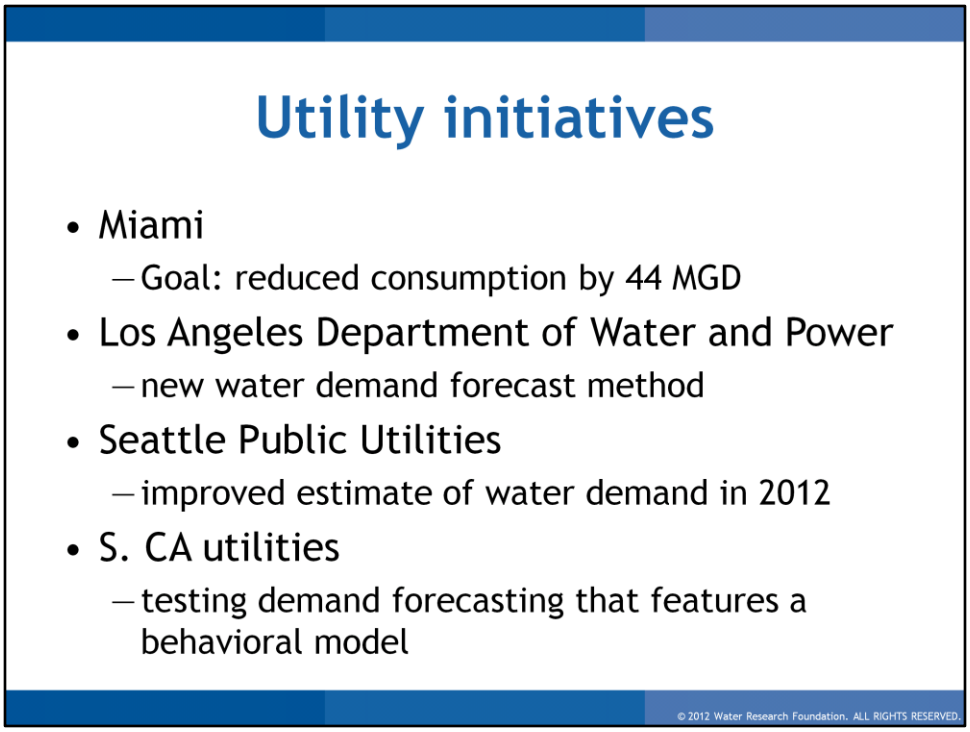


Residential End Uses of Water[1] (Report 90781), Mayer et al, 1999. First large study (~1000 homes in 14 cities) determining residential indoor end uses of water via data logging customer meters and analysis with Trace Wizard software. With 3100 PDF downloads since 2011, it is one of our top 3 most popular reports. Calculated indoor use of 177 gphd.

North America Residential Water Usage Trends Since 1992[1] (Report 4013), Coomes et al, 2010. Webcast 2010. Journal AWWA, Vol 103, No 2, Feb 2011, p76-89. This is our most popular webcast (see Youtube) and included presentations from the U of L researchers plus Louisville Water and Phoenix Water. Found that single family residential water use decreased by 389 gallons annually over 30 years. Compounded annually, that's a 13.2% decline. Data based on 58 utilities. Further analysis (indoor end use analysis by data-logging 60 meters and economic regression)was conducted at Louisville to determine the reasons for their decline. Calculated indoor use of 152 gphd.

Webcast: Assessing Changes in Single Family Water Use, Mayer and Dietmann, 2011. This is the 6th most popular webcast. Peter Mayer, Aquacraft summarizes single family residential end use studies, including the 1999 report, the 2011 California study, and EPA studies of higher efficiency homes. Aquacraft has presented this summary at Water Smart Innovations 2011 and in JAWWA 2012.

[1]These projects received federal funding, so the reports are freely available to the public.



Miami-Dade

- Reported that one of the major initiatives was their Water Use Efficiency Plan which reduced consumption by 44 MGD.
- Source: Miami-Dade Water and Sewer Department, Comprehensive Financial Annual Report, September 2011

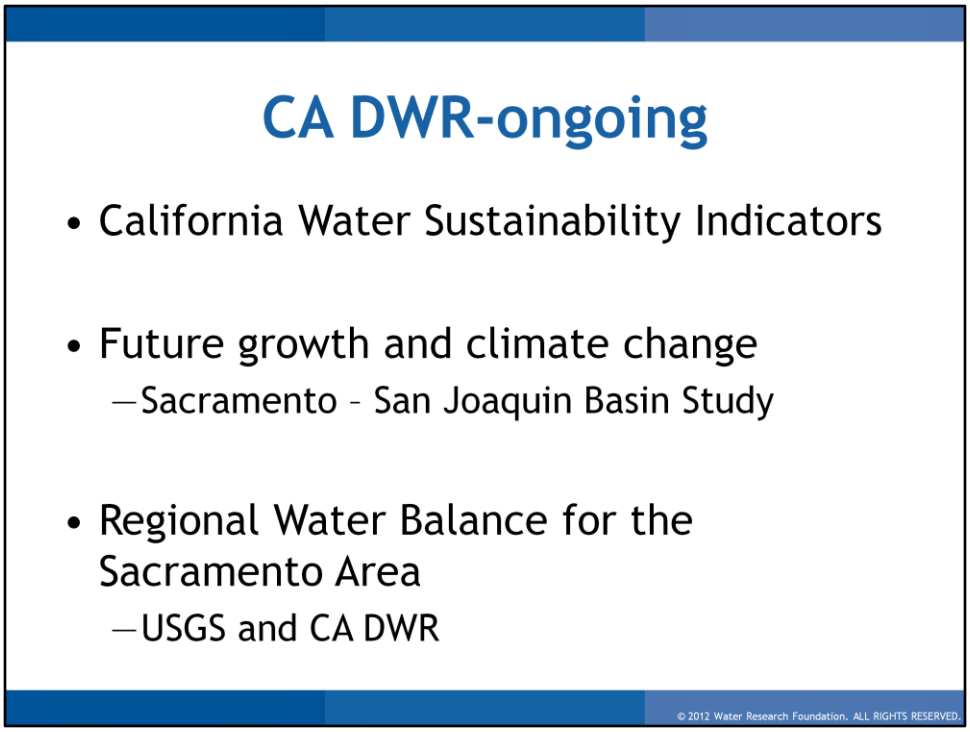
Los Angeles Department of Water and Power

- In 2008 created a Water Supply Action Plan to address reliability issues associated year to year variability in water supplies, contamination of local ground water, and reduced imported water from the future climate change. Plus has to meet California Senate Bill X7 7 (20 x 2020).
- LADWP developed a new water demand forecast based on a more rigorous analysis of water use trends and measurement of achieved water conservation. The model used (1) the latest trends in water use; (2) econometric-derived elasticities for estimating the impacts of weather, price of water, income, and family size on per household and per employee water use; and (3) more accurate estimates of the effectiveness of water conservation in the City.
- Source: Urban Water Management Plan 2010

Seattle Public Utilities

- "total average annual demand is forecast to remain at or below current levels through 2060, significantly lower than what was forecasted in the 2007 Water System Plan"
- Source: 2012 Water System Plan-Plan Summary.

S. CA utilities: testing demand forecasting that features a behavioral model for residential sector from Australia consultants (personal correspondence)

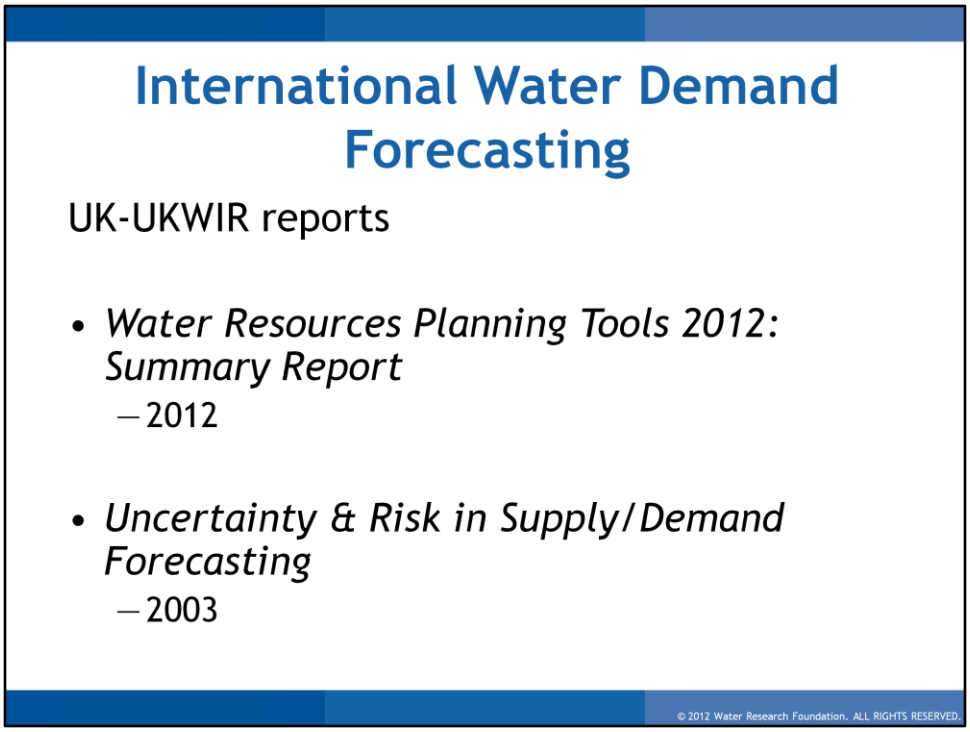


CA DWR: their research interests focus on CA (or specific regions in CA) and hydrologic regions (different scope than an individual utility). We will try to partner with them, but so far we have not found a project in common. Some examples of their interests and projects are below.

