Water Resource Management Challenges in a Time of Changing Climate **

Sharon B. Megdal, Ph.D.
Director, Water Resources Research Center, The University of Arizona
C.W. and Modene Neely Endowed Professor and Distinguished Outreach Professor
Elected Member of the Board of Directors, Central Arizona Project

Summary
Water is scarce relative to demand in Arizona and the Colorado River Basin. Despite 14 years of drought, the likes of which have not been seen for over 900 years, Arizona is not in a crisis. However, central Arizona is particularly vulnerable to Colorado River shortage declaration due to the lower priority of Colorado River water delivered through the Central Arizona Project (CAP). While climate change is projected to impact water supplies and influence water demands, water decision makers must take actions to meet future demands, regardless of the cause of any shortfalls. A suite of policy options is presented, along with a recommendation for engagement of both expert stakeholders and the general public.

Current realities
Water supplies are scarce relative to demands in Arizona and the Colorado River Basin. According to most recent numbers released by the Arizona Department of Water Resources, groundwater, which nature replenishes less quickly than we use it, is pumped to meet about 40% of Arizona's water demands. Water from the Colorado River, including that delivered via the CAP canal, makes up another approximately 40%. The Salt River Project delivers Salt and Verde watershed surface water to the Phoenix area. Reuse of treated wastewater and other surface water supplies make up the rest. In 2011, a special state water resources commission projected that the statewide shortfall between water supplies and demands would reach 1 million acre-feet (MAF) by 2060. One acre-foot of water is 325,851 gallons. In 2012, a U.S. Bureau of Reclamation study offered projections based on alternative assumptions for climate and growth in water demands. For the Colorado River Basin, including Arizona, an average gap in 2060 of 3.2 MAF was projected for the study area, which excluded the Mexico portion of the basin and any detailed study of Native American water uses. Figures 1 and 2 depict the boundaries of the Colorado River Basin and the study area for Reclamation's 2012 study, respectively. Figure 2 shows in crosshatch the communities outside the basin that rely on Colorado River water.

The Colorado River Basin is entering its 15th year of drought conditions. In Fall 2014, Lake Mead, which provides Colorado River storage for the Lower Basin states (i.e., Arizona, California, and Nevada), was at its lowest level since filled and only six feet above the trigger level for a shortage. A declaration of shortage on the Colorado River has never been made. Though climate models project higher temperatures for Arizona and changing precipitation patterns, it is difficult to conclude whether the extended drought reflects climate change or cyclical climate variability. Regardless, a video released by the CAP and available on YouTube, titled "Challenged but Unbroken: Sustaining the Colorado River," reports the sobering reality that the river system faces unprecedented threats. Notably, based on tree ring studies, the flow for the past 14 years is the lowest in any comparable period in over 900 years.

Arizona had to accept lower priority than California for CAP water to secure federal funding. Thus, central Arizona, including Tucson, is in a seriously vulnerable situation if drought conditions persist and become more severe. Arizona's entire CAP entitlement could be curtailed before California experiences any cutback in Colorado River water deliveries. Yet, unlike California, which has experienced severe drought conditions, Tucson and Arizona generally have not faced mandatory cutbacks in water use. There is no local perception of crisis here, which is due to several factors. Arizona municipalities are not subject to cutbacks of CAP deliveries until water levels in Lake Mead decline below the first shortage trigger level of 1,075 feet. Moreover, enabled by Arizona's comprehensive water storage and recovery statutes, the Arizona Water Banking Authority has been storing water since 1997 for "firming" municipal deliveries should a shortage necessitate curtailment of municipal and industrial priority allocations. Importantly, careful planning by water utilities, coupled with compliance with rules requiring physically, continuously, and legally available water for 100 years before new developments can be approved, has enabled utilities to meet the demands of a growing population. In addition, water use in many municipalities has fallen on a per capita basis, resulting in the stretching of existing supplies to meet growing populations.

Scientific opportunities and challenges

Whether transported from afar, diverted from nearby rivers or streams, or drawn from aquifers, the quality of the water is a concern. Although the federal government establishes drinking water quality standards and controls the quality of water discharged into U.S. waters, there are constituents that have no standards. Groundwater, invisible water of great importance to Arizona, resides in aquifer conditions that vary considerably. Therefore, scientific endeavors to monitor, quantify, and treat water quality are of high importance, as are efforts to quantify groundwater in storage and the rate at which it is replenished. Localized drawdown of aquifers is of concern in many areas. Quantification of rates of recharge, whether through natural or artificial means (e.g., spreading basins, which are used extensively in Arizona), is also important. Groundwater quality must also be characterized and groundwater pollution can be difficult to correct. Carbon sequestration in aquifers requires full investigation, especially because deep aquifers are potential future sources of water for human use.

The engineering and science of treatment alternatives provide opportunities for expanding the usability of water supplies. As better membrane treatment systems have been developed, the economics of seawater and brackish (high salinity) groundwater desalination have improved. However, there remain two main issues associated with desalination: (i) the significant energy requirements and (ii) the disposal of the brine. Scientific and economic issues associated with treating wastewater to potable standards are also at the forefront of attention, as are the effects of changing land cover and forest fires.

