Water Availability and Variability Strategies for Public Water Systems

This document covers water availability and variability issues faced by public water systems, the potential consequences of climate change on water availability and variability, and the steps that water systems can take to address these uncertainties. This document is intended for small and medium-sized public water systems as well as technical assistance providers and state programs that support or regulate these systems.

Introduction

Public water systems supply over 44 billion gallons of water per day to supply the domestic water needs of the majority of Americans.[i] This accounts for the third largest withdrawal of fresh water in the United States (13%) following thermoelectric power (49%) and irrigation (31%). Public water supply use increased from 14 billion gallons in 1950 to 29 billion gallons in 1975 and exceeded 44 billion gallons in 2005.[i]

As the nation's population continues to grow, so do the demands on our freshwater resources and the public water suppliers responsible for providing a safe and reliable water supply to consumers. Water managers in 36 of 47 states responding to a survey anticipate water shortages in the next 10 years under normal climate conditions.[ii]

Water shortages can also be exacerbated by the unequal distribution of available fresh water over space and time. Drought, increased pollution and other short or long-term climate impacts that change or degrade water quality as well as increased competition for raw water resources add other constraints to providing a safe, reliable water supply.

What are the potential impacts to water resources from climate change?

Regional climate differences, natural variations in weather patterns, and seasonal changes in supply and usage all contribute to water availability and variability constraints. Weather oscillations may be exacerbated by climate change and typically impact water quality as well as quantity. Some of the projected effects of climate change on fresh water resources include the following:[iii]

1. Increased frequency and duration of droughts. The increased frequency and duration of droughts may result in diminished fresh water supplies in both the short- and long-term. Drought effects can be especially critical in the more arid Southwest and Mountain West regions of the United States; however, other regions, such as the Southeast, are experiencing more frequent and severe droughts (see Figure 1). Ensuring adequate supplies of water during droughts that reduce aquifer recharge and reservoir storage is a critical concern for most water systems. Reduced rainfall in drought conditions can contribute to increased water demand from customers. Extended drought conditions can result in raw water quality changes due to changes in watersheds, lakes and reservoirs or salt water intrusion in coastal areas.