California Water Sustainability Indicators Framework
Goal: Help monitor progress to meeting water sustainability objectives through the development and application of an analysis framework. The framework also includes the development and evaluation of water footprint. The framework is being developed in collaboration with experts from UC Davis and U.S. EPA Region 9, and a wide array of stakeholders. (Notes: part of the California Water Plan Update 2013. As of 2011, the 4 indicators were identified; ecological footprint, water footprint (calculated according to Water Footprint Network), total terrestrial water storage from GRACE satellite data, plant growth index (photosynthetic capacity from data from multiple satellites (Landsat, NDVI, MODIS AVHRR)).

Implementing multi stakeholder Sacramento – San Joaquin Basin Study - The Department of Water Resources is collaborating with the U.S. Bureau of Reclamation, Stockton East Water District, the California Partnership for the San Joaquin Valley, El Dorado County Water Agency, and the Madera County Flood Control and Water Conservation Agency on the development of the Sacramento-San Joaquin Basins Study as part of the federal Water Conservation Initiative. The Sacramento-San Joaquin Basins Study will develop a comprehensive assessment of potential climate change impacts to water supplies and demands in the Sacramento, San Joaquin and Tulare Lake Basins. Where deleterious impacts are identified, the Study will recommend mitigation or adaptive strategies designed to ameliorate the effects of climate change to water facilities, operations and management in the Sacramento, San Joaquin and Tulare Lake Basins. Development of the Basin Study is expected to occur over a two year period, starting in October-November 2012 and completed by November 2014.

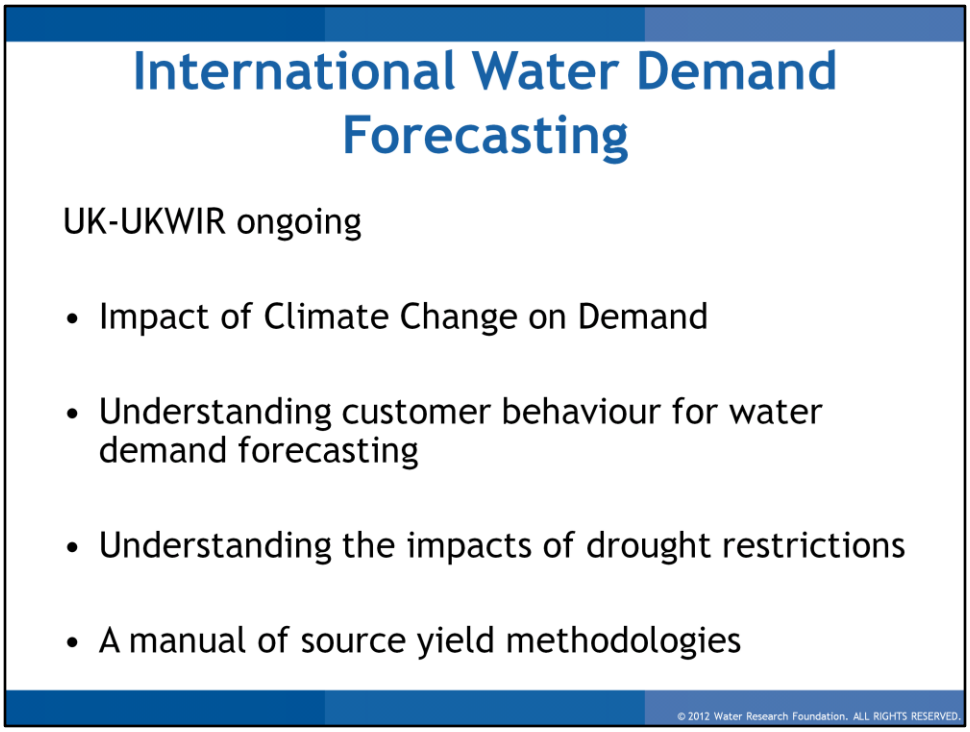
Integrating water use and water supply information between CA DWR and the US Geological Survey - This proposed cooperative effort will help provide needed improvements in data and data networks that define the resource, improve understanding of the links between components of the hydrologic cycle, and improve quantification of water use, including environmental needs. This approach includes a combination of short- and long-term cooperative efforts in support of both state (State Water Plan) and federal (National Water Census) programs. Moving forward in 2013.



Water Resources Planning Tools 2012: Summary Report (12/WR/27/6).
The research project titled 'Water Resources Planning Tools 2012', with a primary focus on the Deployable Output (DO) and the Economics of Balancing Supply and Demand (EBSD) methods, has resulted in improvements to the existing water resources planning tools. These tools include methodologies, guidelines and modelling approaches associated with the production of water management plans. The project developed risk-based DO and EBSD methods. These methods are scalable and allow planners to choose and use techniques of different levels of sophistication, proportional to individual needs, planning issues and available data sets. The improved methods incorporate levels of service to customers. This is highlighted through trade-off relationships between efficient EBSD programmes balanced with water system reliability. The project also evaluated new methods to respond to specific longer term planning needs, such as the need for new forms of economic appraisal. The Summary report has a series of five additional project outputs attached on CD-ROM. Published:2012 Price: £450.00

Uncertainty & Risk in Supply/Demand Forecasting - Volume A (03/CL/09/1)
Two Volume Report (Volume B supplied free of charge with Volume A) The report presents guidelines on how uncertainties in the individual elements of supply and demand can be brought together in an integrated way. The guidelines offer a hierarchical approach that allows the practitioner to select the most appropriate method for a given spatial area. At the simplest level the approach uses data from standard Water Resource Plan Tables, becoming progressively more complex requiring Monte Carlo simulation and then full simulation of the supply-demand balance at a weekly time step. The report also reviews the economic literature and provides guidance on how to interpret uncertainties and improve the process by which investment decisions are made. Published:2003 Price: £310.00

Source: UKWIR website April 2013



United Kingdom Water Industry Research, United Kingdom

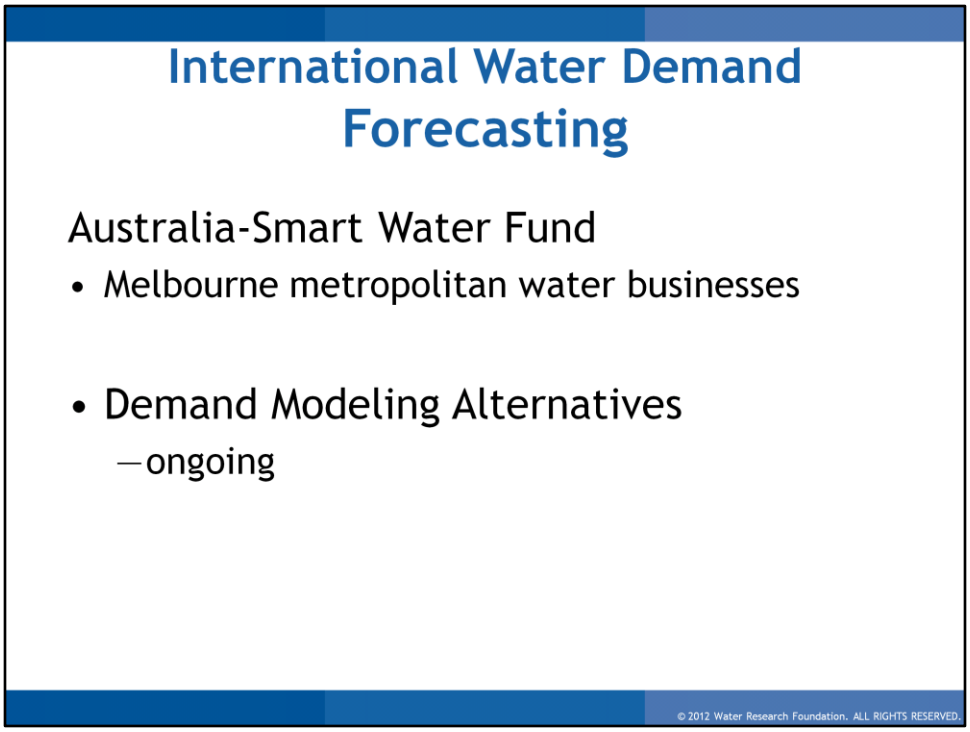
Impact of Climate Change on Demand. Objectives: 1. Provide evidence based estimates of the impact of climate change on the various components of water demand. This must include both annual average and peak period estimates. 2. To recommend to what extent should companies adjust their annual average and peak period forecast demands to account for the likely impact on climate change. 3. Develop a model to allow the application of climate change forecast in water demand forecasting. Commence Date: 13/12/2011.

