A Review of Regional and Global Water Utilities Use of Climate Information
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Global and regional climate change and sea level rise will have significant effects on water supply. Florida will experience its own set of unique challenges related to water supply and climate, and collaboratively identifying and addressing these issues could facilitate future transitions, making change easier, more efficient, and increasingly sustainable. Particularly within the last five years, there has been an increasing amount of both qualitative and quantitative research dealing with the importance of applicable climate data in water resource planning and new methods on how to best integrate applicable data. Despite the abundance of literature, there have been very few water utilities that have successfully incorporated climate information into their quantitative and planning models. This document will give a brief synopsis of the methods used by other water utilities both within the United States and elsewhere in the world to address climate change.

A common research approach has involved the use of regionally-downscaled General Circulation Model (GCM) climate simulations for the area in question, usually for the next 30-60 years. There are many different methods used to statistically or dynamically downscale the GCM simulations with varying degrees of success. For utilities use, focus has been on downscaling the various IPCC future climate scenarios, then using the climate realizations as inputs to models that are generally not already in use by the utilities. D. Yates et al. have used this method with the WEAP integrated model in Sacramento, Inland Empire, CA. [*Groves et al.*, 2008; *Yates et al.*, 2009] and Palm Beach Co., FL. (*no reference*) as a potential method of "stress-testing" utilities' management plans in different climate scenarios. It should be noted that the downscaled climate inputs and WEAP model do not specifically account for potential climate change impacts on the hydrological source regions. There are other utilities that have completed studies with this general methodology to create streamflow inputs under future climate scenarios. These include Seattle Public Utilities [*Hamlet*, 2010; *Snover et al.*, 2003] and the Portland Water Bureau /DHSVM model [*Palmer and Hahn*, 2002]. It does not seem that these assessments are practically utilized by the utilities yet.

The New York City Department of Environmental Protection (NYCDEP) and researchers at Columbia University have utilized both methods of downscaling GCM information from IPCC scenarios and extensive analysis of historic climate variability to inform water resource and sea level rise planning [*Rosenzweig et al.*, 2007; *Rosenzweig and Solecki*, 2010]. The city of Phoeniz, AZ, has also concentrated on historical climate data to quantify possible climate variability impacts on water supply planning, although mostly as an academic exercise [*Balling Jr and Gober*, 2007]. The NYCDEP studies focus on risk management and identifying weak infrastructure under future climate conditions, under the key perception that current and future water supply cannot be looked at as a stationary process. Key tools that emerged from the process were an integrated model with climate scenarios, and a wastewater/sewer model that simulated different sea level rise predictions based on current NYCDEP models. Key issues identified by relative risk and time-frame (such as SLR effect on sewers) are put into a 9-Step Adaptation Assessment procedure, in which options for dealing with the problem are outlined.

These adaptations can include changes in operations and management, infrastructure, and policy. As NYCDEP has been an active participant in the entire process, they have successfully started to integrate climate change planning into their operations. A key to their success has been identified as "high level buy-in" [*Rosenzweig and Solecki*, 2010], in which the Mayor of NYC was identified as a key participant, and recognizing that a 100-year planning horizon was necessary in some cases. Overall, NYC's current level of success can be attributed to both inter-agency coordination and commitment and participation by both utilities and academic institutions.

Globally, Rotterdam (The Netherlands) has demonstrated one of the most holistic climate change and water utilities programs. Although as 50% of the country is below sea level, the country's history has been a battle to sustain settlements. The past 30 years of water management have been changing from top-down to increasingly integrated and participation-based. This was demonstrated in the "Rotterdam Water City 2025" urban planning contest, in which urban renewal was combined with hydrologic planning and climate adaptations [*Van der Brugge and de Graaf*, 2010; *Van der Brugge et al.*, 2005]. A public presence and atmosphere of transition created a more open environment for discussing major infrastructure changes that would affect both policy and citizens. It is worth noting, however, that there has still been opposition to the changes involving moving residential areas off of unsustainable and flood-prone areas, slowing actual policy changes.

The United Kingdom has also addressed water supply management and climate change. The UK Climate Change Impacts Review Group has been active in downscaling IPCC scenarios, and like the NYCDEP, has focused on infrastructure adaptation [*Water UK*, 2007] . Private utilities in the UK were forced to explicitly consider climate change scenarios by incorporation of climate related assessments into investment reviews [*Arnell and Delaney*, 2006]. In the reviews, they determined that over the next five years, no changes were needed. Instead, the focus was on hypothetical long-term potential adaptions to certain scenarios. However, if these adaptations (such as large infrastructure projects),are not started soon, there will not be adequate time to build them before they are needed. Although academic research in UK water resource adaptation is high, there does not seem to be the necessary push by the private utilities or regulatory measures to make it a reality.

Researchers are also pursuing probabilistic methods of incorporating shorter term climate information into water utility operations, although few are past the theoretical stages. Some of these tools have the ability to address utilities' needs on current operational planning scales [*Balling Jr and Gober*, 2007; *New et al.*, 2007; *Towler et al.*, 2010], as well as to allocate short-term water contracts and quantify seasonal risk [*Sankarasubramanian et al.*, 2010, 2003, 2009]. There are many water utilities actively participating in advanced and varied research to incorporate climate information into their planning horizons, as is discussed in this document. However, there has generally been limited success in integrating these scenario and adaptation studies into operations and planning. This is partially due to institutional and political limitations, climate data time-scale mismatches, and some lack of communication between academic researchers and utility managers. Utilities that have achieved the most success thus far are ones that have enthusiastically embraced change within their operational time-frames and to their supply models, have the financial and moral backing of higher-ups in local government, and are open to working across agencies and in a cooperative environment.

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