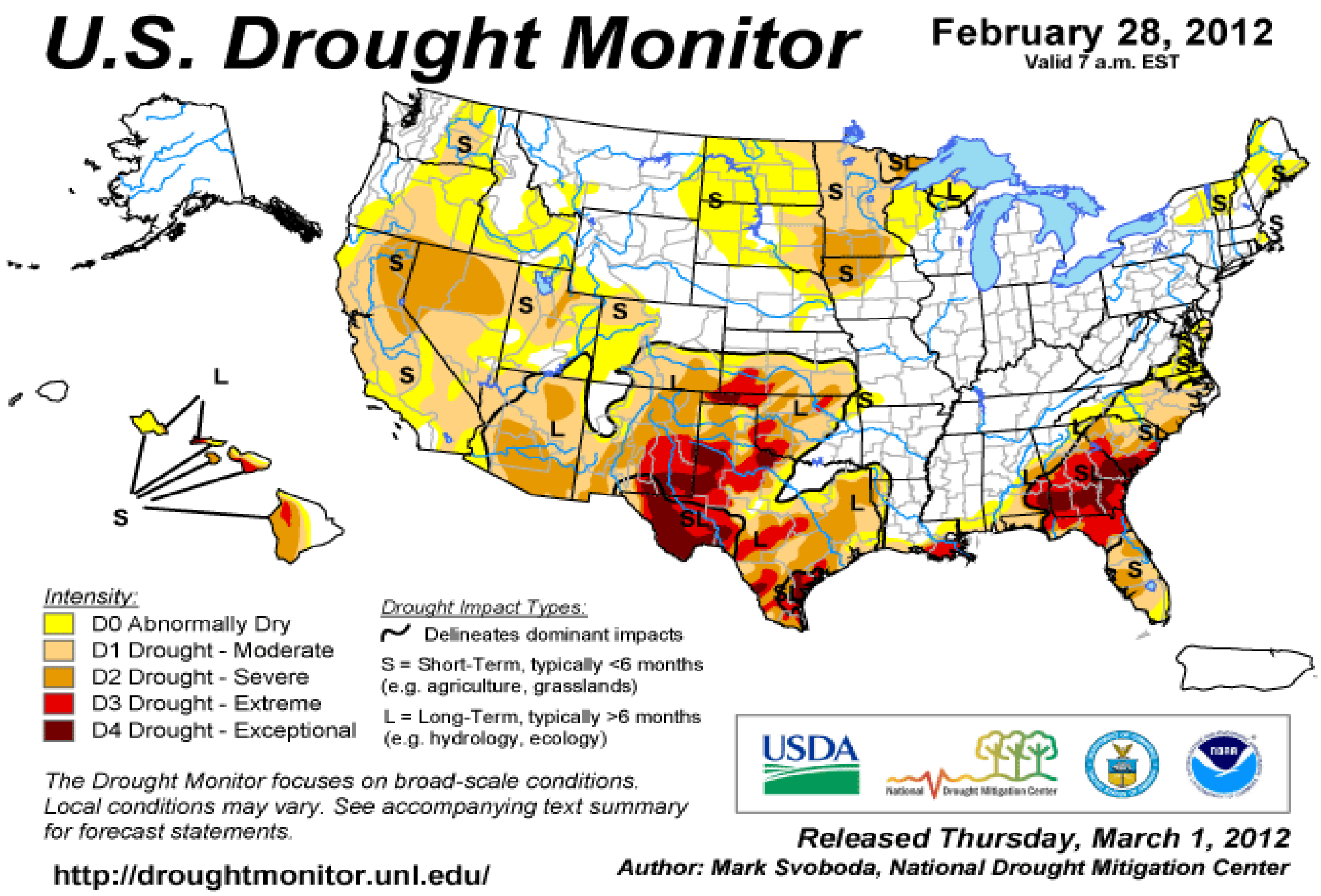

Figure 1. U.S. Drought Monitor

2. Increased frequency and severity of significant wet weather events. Heavier, more extreme precipitation from tropical hurricanes and inland storms will likely increase the risks of flooding. Floods can pose serious threats to the health and safety of communities and the drinking water infrastructure on which they depend.

In addition, significant wet weather events and flooding can negatively alter influent water quality. Intense rainfall and stormwater runoff may result in changes in both water quality (turbidity, pH, alkalinity) and watershed conditions. These events can also result in increases in water pollutants such as nutrients, pesticides, and fecal matter from farms; chemicals from industrial processes; and fuel and organic compounds from vehicles and roadways that may require changes to water treatment practices to continue to meet drinking water standards.

Natural disasters, such as hurricanes and fires, can exacerbate flood or drought conditions. For example, fires are common in much of the Western U.S. during the late summer drought period. Loss of forests and other vegetation due to fire can also lead to changes in water availability and variability in water quality. Severe weather can result in widespread and long duration power outages that can affect the capacity to treat or deliver water.

3. Changes in the timing of stream flow. Changes in the timing of stream flow (higher high flows and lower low flows) alter the volume of available water and increases water pollution problems. In the Northwest, climate change may cause more winter precipitation to fall as rain instead of snow. This change results in higher velocity stream flows and decreased winter snowpack, effectively reducing stored water quantity. Further, higher stream velocities may increase streambed erosion leading to higher source water turbidity or may result in other water quality changes that impact water treatment processes. Warmer air temperatures may result in warmer stream water, which holds less dissolved oxygen, and may foster harmful algal blooms in receiving water bodies.

4. Decreased freshwater availability due to saltwater intrusion from rising sea levels. Rising sea levels will likely move ocean and estuarine shorelines inland and alter the tidal range of coastlines and rivers. In addition, coastal areas may incur increased damage from floods and storms and changes in the timing and volume of freshwater runoff. These phenomena will have a strong influence on coastal water supplies as they change from freshwater to brackish or salt water and may require changes in water treatment processes.