Global and downscaled (i.e., refined) climate models can inform water planning and management. Scientific issues related to water and climate change have to do with understanding its implications for precipitation events, including intensity, amount, and seasonality. Timing of runoff/evaporation of snowpack and rain events affects surface water availability. Changing temperatures, particularly higher temperatures, affect usable water quantities as well as demand for water for such things as outdoor watering and the energy to power air conditioning. How higher overnight temperatures associated with heat islands affect water use is a climate change phenomenon. It is well recognized that energy use and water use are inexorably linked. The amount of water used for energy depends on the type of energy generation. Water delivery and treatment require energy. The third significant nexus item is food. Scientific developments related to food, including the issue of drought-tolerant genetic modification of crops, are relevant to the world's ability to produce food for a growing population. Although water is essentially local (or nearly local), food and forage, with the water embedded in it, are readily transported.

The science of assessing the water needs of the environment — our natural systems — provides both opportunities and challenges. Only limited portions of Arizona's river systems have been sufficiently characterized in terms of the timing, intensity, and amount of water needed to sustain their health. Finally, but no less importantly, the human dimensions of water use, valuation and stewardship are increasingly subject to scientific scrutiny. In addition, study of water governance and robust approaches to stakeholder engagement are at the forefront of local, regional, and international efforts to improve water management. Social scientists see opportunities for transferability of good practices and for better decision-making based on better understanding of consumer perceptions and the water-use options.

Policy issues

Policy is at the heart of managing water under changing climate conditions. Policy decisions depend on many factors, such as the legal structure, including case law, and the degree of (de)centralization of authorities. Many agree that the barriers to implementation of water management solutions have more to do with public perceptions than issues of science, engineering, or even finance. The region has made extensive use of aquifer recharge to reduce costs of using surface water, replenish groundwater, and store water for future use. In the process of relying on a system of storage and recovery, Tucson Water has developed one of the more drought-resilient delivery systems in the region. The Colorado River Basin states have come together with some innovative agreements (e.g., 2007 Shortage Sharing Guidelines, December 2014 agreement to leave water in Lake Mead). Agreements with Mexico have created additional storage in Lake Mead, international shortage and surplus sharing, and the unprecedented March 2014 pulse flow release of water at the border, which flowed to the Colorado River Delta. In the complex setting of the Colorado River and locally, policy choices that do not depend on fundamental legal changes are the more likely pathways forward.

Southern Arizona tends to focus on water scarcity. Actions are needed to close the supply/demand gap, regardless of cause (e.g., climate related or the growth in population and the economy). Consideration of options should include the impacts of alternative options on natural systems, along with their costs, water yield, and time frame for implementation. Financing options, including public-private partnerships, also require careful scrutiny and debate. Although significant changes to law and institutional arrangements may be difficult to accomplish, modifications of governance approaches, such as regional collaboratives, may assist. Solutions development must involve expert stakeholders from within and outside of the water community, along with the general public. While the particulars of the options and trade-offs may vary by location, the suite of policy options is similar and includes combinations of the components listed.

- Reductions in water demand through increased deployment of multifaceted conservation programs and water pricing that encourages conservation.
- Increasing usable supplies through one or more of the following:
    - Reuse (recycling) of treated wastewater. This is a locally controlled rather than an imported resource, which, upon proper treatment, can be used for potable purposes.
    - Rainwater and storm water harvesting, particularly to match the quality of the water with the intended use. This can reduce the demand on the potable system.
    - Desalination of brackish groundwater and/or seawater and also enhanced treatment of poor quality groundwater. Desalination of seawater could benefit Arizona through trade of Colorado River water for payment for desalinated seawater or possible transportation of desalinated water from Mexico. This is a longer-term option. Seawater desalination options clearly are more complex and depend highly on the decision of non-local entities.
    - Water augmentation through development of water banking and storage projects, water transportation projects. These options are highly developed in the Tucson region. Weather modification is an option some discuss.
- Voluntary water transactions. Options are dependent on the water rights framework.
- Reducing systems losses. Utilities strive for low system losses. Improved technologies for metering, sensors, and advanced warning systems are assisting utilities.

Figure 1. Colorado River Basin Boundaries

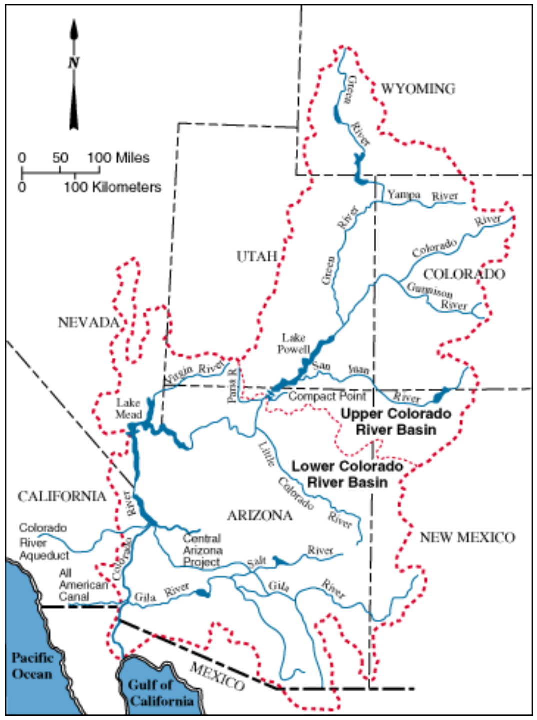

Figure 2. Study Area for Colorado River Basin Water Supply and Demand Study
http://www.usbr.gov/lc/region/programs/crbstudy.html