Understanding customer behaviour for water demand forecasting. To improve understanding of customers' behaviour. Requirements of the project: • Produce improved data sets that can be used to model the impact of weather on the demand for water • Refine the models to account for regional differences in behaviour and water consumption • Refine the models to account for different base per capita consumptions • Improve the understanding of changes to non household demand • Understand the impacts of climate change on behaviour and predict how this could change the demand for water. • Run a survey to: - understand people's perceptions of climate change and drought and how they affect their behaviour - understand how much people are prepared to pay for reduced risk of water use restrictions - develop predictions of the impacts this could have on the demand for water in different climate change scenarios. Commence Date: ?

Understanding the impacts of drought restrictions. Objectives: A clearer picture of the impact of Temporary Use Bans on various customer groups in particular breaking down the commercial sector into relevant categories. Obtain implementation data from companies. Analyse impacts of restrictions and summarise by customer category. Develop a methodology for assessing how to calculate usage impacts by category. Recommend how companies might collect and share data in the future to ensure this analysis can be enhanced. Consider an ongoing exercise to access 'bounce back' following removal of the restrictions. Deliver a report that can be used to inform future Drought Plans and water resource planning. Commence Date: ?

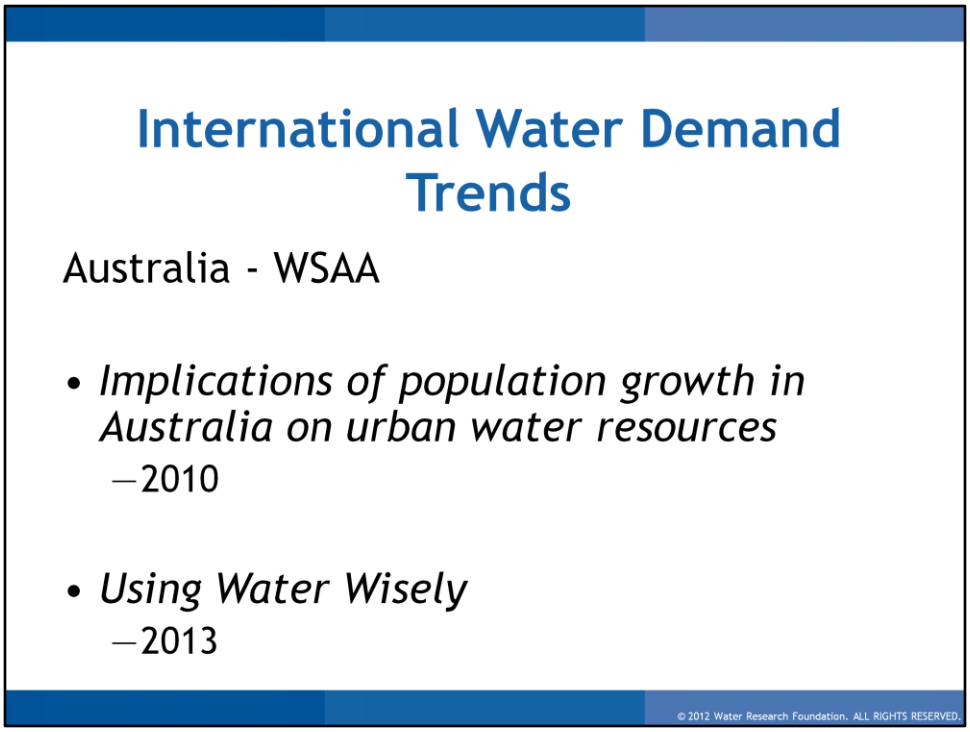
A manual of source yield methodologies. Objectives: To highlight, share, and review the detailed technical approaches that companies take in calculating source yields. How do companies calculate source yields - at a detailed, technical level? How do they build level of service into their yield calculations? For companies with conjuctive use models how is yield calculated? Do companies use scenarios or return periods? What can we learn from abroad? Do other countries calculate source yields? If so how? What improvements could be made, and how should they be taken forward? Commence Date: ?

Source: UKWIR website April 2013



Smart Water Fund, Australia
Demand Modeling Alternatives
The Melbourne metropolitan water businesses are undertaking a review of demand forecasting modelling and methodologies. Currently an End Use Model is being utilised by the water businesses. However, there is a need for an assessment of the strengths and weaknesses of alternatively available, or in-development modelling tools that could be utilised. The development of a robust framework for model evaluation is also required.

Source: Smart Water Fund Website, April 2013

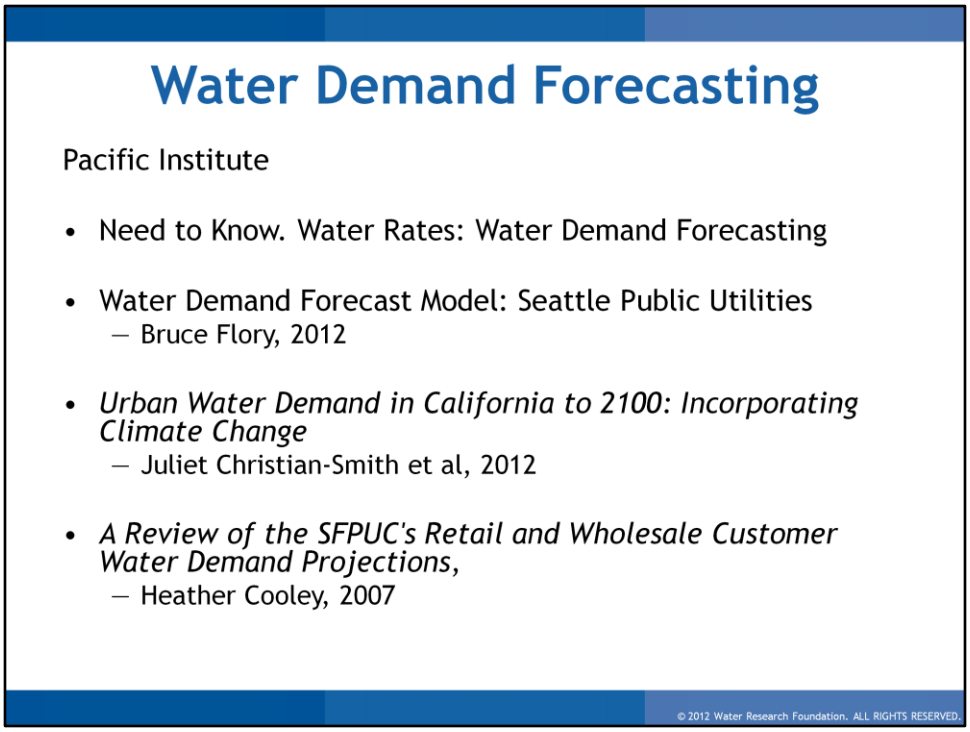


Water Services Association of Australia, WSAA have an "occasional" paper and a "position" paper available at their website. These are general overview papers.

Implications of population growth in Australia on urban water resources, 2010.
Australia's population is predicted to grow by an extra 21.5 million within the next 50 years. Even on the most conservative population growth estimates, it is predicted that major urban centres will have an additional demand of over 600 billion litres annually by 2026, and of over 1000 billion litres by 2056. This report explores these predictions, and anticipates the development of a diverse portfolio of water supply options required to mitigate the risks associated with population growth and climate change.

Using Water Wisely, March 2013
The Australian urban water industry recognises that the recent decade of extremes of dry, rain and floods, and high temperatures could well be our climate future. However the industry delivers water services 24/7, 365 days of the year and to be resilient against these challenges, our customers and the community are seeking a robust and diverse approach. Therefore, a combination of baseline investment in water efficiency (not wasting a drop) as well as developing new sources, particularly including those independent of rainfall, such as desalination and water recycling, is the key to a long and prosperous future. Water efficiency for urban water in Australia is a major success story.
• many of the savings achieved through water conservation and efficiency programs are now locked in, there is a new 'norm' for using water wisely
• customers clearly view using water wisely as the no. 1 priority in doing their part to develop liveable communities
• water security in Australian urban communities has been reached, so water efficiency, desalination and water recycling all form part of a diverse robust portfolio
• providing customers with options and choice on how to reach water efficiency targets will be the focus of the future, restrictions except in emergencies, are a thing of the past.