What steps should public water systems take?

Predictions associated with the timing and severity of climate change impacts, particularly when they are scaled to the local level, and are still imprecise. As a result, planning for an uncertain future with the many potential consequences of climate change can be challenging. However, there are many “no regrets” measures to address water availability and variability issues. “No regrets” measures are measures that can increase the resilience and adaptive capacity of a water system to reduce vulnerability regardless of the direction and extent of future climate changes. Many of these steps are also good industry practices that water systems should adopt regardless of potential climate change impacts and the uncertainty associated with those impacts.

EPA’s Climate Ready Water Utilities (CRWU) initiative assists drinking water, wastewater, and stormwater utilities in understanding and adapting to climate change impacts. CRWU provides a number of practical and easy-to-use tools (referenced below) that translate complex climate projections into accessible and actionable information for utilities to use. This information helps utility owners and operators better prepare their systems for the impacts of climate change.

The following steps will help public water systems think through their water availability and variability issues, be more effective stewards of our freshwater resources and prepare for potential climate change impacts. These steps include improving system knowledge, reducing water loss, diversifying the water supply and management “portfolio”[iv] and looking at water system infrastructure more expansively to include green infrastructure.[v] It is important to note that there is no “one size fits all” approach to addressing water availability and variability. A public water system’s vulnerability to these issues and the solutions available to them will vary based on the complexity of the system, the community's size and composition as well as local conditions.

- ☛ **RESOURCE: CRWU Adaptive Response Framework.** http://water.epa.gov/infrastructure/watersecurity/climate/upload/epa817f12009.pdf

Step 1 – Improve system knowledge. Local, system-level knowledge is the best way to assess current water availability and variability concerns and to begin to prepare for potential future changes. Table 1 provides information needs and questions a water system should be able to answer or should work toward answering, as well as state and local resources for gathering this data.

Table 1. Information Needs and Resources for Improving Local Knowledge

Source Characterization	System Information	Local Resources
▪ Does supply vary by season? ▪ During which time of year is water most abundant? ▪ Does the intensity of precipitation vary? ▪ Is supply affected by drought? ▪ How frequent are drought events? ▪ What is the average duration of drought events? ▪ Does the water system experience frequent water shortages or supply emergencies? ▪ Is the system vulnerable to quality changes at the source? ▪ Do changes in water quantity drive changes in quality? ▪ How does the system currently manage changes in water quality and/or quantity? ▪ If those changes were exacerbated, could the system manage? How?	▪ Estimated service population ▪ Estimated service area (square miles) ▪ Types and number of service connections ▪ Total system demand (design) ▪ Average-day demand ▪ Peak-day demand ▪ Rate structure ▪ Metered sales ▪ Unmetered sales ▪ Water loss (apparent and real losses) ▪ Does the water system have substantial water loss? ▪ Is the system experiencing a high rate of population and/or demand growth? ▪ Is the system forecasting future demand? ▪ Is the system planning for substantial improvements or additions? ▪ Is the system in a designated critical water supply area?	▪ Ongoing and historical source water monitoring records: stream flows, surface water levels, well/groundwater table measurements ▪ State source water assessments ▪ Water conservation plans ▪ Drought or emergency planning documents ▪ Capital, facility, or supply plans ▪ Periodic supply assessments ▪ State capacity reports ▪ Sanitary survey results ▪ Local climate data

- ☛ **RESOURCE: Climate Ready Water Utilities (CRWU) Adaptation Strategies Guide** http://water.epa.gov/infrastructure/watersecurity/climate/upload/epa817k11003.pdf
- ☛ **RESOURCE: CRWU Climate Resilience Evaluation and Awareness Tool (CREAT)** http://water.epa.gov/infrastructure/watersecurity/climate/upload/epa817k12002.pdf
- ☛ **RESOURCE: Climate Ready Water Utilities Toolbox.** http://www.epa.gov/safewater/watersecurity/climate/toolbox.html
- ☛ **RESOURCE: 1998 EPA Water Conservation Plan Guidelines.** http://www.epa.gov/WaterSense/pubs/guide.html

