Emerging Issues: Adapting To Climate Change

G. Tracy Mehan, III, The Cadmus Group, Inc.

DISCLAIMER: The opinions presented by the author do not necessarily reflect the policies or opinions of the U.S. Environmental Protection Agency or The Cadmus Group, Inc.

Introduction and Background

Climate change and variability portend significant consequences for water utilities, especially in the western United States, in terms of the quantity, quality, and flow regimes of their source waters. Water infrastructure can be severely damaged, even destroyed, by climate-related phenomena such as floods, rising sea levels, and hurricanes.

Scientists generally agree on the broad features of likely hydrological changes, such as increases in global average precipitation and evaporation due to warmer temperatures. But significant uncertainty remains about the amount of precipitation and runoff at the regional or watershed levels. This situation makes reliable predictions impossible. That said, current science suggests that the global climate cycle will become more intense, resulting in heavier but less frequent periods of precipitation. In other words, the science points to the possibility of longer periods of drought alternating with spells of heavy rainfall and runoff.

A report by the Awwa Research Foundation (AwwarRF) and the University Corporation for Atmospheric Research (UCAR) released in 2006 notes the difficulties these changes could create for water utility planning and operations:

- Greater variability in runoff would make maintaining optimal reservoir levels more difficult and would reduce the reliability of water storage.
- Increased reliance on groundwater during extended dry spells would reduce aquifer levels and discharges to surface water bodies, with unintended consequences for aquatic ecosystems.
- Shorter periods of snow accumulation in mountainous regions, especially at lower altitudes, would result in reduced snow pack, which along with earlier melting in the spring would lead to reduced flows in late summer when water is scarce and demand is greater.
- More precipitation would fall as rain rather than snow due to warmer winter temperatures.
- Treatment costs would increase due to heavier runoff.
- Floods, droughts, hurricanes, and wildfires—as well as the soil erosion they lead to—would increase.

- Rising sea levels would lead to saltwater intrusion and flooded infrastructure.

Particularly troubling is the warming experienced throughout the Colorado River region[1] in the past century, which is affecting precipitation and water supplies. According to a 2007 report by the National Research Council (NRC) of the National Academies, the water years 2002 and 2004 were among the 10 driest on record in the upper basin states, and flows into Lake Powell above Glen Canyon Dam were almost 25 percent of mean values in 2002.

Nearly all global-climate models forecast increasing temperatures in this region. Multi-century, tree-ring-based reconstructions of Colorado River flows indicate that extended droughts are a recurrent and integral feature of the basin's climate. They also show greater hydrologic variability than that reflected in the record of measured Colorado River flows. The NRC believes these reconstructions indicate that future droughts will be more severe than those of the late 1990s and early 2000s.

Notwithstanding the regional and local uncertainties related to climate change and their implications for water utilities, prudence dictates that utility managers undertake "planning for uncertainty" as described by AwwaRF and UCAR. This approach calls for managers to pursue precautionary, adaptive strategies designed to foster utility systems and operations that are robust, resilient, and flexible in anticipating alternative climate scenarios. Just this year the Western Governors' Association called for more federal funding of research on adaptation under the auspices of the U.S. Global Challenge Research Program to make it more user-driven.

AwwaRF and UCAR contend that Integrated Water Resources Management (IWRM) is the most effective method for assessing adaptation options and their implications. This systematic approach to planning and management involves stakeholders and customers in the process. Through continual monitoring and review of water resources, IWRM facilitates adaptive management. It also provides an opportunity to articulate the supply- and demand-side options available for addressing factors relating to biological systems and socio-economic management realities.

Although IWRM uses hydrologic modeling tools, it can also rely on scenarios derived from climate models. But no single climate model will yield reliable projections of future climatic conditions. Moreover, a climate change model must be "downscaled" to the relevant watershed level. AwwaRF and UCAR recommend that any analysis use several projections from several models to generate a range of plausible scenarios of the impacts of climate change on a utility's water resources.

Office of Water Activities to Develop a Strategy on Climate

On March 1, 2007, Benjamin H. Grumbles, Assistant Administrator for Water, U.S. Environmental Protection Agency (EPA), signed a memorandum to all Office of Water (OW)

---

[1] The Colorado River basin covers more than 240,000 square miles and is home to a booming population with states such as Arizona and Colorado experiencing growth rates of 40 percent and 30 percent, respectively, between 1990 and 2000. In Clark County, Nevada (Las Vegas), water consumption nearly doubled between 1985 and 2000.