Source: WSAA Website April 2013



Pacific Institute

Need to Know. Water Rates: Water Demand Forecasting. Five page summary including some models.

Water Demand Forecast Model: Seattle Public Utilities, Bruce Flory, 2012. Powerpoint presentation.

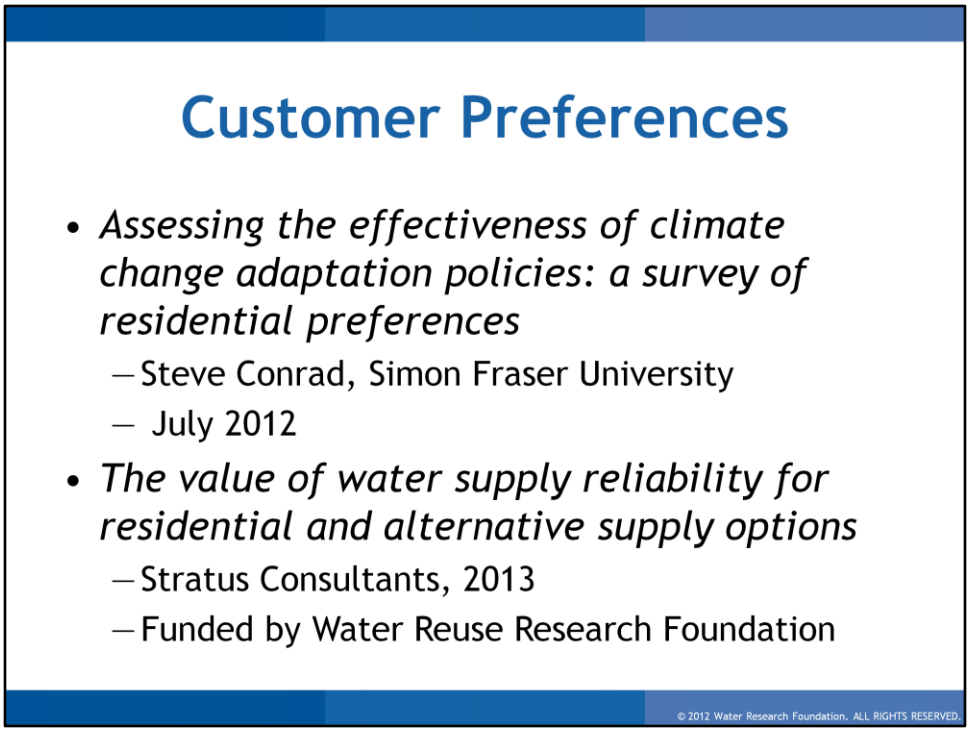
Urban Water Demand in California to 2100: Incorporating Climate Change, Christian-Smith, et al, 2012.

- See other slide for more info.

A Review of the SFPUC's Retail and Wholesale Customer Water Demand Projections, Heather Cooley, 2007

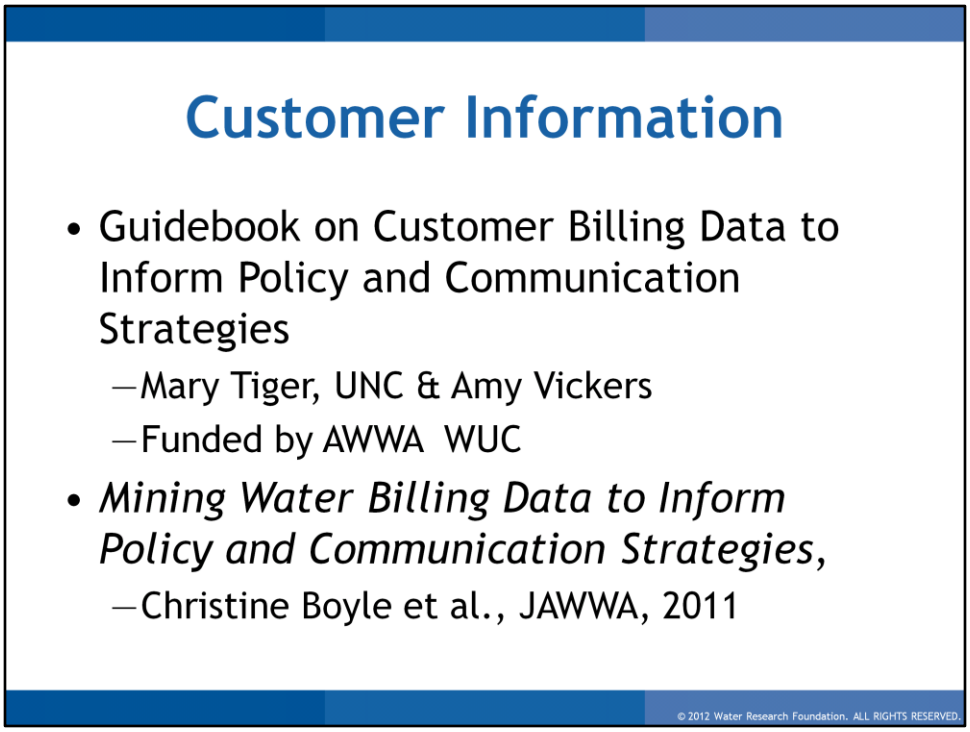
In an effort to satisfy the future water needs of its wholesale customers, the San Francisco Public Utilities Commission (SFPUC) commissioned a series of comprehensive assessments on the area's future water demand, conservation potential, and recycled water potential. Based on these studies, the SFPUC projects that by 2030, the total water demand of its wholesale and retail customers will increase by 14%, or 33 million gallons per day (mgd). To meet this projected demand, the SFPUC proposes to divert an additional 25 mgd from the Tuolumne River. In response to the SFPUC's proposal, the Tuolumne River Trust asked the Pacific Institute to independently review the SFPUC wholesale and retail customer demand projections along with the companion re-ports on water conservation and recycled water. Our analysis reveals that the SFPUC's studies are inadequate. They may significantly overestimate future regional demand for water. Furthermore, they underestimate the potential for cost-effective demand management and recycled water.

Source: Pacific Institute website April 2013



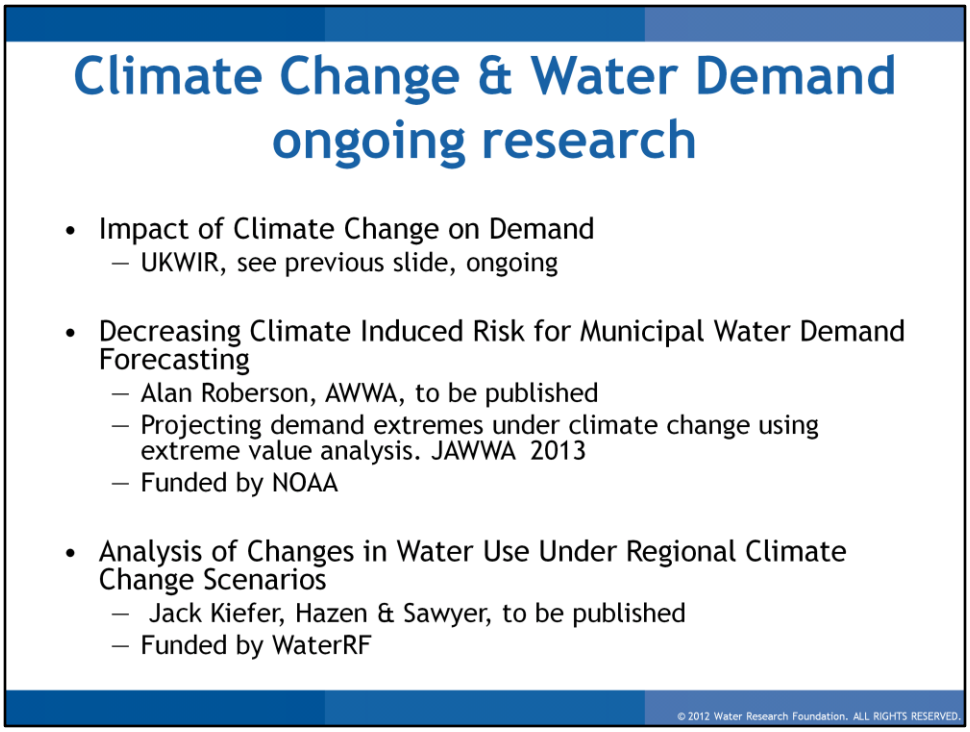
Simon Fraser University, Steve Conrad
Studying the response of water users under different policy/management options in anticipation of increased demands and water scarcity. Documented in 1-Natural Resources Canada's Regional Adaptation Collaborative Report on *Assessing the effectiveness of climate change adaptation policies: a survey of residential preferences*, Project Technical Summary, July 2012 and 2-*Okanagan Water Study: Resident Descriptive Statistics*, December 2012.