- **RESOURCE: Alliance for Water Efficiency, AWE Resource Library, Water Conservation Programs.** http://www.allianceforwaterefficiency.org/Water_Conservation_Programs_Library_Content_Listing.aspx
- **RESOURCE: National Environmental Services Center.** http://www.nesc.wvu.edu/futurewater/
- **RESOURCE: Control and Mitigation of Drinking Water Losses in Distribution Systems.** http://water.epa.gov/type/drink/pws/smallsystems/upload/Water_Loss_Control_508_FINALDEc.pdf
- **RESOURCE: American Water Works Association (AWWA) Free Water Audit Software©** available at: http://www.awwa.org
- **RESOURCE: U.S. Census.** http://www.census.gov/
- **RESOURCE: U.S. Drought Monitor.** http://droughtmonitor.unl.edu/

Step 2 – Identify water losses and invest in water efficiency measures. Public water systems depend on abundant water sources of the best quality possible to meet increasing water demands and resources to locate, develop, treat and maintain these sources. When insufficient availability or extreme variability becomes an issue, a water system may increase the capacity of the existing water treatment facility, find and develop another source or buy additional water from another water system. However, finding a new, reliable source of adequate quality may not always be an available option and capital improvement projects can be prohibitively expensive. One option is to take steps to reduce water demand. This can be accomplished by both supply-side water efficiency and end-user conservation. On the supply-side, a public water system should investigate system processes and operations and determine if there is any way to save water internally (for example modifying backwash processes and reducing distribution system losses). This also may be a good time to develop and implement a water loss control and accounting program at the public water system if one is not already in place. Such a program may be able to defer development of new sources and reduce or eliminate the need to supplement supply from another water system. On the demand side, a water system can work with consumers to reduce demand through several means including: price signaling/conservation pricing; free water audit programs for large volume users and residential customers; retrofit/replacement programs to repair or replace old toilets and fixtures with new, more water efficient models; and changing customer behavior through public education and outreach (advertising campaigns, water-bill inserts, etc.).

- **RESOURCE: CRWU Adaptation Strategies Guide Energy Management Sustainability Brief** http://water.epa.gov/infrastructure/watersecurity/climate/upload/epa817k13001.pdf
- **RESOURCE: EPA's Energy Use Assessment Tool** http://water.epa.gov/infrastructure/sustain/energy_use.cfm
- **RESOURCE: Water Audits for Public Water Systems** (EPA 816-F-13-002). http://water.epa.gov/type/drink/pws/smallsystems
- **RESOURCE: Water Efficiency for Public Water Systems** (EPA 816-F-13-003). http://water.epa.gov/type/drink/pws/smallsystems
- **RESOURCE: Control and Mitigation of Water Losses in Distribution Systems.** (EPA 816-R-10-019). http://www.epa.gov/safewater/pws/pdfs/analysis_wa-03_water_loss_doc_final_draft_v62.pdf
- **RESOURCE: WaterSense** http://www.epa.gov/watersense/
- **RESOURCE : AWWA Free Water Audit Software©** http://www.awwa.org/resources-tools/water-knowledge/water-loss-control.aspx

Step 3 – Assess and plan. After assessing its potential vulnerabilities to climate change and water availability and variability using Steps 1 and 2 above, a water system can analyze various scenarios and identify solutions. Increasing water and energy efficiency, implementing conservation and demand management programs, developing emergency preparedness plans for floods and droughts and protecting green infrastructure are all examples of "no regret" solutions. These solutions can address multiple conditions that impact the public water system and have immediate economic and environmental benefits, in addition to addressing future uncertainty.[vi]

