The Hardest Working River in the West:
Common-Sense Solutions for a Reliable Water Future for the Colorado River Basin

American Rivers
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WESTERN RESOURCE ADVOCATES

JULY 17, 2014

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American Rivers protects wild rivers, restores damaged rivers, and conserves clean water for people and nature. Since 1973, American Rivers has protected and restored more than 150,000 miles of rivers through advocacy efforts, on-the-ground projects, and an annual America's Most Endangered Rivers® campaign. Headquartered in Washington, DC, American Rivers has offices across the country and more than 200,000 members, supporters, and volunteers.

Rivers connect us to each other, nature, and future generations. Find your connections at AmericanRivers.org, Facebook.com/AmericanRivers, and Twitter.com/AmericanRivers.

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For the last 25 years Western Resource Advocates has been the West's premier group of experts protecting the region's air, land and water. WRA's pragmatic team of lawyers, scientists and economists craft innovative solutions for the most complex natural resource challenges in the region. WRA shapes a clean energy future that reduces pollution, protects our unique western lands, and addresses climate change. The organization restores degraded rivers and champions solutions to ensure a reliable water future.

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The Hardest Working River in the West: Common-Sense Solutions for a Reliable Water Future for the Colorado River Basin

THE MAJESTIC COLORADO RIVER cuts a 1,450-mile path through the American West before drying up well short of its natural finish line at the Gulf of California. Reservoirs once filled to the brim from the river and its tributaries are at historic lows due to an unprecedented drought and growing human demands. Diminished stream flows now pose serious challenges for wildlife and recreation, as well as cities, farms, and others who rely upon the river.

Steps currently being taken to improve the situation are not up to the task of bringing the river system back into balance and providing a reliable water supply for all the communities who depend upon the Colorado River. Fortunately, we have five feasible, affordable, common-sense solutions that can be implemented now to protect the flow of the river, ensure greater economic vitality, and secure water resources for millions of Americans.

A supply and demand imbalance on the river

THE FACTS ARE CLEAR: **the demand for water from the Colorado River exceeds the supply.** By 2060, we can expect a 3.8 million acre-foot* deficit in river supply. To put that in perspective, one acre-foot is about how much water 2-3 American families use each year. Coming up short could put 36 million people's drinking water, agriculture, future economic growth and the $26.4 billion outdoor recreational economy and put a quarter-million jobs in jeopardy.

In addition, the river's imbalance is wreaking havoc on the West's natural ecosystems, harming world-class fisheries and unique natural wonders. The ripple effect goes even further, and will impact everything from cost of vegetables to the eroding economic base for the hundreds of communities along the banks of the river, and the entire Western United States.

What's driving the supply and demand imbalance? Demand is increasing because of the skyrocketing population growth in the Colorado River basin's seven states: Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming. Supply is dwindling because of a downward trend of less runoff from rain and snowmelt.

The Colorado River, which flows from the Rockies to southern Arizona, is being exhausted by a 14-year drought, unprecedented in the last 1,000 years.

Applying strategies to correct this supply and demand imbalance is necessary today, or millions of people in both rural and urban communities will face serious water shortages affecting economic development, essential agricultural economies and the region's recreation and tourism businesses. In addition, if there is less water in the Colorado River, its natural habitats will be degraded and several bird, plant and fish species could lose their habitats. Finally, any hopes of restoring flows to the Colorado River's Delta near the Gulf of California would be lost. Imagine, we might again have the Colorado River flowing all the way to the sea, something that has only happened twice in the last half a century.

Common-Sense Solutions Meet Current Challenges

More than 82 percent of Westerners agree **that low water levels in the Colorado River are a serious problem, according to a February 2014 regional poll**. However, there is no single solution—or magic infrastructure project—that will produce enough water to overcome the imbalance of supply and demand. A fresh approach with a suite of measures that fits our contemporary reality is required, and this will necessitate updating antiquated water laws and addressing entrenched approaches to water management.