The Value of Water Supply Reliability for Residential and Alternative Supply Options, Stratus, 2013. Surveyed customers on their preferences for water restrictions versus paying extra to avoid restrictions and use alternative water supplies.



Guidebook on Customer Billing Data to Inform Policy and Communication Strategies
Mary Tiger, UNC & Amy Vickers
Funded by AWWA WUC
Mary Tiger presented April 2013 at AWWA Sustainable Water Management Conference

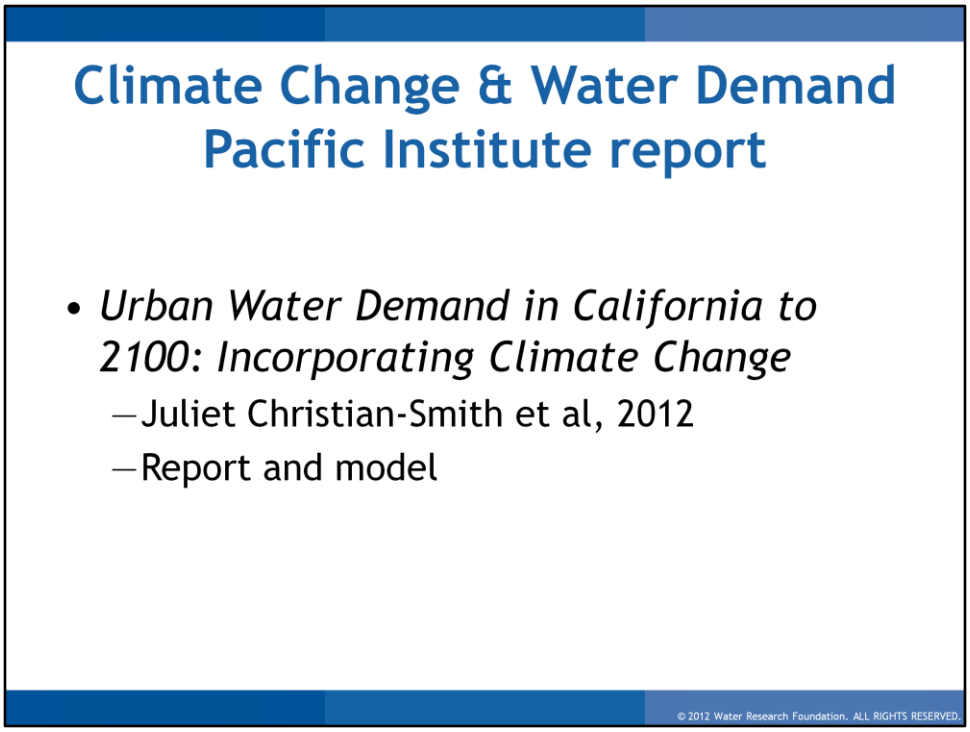
Mining Water Billing Data to Inform Policy and Communication Strategies, Christine Boyle et al., JAWWA, November 2011, Volume 103, Number 11, Page(s): 45-58.
ABSTRACT: Every utility serves a unique customer base with its own water use and revenue generation patterns. Knowing its customers in detail helps a water provider customize policies and communication strategies not only for the customer base but also for smaller, targeted groups. This article introduces a relatively inexpensive way that utilities can use existing billing data to learn more about customer use patterns and applies this methodology at five North Carolina utilities. Developing smarter revenue and water use analytics that take into account changes in use behavior helps utilities be proactive in planning for resources changes (and the resulting financial implications) and be more effective in their communications and marketing. By moving away from engaging with residential customers as one homogeneous mass and instead treating them as groups of customers with distinct habits and values, utilities can use targeted messaging and outreach to bring customers on board with new policy rollouts.



Decreasing Climate Induced Risk for Municipal Water Demand Forecasting

- Alan Roberson, AWWA (plus GWU and CU), to be published. Presented at AWWA Sustainable Water Management Conference, April 2013, Nashville, TN.
- Funded by NOAA (Climate Program Office, Climate and Societal Interactions). This program has funded projects on water supply, demand, and conservation but for wider audience.
- Projecting demand extremes under climate change using extreme value analysis, Haagenson et al., JAWWA, February 2013, Volume 105, Number 2.
- In this research, an integrated approach with two components was developed. First, extreme value models based on climate attributes were created for both water demand maximums and water demand over a specified threshold; these models were then fitted to the historic water demand and climate data. Second, ensembles of future weather sequences conditioned on climate change projections were generated using a stochastic weather generator. Together these two components provided scenarios of water demand extremes under various climate projections. The city of Aurora, Colo., was used as a case study to demonstrate the utility of this approach. (Source AWWA website April 2013.)

Analysis of Changes in Water Use Under Regional Climate Change Scenarios (Project 4263), Jack Kiefer, Hazen & Sawyer, to be published.
Will study anticipated water demands and use patterns under a range of climate change scenarios, categorized by specific customer class and industry sector, so that water utilities may better plan for and respond to changing water use patterns as a result of climate change. Will provide recommendations for water utilities to plan for and respond to the anticipated water use patterns, and will identify key concerns and areas for additional analysis by region. Features MWRA, San Diego, LVVWD, Tampa, Durham (Canada).

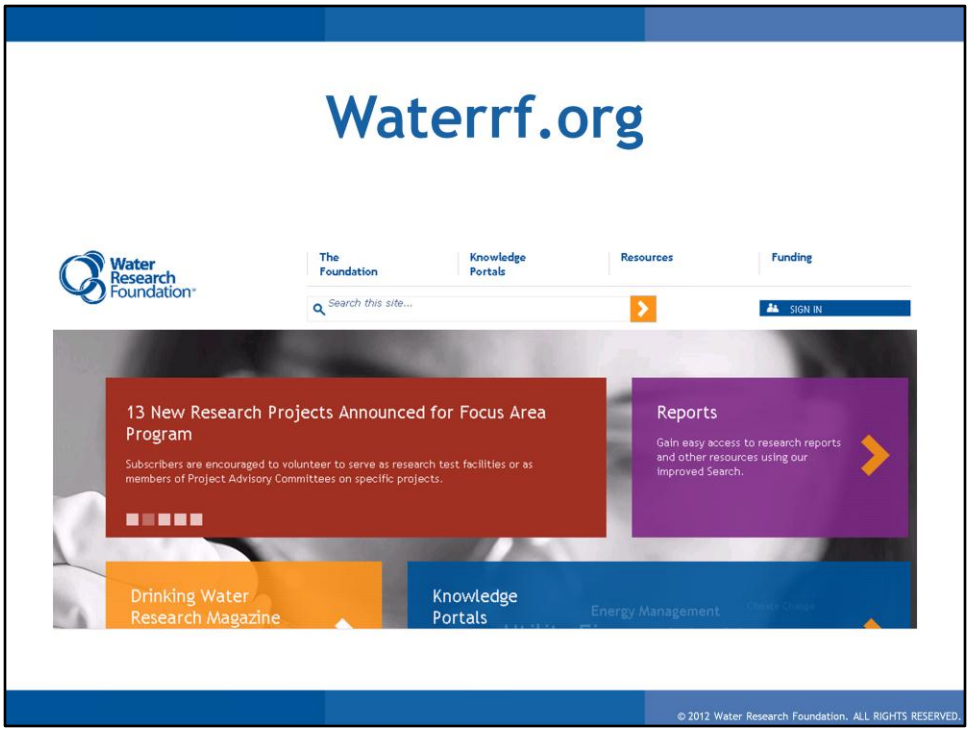


Pacific Institute

Urban Water Demand in California to 2100: Incorporating Climate Change, Christian-Smith, et al, 2012.

- Report and model
- A new, free tool from the Pacific Institute helps water managers to forecast urban water demand with four global climate change models and compare different possible futures to the year 2100 by altering greenhouse gas emissions, population projections, conservation and efficiency measures, and more. The research shows climate change will cause increased water use in California's cities and suburbs, even as water supply is expected to diminish.
- Tools for Success: Forecasting Water Demand, Christian-Smith, 2012. Powerpoint presentation.