Office Directors, Regional Division Directors, and Great Waterbody Program Office Directors on the matter of "Climate Change and the National Water Program" (www.epa.gov/water). The Assistant Administrator's memorandum notes that climate change has the potential to affect water resources in five areas: atmospheric temperature; rainfall, snowfall levels, and distribution; storm intensity; coastal/ocean characteristics such as temperature and chemistry; and sea level rise. (EPA has a new Web site on these and other climate topics: http://www.epa.gov/climatechange/.)

While acknowledging that climate change's scope, timing, and related effects are uncertain, Assistant Administrator Grumbles noted that "the National Water Program (NWP) and its partners should take prudent steps now to assess emerging information, evaluate potential impacts of climate change on water programs, and identify appropriate response actions." He set out general principles and an organizational approach to developing an NWP strategy on climate, and he described the following principles that will guide the NWP in its efforts to evaluate potential impacts of climate change:

- *Common Strategy Framework*: NWP will ground its work on climate change in EPA's existing framework to focus on mitigation, adaptation, and research.

- *Cooperation with Other EPA Offices*: The Office of Research and Development (ORD) and the Office of Air and Radiation (OAR) are key partners. Moreover, the NWP will seek to support ongoing Administration initiatives on climate change.

- *Implement Response Actions*: The NWP will create capacity to develop and implement specific response actions in coordination with federal, state, and other partners.

- *Open Communication*: The NWP intends to open a dialogue on climate change impacts and emerging best practices.

- *Iterative Process*: The NWP will monitor implementation of response actions and will review and revise strategies as needed.

The NWP will establish a Climate Change Workgroup to prepare a Strategy on Climate Change. The Workgroup will focus on appropriate, effective, and feasible response actions to the effects of climate change on national water resources. It will also oversee all work on climate change, providing information and educational support as well as external and internal communications.

The Workgroup will be made up of managers from each Headquarters water program office and several Regional offices. Deputy Assistant Administrator Michael Shapiro will chair the workgroup, which will also include senior managers from ORD and OAR.

Assistant Administrator Grumbles anticipates that the Workgroup will focus primarily on adaptation. However, OW has already started working on mitigation issues such as geosequestration and energy efficiency.

The schedule outlined in the Assistant Administrator's memorandum contemplates a stakeholder comment period on the draft water climate change strategy during the summer. The NWP will begin to prepare for prompt implementation in advance of the strategy's final publication in late 2007.

Western Utilities Address Climate Change and Prepare for the Future

The 2006 report by AwwaRF and UCAR, *Climate Change and Water Resources: A Primer for Municipal Water Providers*, contains several case studies of utilities in the arid western United States and elsewhere that are working to anticipate and adapt to the changing climate and its impacts on water management. Here are two examples.

Boulder, Colorado. This case highlights the use of alternative climate scenarios in assessing vulnerability to climate change and future needs. Boulder evaluated 12 potential water supply/demand "futures," including 4 alternative projected future water demands with 3 hypothetical climate scenarios. It made use of a 300-year tree-ring hydrologic reconstruction to derive alternative hydrologic traces based on changes in mean flow and annual variability. It also took a sensitivity approach to investigate the vulnerability of its system to climate variability. Climate change studies provided the bounds for Boulder's stylized scenarios, which were designed to define "reasonable worst-case outcomes.…"

The study concluded that, if climate change causes significant reductions in stream flows, Boulder's water supply system would not be able to meet future demand in some drought years with a reasonable margin of safety. It projected that the city would be able to meet future water needs "up to a defined level of reliability in 3 out of 4 of the water demand scenarios under present hydrologic conditions and one of the scenarios assuming stream flow changes."

In 7 of the 8 scenarios that assumed large reductions in stream flow due to global climate change, Boulder would have to implement water use restrictions more frequently than allowed under current reliability criteria. If stream flow variability increases by 25 percent, the city would be able to meet future water needs by applying drought year restrictions "slightly more often than presently anticipated."

Shortages will occur in some drought years assuming a 15-percent reduction in stream flow "even with a greatly increased application of water use restrictions" unless additional water supplies are acquired or developed, or per capita water use is reduced even more than currently anticipated by Boulder's water conservation program.

Portland, Oregon. The Portland Water Bureau is trying to come to terms with warming temperatures, which result in more precipitation falling as rain rather than snow. This phenomenon yields increased flow in winter, early peak runoff in spring, and reduced stream flow in late summer. Such changes can affect Portland's ability to meet customer demand during the summer and to support fish habitat. Summer demand can peak at over 220 million gallons a day, twice the average daily use.