For a century, federal and state governments proactively facilitated the export of water from the Colorado River to settle and develop the West. Now, the era of "free water" is over. **Emerging water needs can't be addressed as they were in the past by simply diverting more water from the Colorado River and its tributaries, since those resources are drying up**. Furthermore, proposals to augment our supply by piping in water from another river basin or the ocean are unrealistic and often carry huge price tags, regulatory and jurisdictional impediments, as well as negative environmental impacts. Instead, policymakers must focus on becoming smarter and more flexible with our existing water resources.

The right changes now will produce more water and save more money.

Several solutions—which can be implemented soon and with realistic investments—will dramatically meet our current and future needs. Other changes requiring more commitment and cooperation are being implemented by some local governments in the West. Combined, these steps can provide big returns—up to 4.4 million acre-feet, or a surplus of 600,000 acre-feet of water for the basin's economic and environmental future.

There are some good real world examples to follow, including how agencies delivering water in Southern California actually delivered four percent less water in 2008 than in 1990, despite delivering water to almost 3.6 million more people.

Five Affordable Solutions To Ensure A Reliable Water Future

These five solutions below can help improve the health of the Colorado River, grow the economies of the seven basin states, and protect essential western natural habitats.

1. **Municipal conservation, saving 1 million acre-feet—**Water efficiency programs have worked time and again, and represent the lowest cost and greatest business benefits; they sometimes cost five to 10 times less than structural projects. Conservation can happen without infringing on consumers and businesses; instead conservation can occur through improved landscaping techniques, rebate programs that incentivize water-saving devices, installing new appliances and fixtures. In addition, standardized water audits across municipalities routinely result in dramatic savings.

2. **Municipal reuse, saving 1.2 million acre-feet—**Wastewater and gray water can be treated for potable use, and reused for irrigation, industrial

processing and cooling, dust control, artificial lakes and replenishing groundwater supply. Rainwater harvesting using innovative new technologies is a simple additional step.

3. **Agricultural efficiency and water banking, saving 1 million acre-feet**—Agriculture is the river's largest water use, extending across 5.7 million acres of arid western land and consuming more than 70 percent of the river's water. But water shortages will soon inevitably impact the agricultural economy and farmers' livelihood. Voluntarily irrigation efficiency, regulated irrigation, rotational fallowing, crop shifting and innovative irrigation technologies are concepts that many farmers already are using. In addition, water banking is a market-based approach that allows farmers (and others) to bank their unused water voluntarily.

4. **Clean, water-efficient energy supplies, saving 160 thousand acre-feet**—Generating enough energy for the area's population requires a significant amount of water, particularly to cool down thermoelectric power generation. To reduce the need for water to cool thermoelectric power plants, Colorado River basin states can continue to pursue energy efficiency and renewable sources of energy like wind, solar photovoltaics, and geothermal, which require little or no water. And new fossil plants can use waste water for cooling or air-cooled towers to save water-technologies already adopted by power plants in Colorado River Basin states.

5. **Innovative water opportunities, generating up to 1 million acre-feet**—Inland desalination in certain areas with brackish groundwater and surface water is a viable option to stretch water supplies, potentially generating 620,000 acre-feet of water. In addition, dust-on-snow management can help save a minimum of 400,000 acre-feet of water. Finally, tamarisk is an invasive plant that hoards water along the river. Removing dense invasive plants in upland areas will save a minimum of 30,000 acre-feet of water.