Source: Pacific Institute website April 2013

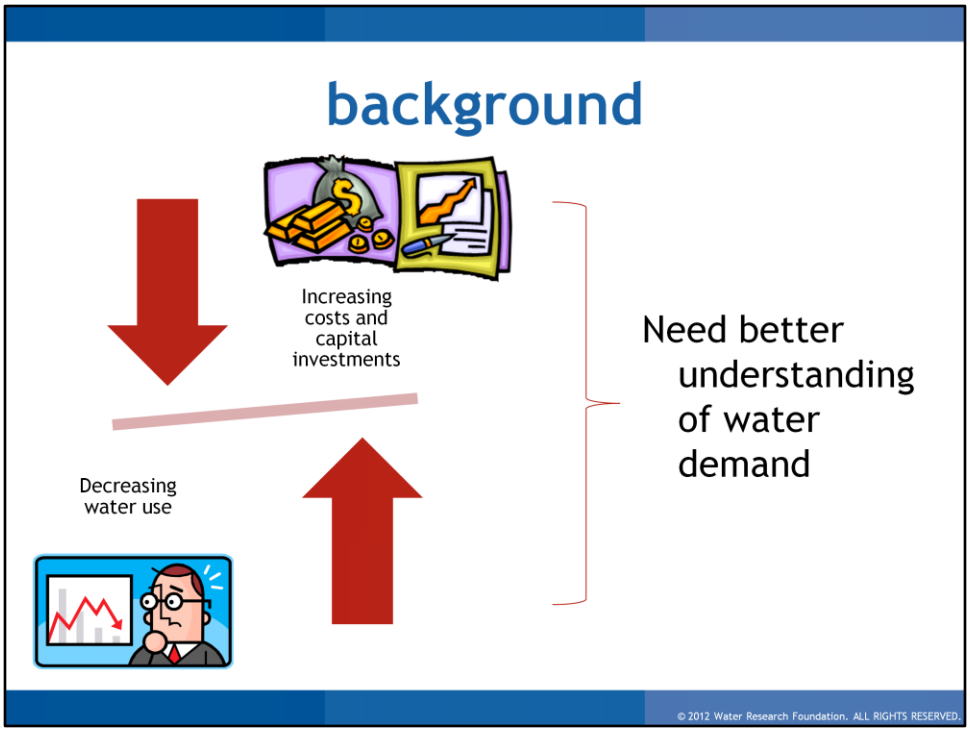


Organizations (utilities, consulting firms, manufacturers) are subscribers to WaterRF. We no longer allow IWA and AWWA to sell our reports. Most of our reports are subscriber only, however some are free to the public. All executive summaries are free to the public. We also offer webcasts, a quarterly magazine and an e-newsletter. The magazine and newsletter are publically available. We rely on many volunteers from the water community for research planning, overseeing technical aspects of the project, or participating in the research. If your organization is a subscriber, you may request access to the website via the Sign In dialog box.

In 2011-2012, we revised our research program and created 10 research focus areas where we would strive to have more strategic links between projects. We allocate 60% of our research funding to the Focus Area Program. Focus areas were primarily identified by staff and our volunteer advisory committees. We have focus areas on hexavalent chromium, nitrosamines, carcinogenic VOCs, infrastructure and risk management, water and energy nexus, utility finance and rates, contaminants of emerging concern, water demand, and biofiltration. In 2012, the volunteer advisory committees scoped out research agendas for 3-5 years for each focus area. Focus areas are review on an annual basis and will close out at different times. New focus areas will be adopted as needed.

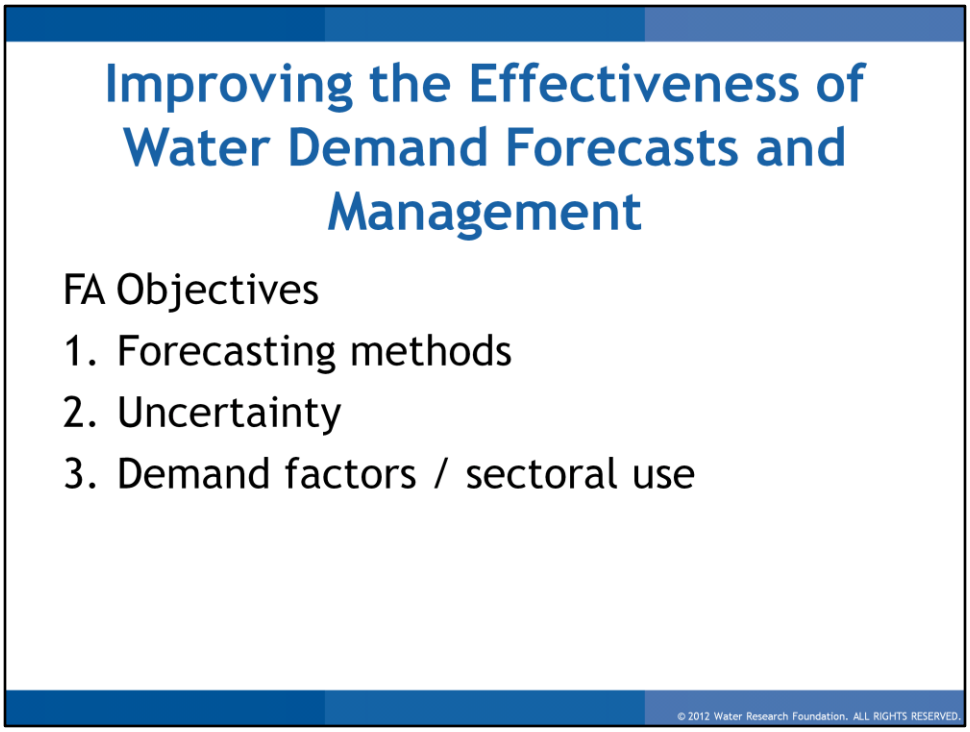
Demand Technical Advisory Committee

- Dave Bracciano, Tampa Bay Water
- Ray Quay, Arizona State University
- Bruce Flory, Seattle Public Utilities
- Chris Meenan, Las Vegas Valley Water District
- Jack Kiefer, Hazen and Sawyer
- Vlada Kenniff, NYC DEP
- Maureen Hodgins
- Jennifer Warner
- Jonathan Cuppett



The demand forecasting focus area was created due to the trend in declining residential water use and the large needs in capital investments. We also realized that large national end use type research is a current research need, is expensive, and likely no other organization would fund.

Traditionally, the concern was with having adequate water supply to meet the growing population's needs. Future uncertainty usually over estimated demand, and soon the population would grow into that excess capacity. Now, utilities are concerned about increasing costs, decreasing sales, and insufficient revenue. Water use is not tracking with population growth, due to water efficiency and conservation. Water use is decreasing (2011 report 4031 (NA residential water use trends) found decreasing single family water use nationally by 13% over 30 years. The single family residential sector is anywhere from 60-70% (USGS 58%, LADWP 67%, Denver 65%, LVVWD 59%). There are increasing utility costs (personnel, retirement/pensions), the need for increasing capital investment costs (AWWA estimates $1 trillion over 25 years to sustain our drinking water infrastructure) and water supply is still a concern for some areas. All together this creates an uncertainty which needs to be managed. Capital projects need to be considered carefully, to make sure that capacity meets demand. Revenue projections and rate setting need to really have good estimates of demand.



See WateRF website for more info.

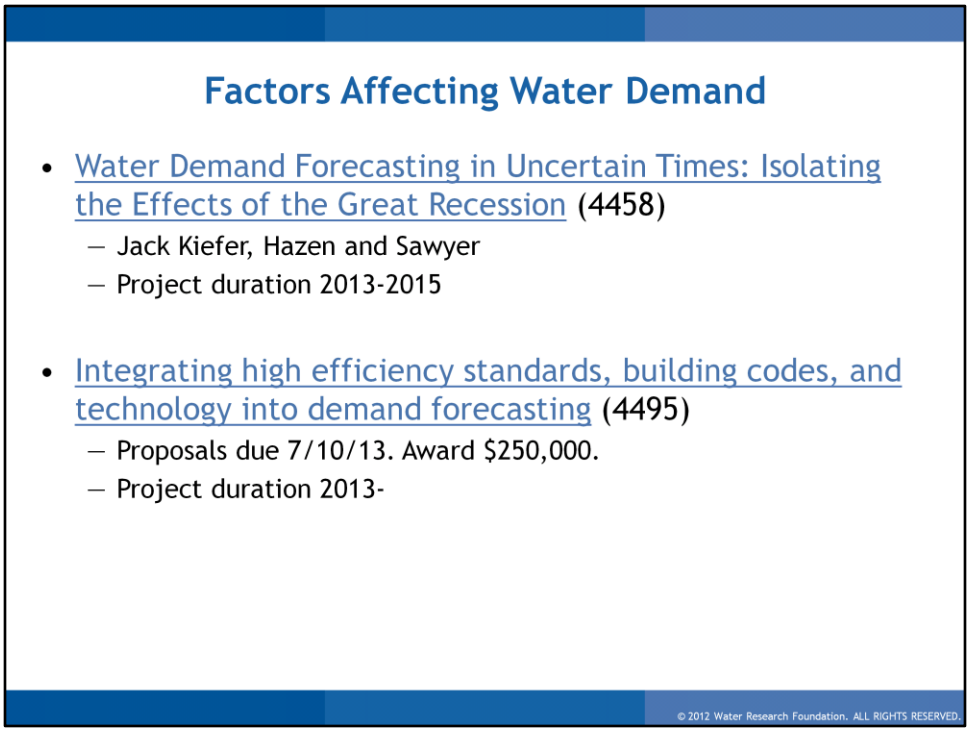
By 2016, increase the effectiveness of demand forecasting and management, by increasing our knowledge of water demand factors, providing guidance on preparing forecasts, understanding the uncertainty associated with them, and more effectively incorporating demand forecasts and their uncertainty into financial, infrastructure and water resource plans.