- **RESOURCE: Climate Ready Water Utilities -CREAT**. http://water.epa.gov/infrastructure/watersecurity/climate/
- **RESOURCE:: CRWU's Preparing for Extreme Weather Events: Workshop Planner for the Water Sector** http://water.epa.gov/infrastructure/watersecurity/climate/

Step 4 – Diversify the water supply and management portfolio. Diversification is key to increasing resilience and adaptive capacity. A financial investment portfolio, for example, will balance short-term and long-term objectives by diversifying its investments. Similarly, a water system can diversify its water supply and management portfolio by balancing short-term and mid-term strategies, such as demand management efforts, with long-term strategies like the development of new storage and transfer programs.[vii] The need to leverage innovative technologies and alternative water supply is also important as water supplies are stressed by growing populations, the impacts of climate change and greater competition of raw water resources. For example, an increasing number of communities are viewing stormwater and wastewater as a resource rather than a waste. As source water becomes scarcer and treatment technology improves, desalinization is also becoming a more attractive option for some communities. A summary of diversification options are listed in Table 2.

Table 2. Water Diversification Options

- Protect existing sources
  - Source water protection
  - Watershed protection
  - Watershed partnerships
- Manage storage to complement anticipated supply
  - Large storage for multi-year variation
  - Small storage sufficient for annual variation
- Water efficiency of system operations
  - Metering
  - Water accounting
  - Leak detection and repair
  - Pressure management
- Partnerships with other systems
  - Interconnection for emergency use
  - Bulk water purchases
- Green infrastructure/stormwater catchment
- Water reuse/recycling for non-potable use
- Desalinization

- **RESOURCE: U.S. EPA's Web site on Water Availability.**

[http://water.epa.gov/infrastructure/sustain/availability_wp.cfm]

Step 5 – Look for opportunities to include green infrastructure. Examples of green infrastructure include wetlands, forests, parks, rain gardens, green roofs and porous pavement. Green infrastructure absorbs runoff, reducing flood potential and improving water quality. The runoff absorbed by wetlands and forests is slowly released at a later time, reducing the variability of the water supply by recharging aquifers and maintaining baseflow in streams.[viii] Often termed "total water management" or "integrated resource planning," this holistic approach to managing water resources is cost-effective and has multiple benefits. In addition, many communities are beginning to look at stormwater as a valuable resource that can be captured or injected into the ground, while ensuring appropriate protection of aquifers, to restore depleted aquifers. Solutions range from retention ponds, to rain barrels and cisterns, to a whole suite of strategies for infiltrating stormwater where it falls, rather than channeling it away through piped systems. Fostering these approaches in your community can reduce the demands on your drinking water system, extend the life of water supplies and have numerous other environmental benefits.

- **RESOURCE: EPA's Web site on Green Infrastructure.**
  http://cfpub.epa.gov/npdes/home.cfm?program_id=298
- **RESOURCE: EPA Workshop on the Challenges of Green Infrastructure.**
  http://www.epa.gov/region07/newsevents/events/proceedings/om_green_infrastucture/index.htm
- **RESOURCE : CRWU Adaptation Strategies Guide Green Infrastructure Sustainability Brief**
  http://water.epa.gov/infrastructure/watersecurity/climate/upload/epa817k11003.pdf

ADDITIONAL RESOURCES

What funding options are available?

The **Drinking Water State Revolving Fund** (DWSRF) can provide low-interest loans for a variety of energy efficiency and water efficiency projects. States are encouraged to continue to use their DWSRF capitalization grant to fund green drinking water projects to address green infrastructure, water and energy efficiency improvements and other environmentally innovative activities. In FY2010 and FY2011, states were required to use a minimum of 20 percent of their capitalization grant for green projects (also known as the Green Project Reserve or GPR). For the FY2012 capitalization grant, designating green projects is at the discretion of the state. Examples of fundable green projects include energy audits, equipment upgrades, leak detection equipment, water meter installation and installation of water efficient devices. Other improvements, which in FY2010 and FY2011 required the development of a business case to be designated for GPR, include retrofit or replacement of pumps and motors with high efficiency motors, replacement or rehabilitation of distribution lines or installing Supervisory Control and Data Acquisition (SCADA) systems. These improvements may also still be eligible for funding even if they are not designated for GPR. Drinking water systems should contact their state DWSRF programs to find out more about the state's priorities and funding options.