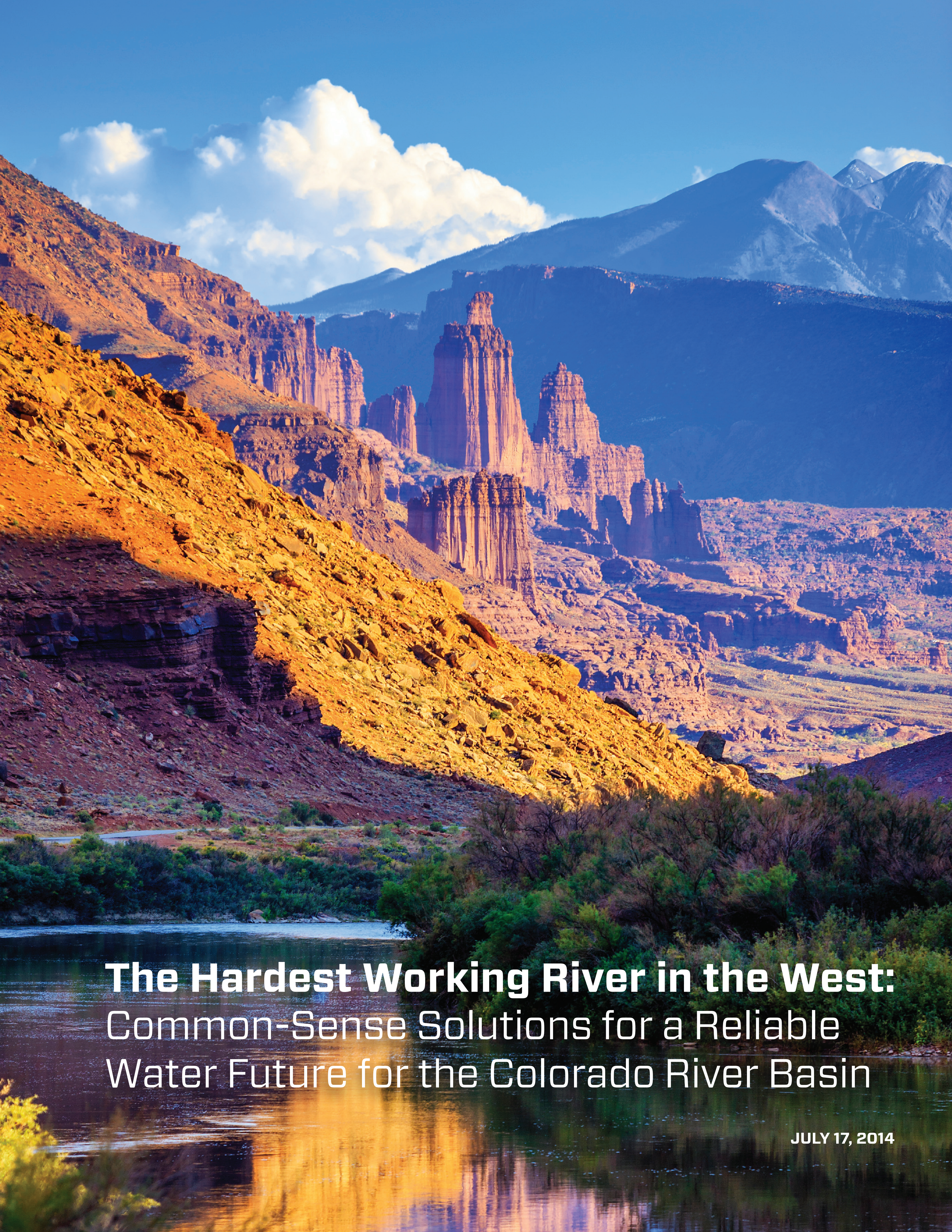
Proven Solutions, Progress We Can See

Federal, state and local officials can help make most these changes today, and start reaping many benefits within a year or two. A few solutions will require longer-term collaboration among governments and users, sometimes a rarity in today's national political and economic climates. Yet, Colorado River basin states and the U.S. Bureau of Reclamation have a solid record of increased cooperation over the last two decades. What's more, many basin states are already taking steps to update their state water plans with innovative, creative ideas for improving water management.