1-Explore the methods and effectiveness of past and current water demand forecasting activities.

2-Explore the role of uncertainty within water demand forecasting methods and how knowledge of such uncertainty can be incorporated into planning activities.

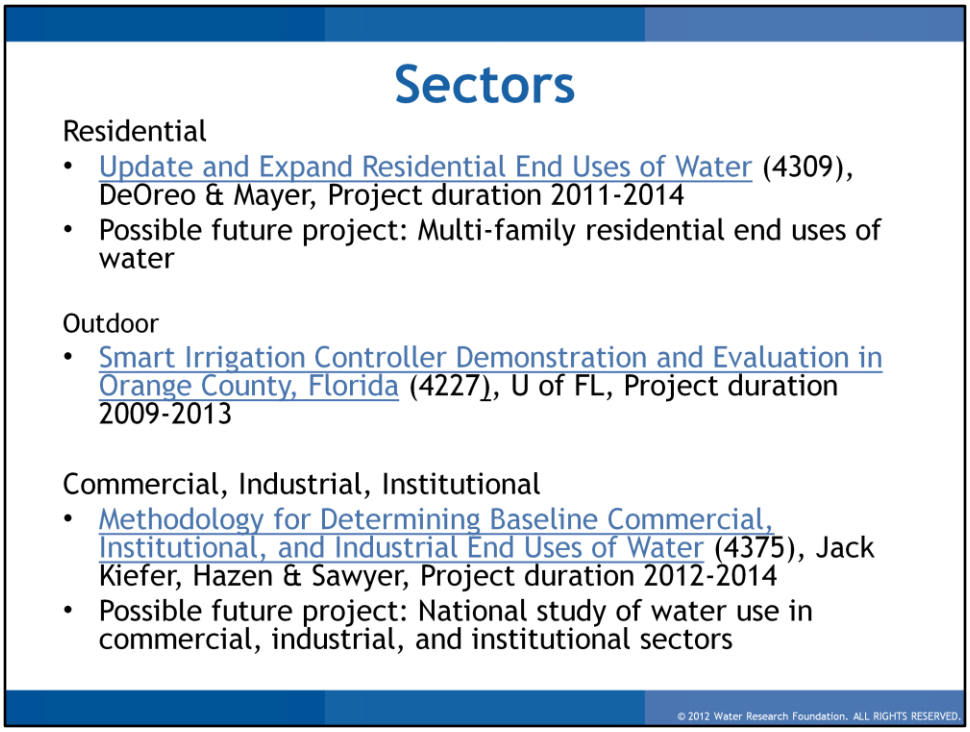
3-Explore at a greater level of detail the current and possible future structure of and factors affecting water demand within all sectors of water use.

Year	Research Agenda Sep 2012	FA Objectives		
		methods	uncertainty	demand factors & sectors
2012	Water Demand Forecasting in Uncertain Times: Isolating the Effects of the Great Recession (4458)			x
2013	Analysis of the effectiveness of long term demand forecasting and recommendations for improvement (4501)	x		
	Integrating water use from efficient technology into demand forecasting (4495)			x
TBD	Analysis of the effectiveness of short term demand forecasting and recommendations for improvement	x		
	Exploration of uncertainty within demand forecasting		x	
	Comparison of short vs long term forecasting: objectives, techniques and potential for integration	x		
	Methods of planning with uncertainty in demand forecasts		x	
	National study of water use in commercial, industrial, and institutional sectors			x
	Multi-family residential end uses of water			x



4458, Water Demand Forecasting in Uncertain Times: Isolating the Effects of the Great Recession
Assess how water demand is affected by short-term economic shocks, such as the recent recession. Evaluate how economic shocks can be differentiated from the many other factors known to have an impact on demand. Analyze how water utilities may be better able to anticipate, adapt to, and minimize impacts of future economic cycles on water demand planning.
Jack Kiefer, Hazen and Sawyer
Project duration 2013-2015

4495, Integrating high efficiency standards, building codes, and technology into demand forecasting
Quantify and evaluate the water savings from new building codes, manufactured products, and third party certification programs. Provide guidance on how these water savings can be integrated into demand forecasting methods.
Proposals due 7/10/13. Award $250,000



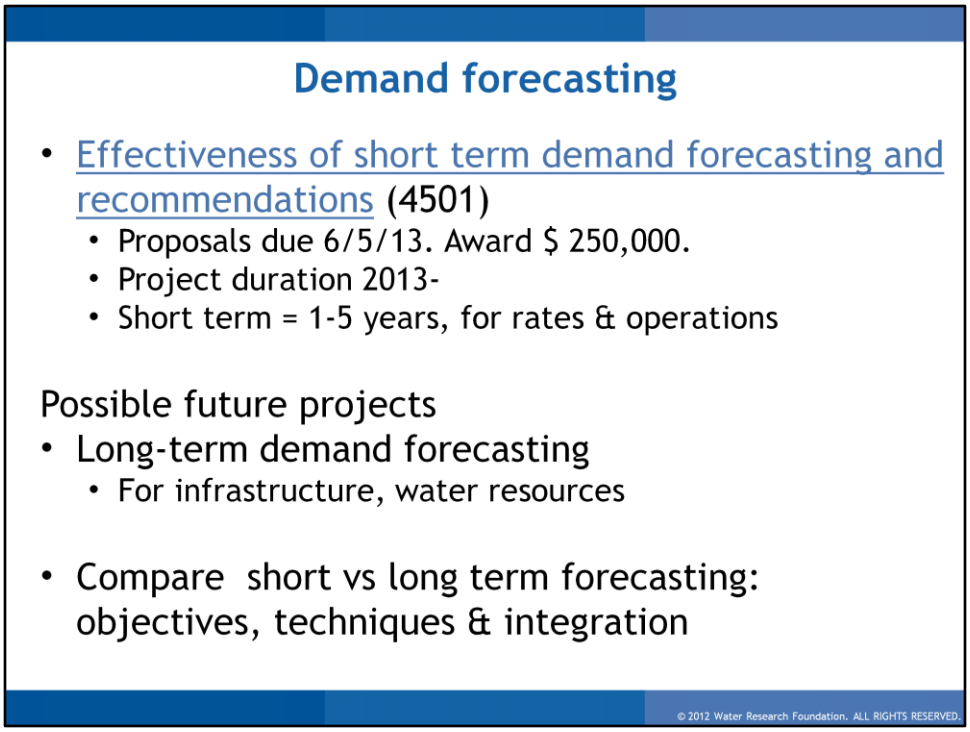
Sectors:

- Residential sector is anywhere from 60-70% (USGS 58%, LADWP 67%, Denver 65%, LVVWD 59%). This includes the single family and multi-family (LADWP 29%, Denver 17%, LVVWD 14.5%).
- CII is about 30-40% (LADWP 28%, Denver 30%, LVVWD 38% (remove 5-10% for public agencies))

Residential

- Single family: we know a lot about this sector. It is very easy to compare households (compared to comparing CII businesses).
- MF- Compared to CII, the MF sector is smaller and we know something about this sector from the single family residential studies. However, < 10% of the units are metered. MF is a growing sector, so it will be important to understand it for future estimates. Studies suggest different water use patterns than SF, some MF use less water, some use more water.

CII- This is a larger segment than MF but we know very little about CII. Kiefer's ongoing project (4375) will develop a framework for estimating end use of the CII sectors, but will not gather much end use data.