Portland looked at future climate scenarios from four climate models that considered watershed hydrology, population growth, and system management to simulate impacts on system reliability and reservoir conditions. Trends were generally consistent among the models. The results indicated decreased reliability of supply, higher summer demand, and greater overall vulnerability. The utility anticipates increased seasonal demand of 8 to 10 percent—an extra billion gallons of demand in summer, equal to 10 percent of current storage capacity—mostly due to population growth.

Portland is concerned primarily with a change in the timing of runoff due to climate change, which will aggravate a deficiency in storage capacity. Winter flows will increase 15 percent, and late-spring flows will decrease by 30 percent. Combined with an increase in summer demand, these changes will result in a decrease in storage volume of between 2.8 billion and 5.4 billion gallons—15 to 30 percent of current storage—by the end of the drawdown period.

As a precaution, Portland is considering expansion of the existing groundwater supply or source-water reservoirs. It is also evaluating "conjunctive use" strategies "that coordinate optimal use of existing surface and groundwater supplies, including the use of aquifer storage and recovery (ASR)."

The examples of Boulder and Portland demonstrate the effective use of climate modeling and multiple scenario planning in assessing an uncertain future in terms of climate and water resources. Of course, the response to the assessment can encompass a wide range of supply- and demand-side management options as well as technologies.

The NRC cites a number of examples "to help stretch water supplies" such as underground storage of water, water reuse, desalination, weather modification, conservation, and changes in water pricing, structures, and rates. It also views interstate cooperation as an essential tool for shared resources such as the Colorado River.

What Support Will Water Utilities Need to Cope with Climate Change?

The focus on climate change and IWRM presents challenges and opportunities pertaining to research, program integration, and cooperation within both OW and the larger EPA family. It also necessitates the creation of effective public-private and federal-state-local partnerships to achieve common goals. These matters are literally and figuratively global in scale, yet they must be addressed at the regional, local, watershed, and facility levels.

The planned NWP Climate Change Workgroup represents a process solution to the problem for the time being. Given that three major program offices will be participating—OW, ORD, and OAR—the Workgroup is the logical platform for integrating work on climate and water utilities across programs and media.

Assuming a sustained and productive collaboration between these three EPA offices, there will be an opportunity to form partnerships with other federal as well as state, local, and academic bodies to undertake research and provide technical assistance to communities, say, in the use and “downscaling” of climate models for application at the regional or local watershed level. Of course, the “customers”—water utilities—should be consulted extensively in evaluating their needs and opportunities to assist them. Properly focused partnerships may yield greater synergies.

It may be time for EPA and its partners to review and update the Four Pillars of Sustainable Infrastructure in new, creative ways to assist utilities in adapting to or mitigating the impacts of climate change. Among the possible avenues to explore are:

- Affinities between asset management and multiple climate scenario modeling and planning.

- System consolidation or collaboration in addressing water shortages due to climate change or variability.

- The nexus between water and energy efficiency.

- Refinement and promotion of pricing and metering as an efficiency or conservation tool.

- Reductions in barriers to watershed protection, such as non-structural approaches including source water protection, which can mitigate costs of treatment and prevent non-point source runoff due to increased precipitation, wildfires, and soil erosion.

As climate change, economic growth, and population distribution cause more severe water shortages or disruptions to flow regimes, there will be a need to fully explore the environmental, policy, and legal implications of the inevitable demand for increased inter-basin transfers, especially in the arid west. There will also be ample opportunity to explore technological and managerial innovations to assist in the adaptation to and mitigation of climate effects in terms of treatment, energy and water efficiency, and source water protection. Non-structural (“green infrastructure”) distributed approaches should be part of this enquiry.

It will be most useful for all partners to recall the principle of “Iterative Process” articulated by Assistant Administrator Grumbles in his memorandum establishing the new Workgroup. As the NWP Workgroup forms, reaches out to various partners, and commences its internal and external conversations, all stakeholders will inevitably discover better ways of addressing the challenge of climate change and the vulnerabilities of water utilities, while discarding those that are ineffective or impractical.

For Future Reference

American Water Works Association Research Foundation (AwwaRF) and University Corporation for Atmospheric Research (UCAR). 2006. *Climate Change and Water Resources: A Primer for Municipal Water Providers*. Denver, CO: AWWA.

National Research Council (NRC). 2007. *Colorado River Basin Water Management: Evaluating and Adjusting to Hydroclimatic Variability*. Washington, D.C.: The National Academies Press.