- **Resource: DWSRF Green Project Reserve 2010 Guidance.** http://www.epa.state.il.us/water/financial-assistance/publications/green-project-reserve-guidance.pdf

- **Resource: DWSRF Contacts by State.** http://water.epa.gov/Grants_Funding/DWSRF/upload/DWSRFCONTACTS.pdf

- **Resource: EPA FedFUNDS** http://water.epa.gov/infrastructure/watersecurity/funding/fedfunds/

- **Resource: EPA/HUD/DOT Sustainable communities partnership** http://www.sustainablecommunities.gov/

- **Resource: Green Infrastructure funding sources**. http://water.epa.gov/infrastructure/greeninfrastructure/gi_funding.cfm

- **Resource: USDA Rural Development Grants** . http://www.rurdev.usda.gov/RD_Grants.html

How can States help water systems?

State drinking water programs can play various roles in the promotion of water availability and variability issues including providing input and/or coordinating activities of other agencies, organizations and programs; fostering coordination and partnerships; developing new laws and policies; providing technical assistance to water utilities; and promoting tools and information sharing. The Association of State Drinking Water Administrators (ASDWA) released a white paper on the topic in February, 2009, that outlines an assortment of state strategies and plans, legal/regulatory frameworks for water withdrawals, water conservation/efficiency policies and public education programs.[ix] State strategies to promote water availability and variability may include Climate Action Plans or Growth and Development Plans, Water Management or Drought Plans, or regulations, permitting or water reuse programs. According to a recent comparison of water loss policy by state, water loss policies were found in 33 states and 26 states have water loss standards.[x]

- **Resource: ASDWA National Analysis of State Drinking Water Programs in the Areas of Water Availability, Variability and Sustainability (WAVS).** http://www.asdwa.org/_data/n_0001/resources/live/WAVS%20Report%20FINAL.pdf
- **Resource: CRWU- Preparing for Extreme Weather Events: Workshop Planner for the Water Sector.** http://water.epa.gov/infrastructure/watersecurity/climate/

Case studies

GEORGIA WATER COUNCIL. The Georgia Water Council has adopted the state's first comprehensive water-use plan to address severe drought conditions. Representatives from local and state government and the Georgia American Water Works Association and National Rural Water Association state affiliates comprise the membership of the Council and were directly involved in developing the state's plan. The plan calls for the establishment of 11 regional management districts that will oversee the measurement and withdrawals of water from lakes, rivers and aquifers. The estimated cost to gather data and create regional water plans for the districts over the next three years is approximately $30 million. The regional water plans will likely involve local governments and include growth and development strategies based on water availability.

TEXAS WATER DEVELOPMENT BOARD (TWDB). The TWDB's mission is to provide leadership, planning, financial assistance, information, and education for the conservation and responsible development of water for Texas. Texas was the first state in the United States to pass legislation requiring water utilities to submit water audits (initially every five years) to the TWDB, to promote water conservation to meet the water demands of Texas' growing population, while protecting its natural resources. The TMDB has also developed a water conservation best practices guide. Over 2,000 completed water audits were submitted to TWDB for calendar year 2005.

STATE OF WASHINGTON. The State of Washington passed comprehensive legislation promoting greater water use efficiency. Major provisions of the legislation include requiring water utilities to meet a distribution system leakage standard of less than 10 percent, establish goals for their customers, create a water use efficiency plan and submit an annual report to measure progress, and install meters on all customer service connections within 10 years of the 2004 legislation. Water utilities must also install meters on all customer service connection by 2017.