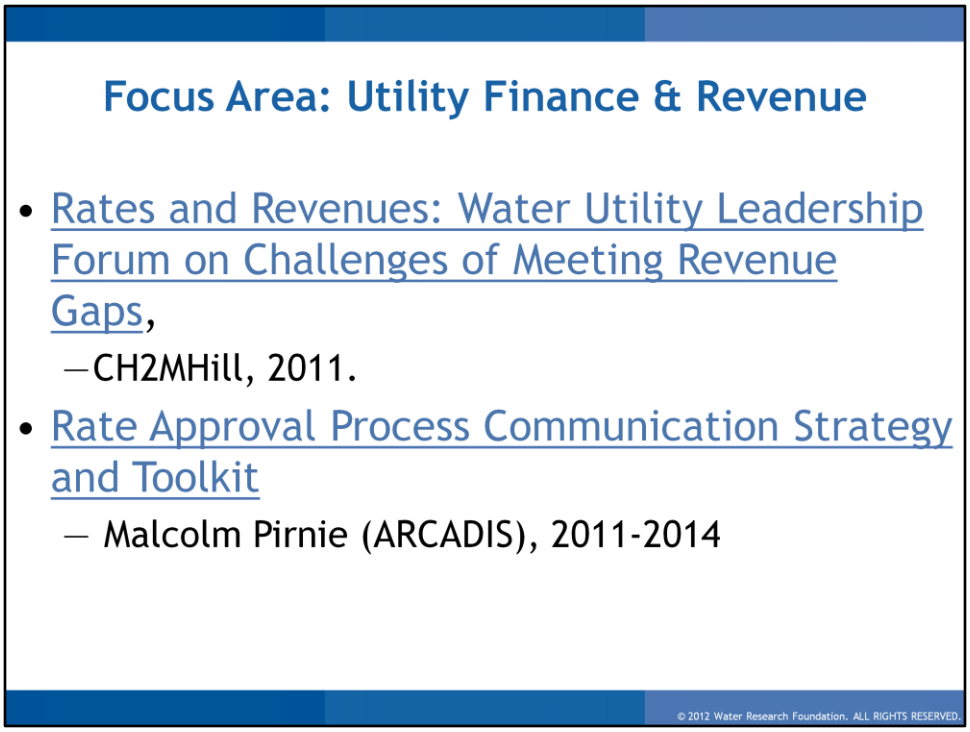


Effectiveness of short term demand forecasting and recommendations (4501)
Establish a short-term water demand forecast process baseline. Document short-term forecasting processes in the water industry. Provide an analysis of strengths and weaknesses of the processes. Discuss how short-term demand forecasts are used for developing rates & revenue, conservation programs, etc.
Proposals due 6/5/13. Award $ 250,000.

Uncertainty

Possible future projects

- Uncertainty within demand forecasting
- Include forecast uncertainty in your utility planning

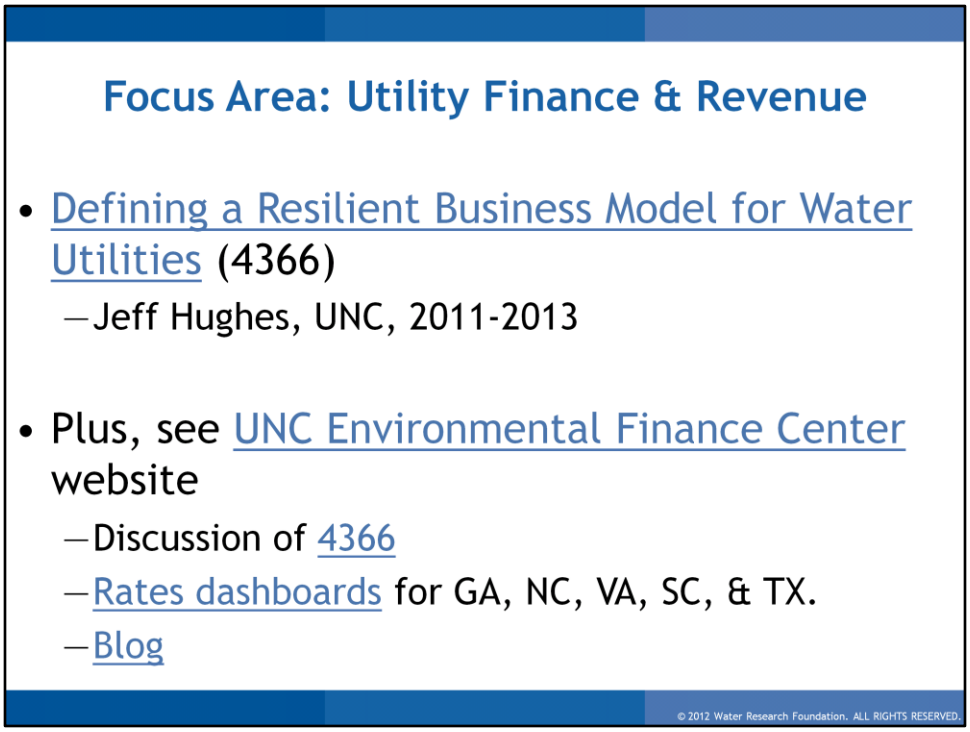


Rates and Revenues: Water Utility Leadership Forum on Challenges of Meeting Revenue Gaps (4405)

In May 2011, the Water Research Foundation convened a working group of over 20 water utility officials from across the country to discuss strategies to bridge the ominous financial gap facing many utilities. Over the course of two days, the officials discussed many different strategies, promoting some and dismissing others. This project produced a number of products derived from discussions at that workshop including eight strategy bulletins, a workshop summary report, PowerPoint slides for utility leaders to use for background information and in their own presentations, and a Webcast that will be held on September 1 and available as an archive. Published in 2011.

Rate Approval Process Communication Strategy and Toolkit (4455)

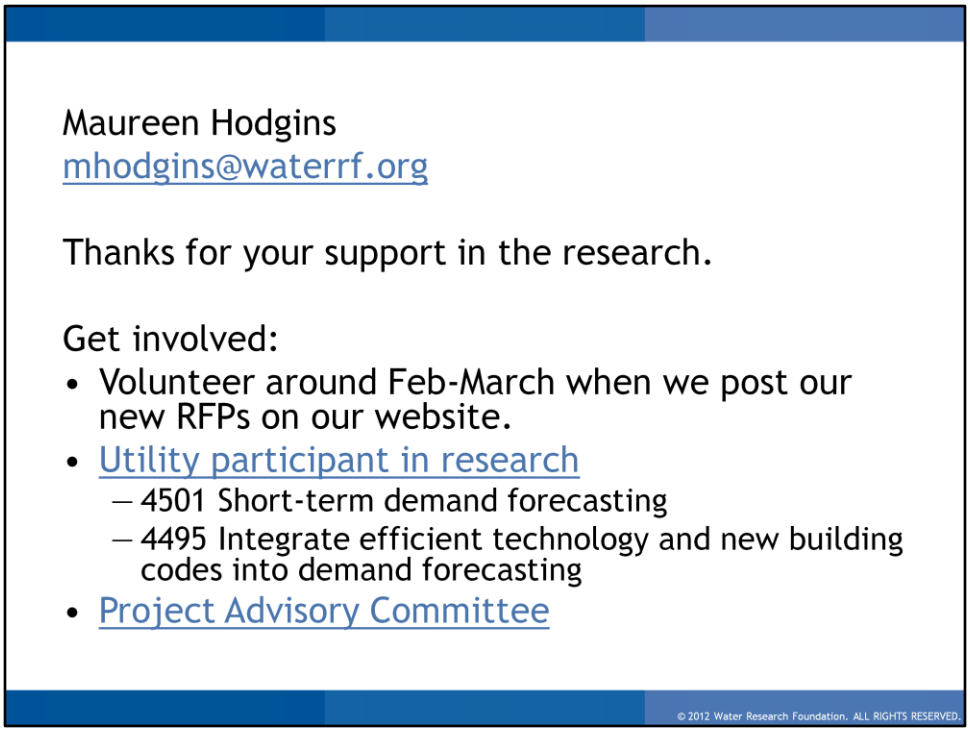
The primary objective of this project is to identify and develop communication strategies and specific messages that utilities can use to gain support during their rate approval process, and complement these communication strategies and messages with a set of scalable and ready-to-use products to support utilities and governing boards throughout this process. First, the project will produce a messaging strategy and communication framework, with specific guidelines, processes, innovative products, and ready to use communication tools that support water utility use of the framework. Second, the project will develop an electronic clearinghouse of utility-specific communication strategies to support peer-to-peer learning, and effectively communicate the benefits of the strategies, tools, and products to encourage widespread utility application of this research.



Defining a Resilient Business Model for Water Utilities (4366)
The purpose of this project is to help utilities address the challenges of revenue gaps, which are exacerbated by rising customer expectations, declining water consumption, aging infrastructure, and necessary integration of utility finance functions with asset management, environmental justice, risk management, and other initiatives. The products of this project will lay the groundwork for a shift in thinking by utilities to modernize financial and management practices by strengthening linkages among systems, processes, and decision-making practices. Research partner: USEPA.

Plus, see UNC Environmental Finance Center website

- Discussion of 4366
- Rates dashboards for GA, NC, VA, SC, & TX. Compiled utility rate information, separated by state.
- Blog



WaterRF relies on many volunteers. Thanks for your support in our research. If you like our water use, conservation, and demand forecasting work, then let us know. Also tell you general manager or whomever decides to support WaterRF. If you aren't a subscriber you can still volunteer with WaterRF, either as a participating utility or on a project advisory committee. While the PACs are full now, you may still volunteer to be a utility participant in research.