- Case Study on Water Reuse: El Paso Texas. http://www.epwu.org/reclaimed_water/rwater.html
- Case Study on Desalinization: Tampa Bay-Seawater Desalination. http://www.tampabaywater.org/facilities/desalination_plant/index.aspx

Government Resources

National databases on surface water and ground water resources are available online and may be helpful in evaluating your water system's source water viability.

- **RESOURCE: USGS Water Data Discovery** features water maps including droughts, floods, streamflow, and ground water response to climate change. http://water.usgs.gov/
- **RESOURCE: The National Hydrography Dataset (NHD)** is a comprehensive set of digital spatial data representing the surface water of the United States These data are designed to be used in general mapping and in the analysis of surface-water systems using geographic information systems (GIS). http://nhd.usgs.gov/
- **RESOURCE: Ground Water Atlas of the United States.** http://pubs.usgs.gov/ha/ha730/
- **RESOURCE: Climate Assessment Tool (CAT)** element of the BASINS water modeling program can be used to support assessment of climate-related water resources impacts and program decisions. http://water.epa.gov/scitech/datait/models/basins/b3webdwn.cfm

Additional resources available to assist water systems in addressing water availability and variability include:

- **RESOURCE: U.S. EPA Climate Change Program.** http://www.epa.gov/climatechange/effects/water/availability.html
- **RESOURCE: CRWU: Final Report of the National Drinking Water Advisory Council.** http://water.epa.gov/drink/ndwac/climateccchange/index.cfm
- **RESOURCE : CREAT:** EPA developed CREAT, a software tool to assist drinking water and wastewater utility owners and operators in understanding potential climate change threats and in assessing the related risks at their individual utilities. http://water.epa.gov/infrastructure/watersecurity/climate/creat.cfm
- **RESOURCE: Community-Based Water Resiliency Tool. EPA 817-C-11-001.** http://water.epa.gov/infrastructure/watersecurity/techtools/cbwr.cfm

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[ii] U.S. Government Accounting Office. 2003. FRESHWATER SUPPLY: States' Views of How Federal Agencies Could Help Them Meet the Challenges of Expected Shortages. http://www.gao.gov/htext/d03514.html

[iii] Intergovernmental Panel on Climate Change (IPCC). 2007. IPCC: Climate Change 2007: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate. Cambridge University Press, Cambridge, United Kingdom, 1000 pp. http://www.ipcc.ch/publications_and_data/ar4/wg2/en/contents.html

[iv] Climate Ready Water Utilities Working Group, 2010. Final Report of the National Drinking Water Advisory Council; December 9, 2010. http://water.epa.gov/drink/ndwac/climatechange/upload/CRWU-NDWAC-Final-Report-12-09-10-2.pdf

[v] Climate Ready Water Utilities Working Group, 2010. Final Report of the National Drinking Water Advisory Council; December 9, 2010. http://water.epa.gov/drink/ndwac/climatechange/upload/CRWU-NDWAC-Final-Report-12-09-10-2.pdf

[vi] Water Utility Climate Alliance, 2010. Decision Support Planning Methods: Incorporating Climate Change Uncertainties into Water Planning. www.wucaonline.org/assets/pdf/actions_whitepaper_012110.pdf

[vii] Miller, K., Yates, D., 2005. Climate Change and Water Resources: A Primer for Municipal Water Providers. Water Research Foundation.

[viii] Climate Ready Water Utilities Working Group, 2010. Final Report of the National Drinking Water Advisory Council; December 9, 2010. http://water.epa.gov/drink/ndwac/climatechange/upload/CRWU-NDWAC-Final-Report-12-09-10-2.pdf

[ix] ASDWA (2009). *National Analysis of State Drinking Water Programs in the Areas of Water Availability, Variability and Sustainability (WAVS)*. http://www.asdwa.org/_data/n_0001/resources/live/WAVS%20Report%20FINAL.pdf

[x] Beecher, Janice A. 2002. *Summary of State Agency Water Loss Reporting Practices*. Final Report to the American Water Works Association.