The common-sense and money-saving approaches outlined here are the best path forward. We've already seen strong progress; dozens of successful programs have already been implemented. From citywide conservation efforts to innovative rainwater capture, to successful and mutually beneficial agricultural solutions, we know these work. What's more, we know they are the most efficient, cost-effective, widely available steps we can take right now to solve our supply/demand gap on the Colorado River without doing any harm, while continuing to grow our western economy.

Find out more at ColoradoRiverSolutions.org

*One acre-foot of water equals the amount of water that covers one acre of land to a depth of one foot, or 326,000 gallons.



The Hardest Working River in the West:
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I Introduction: Solutions for a Reliable Water Future for the Colorado River

This white paper provides a roadmap of how to apply innovative programs to reverse the imbalances between water supply and demand across the Colorado River basin while sustaining rural communities and restoring healthy river flows. Many of these programs, such as increased levels of urban and agricultural conservation, represent consensus approaches summarized in the landmark December, 2012 U.S. Department of Interior, Bureau of Reclamation's (USBR) Colorado River Basin Water Supply & Demand Study (Basin Study). Other proposals suggested here call for more creative and cost-effective approaches.

Combined, the programs described in this white paper offer a strategy to reduce water resource vulnerability, improve the resiliency of water supplies, decrease the risk of supply interruptions and help restore healthy flows in key reaches of the Colorado River and its tributaries.

Many of these proposed solutions represent the lower-cost options available to ratepayers and taxpayers. They will help protect the basin's agricultural industry, municipal water users, the environmental health of the river and the $26.4 billion outdoor recreational economy that relies on the river. The technologies needed for these proposals already exist and can be implemented more quickly than the 30-years required for new pipelines. The time to act is now.

II Background: The Colorado River in Peril

The Colorado River basin spans seven states: Arizona, California, Colorado, New Mexico, Nevada, Utah, and Wyoming (basin states).[1] Together, the Colorado River and its tributaries are one of the most critical sources of water in North America. The Colorado River's unique environmental wildlife habitat

1 This white paper, like the Basin Study, focuses on the Colorado River basin in the United States. The Colorado River also flows through two Mexican states. In 2012, the United States and Mexico signed a cooperative agreement, known as Minute 319, which includes programs related to water conservation, water banking and flexible management of water resources in wet and dry times, and water for the environment. Minute 319 provides supply reliability and river health benefits to both nations.

and iconic natural scenery support a $26.4 billion recreational economy, a 234,000-job payroll and $17 billion in retail sales, while attracting 5.36 million recreational users each year into the seven basin states. The river and its tributaries also provides municipal drinking water to approximately 36 million people (both in and outside of the Colorado River basin, including Mexico). It irrigates nearly 5.7 million acres of farmland supporting diverse rural communities that grow 15 percent of all U.S. crops. An environmental treasure, the Colorado River serves as the lifeblood for 22 federally recognized Native American tribes, seven national wildlife refuges, four national recreation areas, and 11 national parks. Hydropower facilities and thermoelectric power plants served by the Colorado River provide more than 19,200 megawatts of power annually, helping to meet the energy needs of the West. Finally, the Colorado River is vital to Mexico to meet its agricultural, cultural, environmental and municipal water needs.

The Colorado River and its tributaries are a network of beautiful, powerful, meandering waterways that provide a wide variety of recreational opportunities and a home to a diverse array of native plant life. Although the river boasts more than 30 fish species found nowhere else in the world, 50 percent of all native fish species in the basin have either gone extinct or are considered vulnerable. Multiple river diversions and overuse mean the Colorado River dries up in the Sonora Desert of Mexico, usually failing to reach its formerly vibrant delta in the Gulf of California.

Dramatic changes in the river's flows have facilitated the dominance of invasive plant species, such as tamarisk and Russian olive, which create poor riverside habitats and consume more water than native vegetation. Recognizing these threats, in April 2013, American Rivers designated the Colorado River as "America's Most Endangered River." Preserving the basin's extraordinary lifestyle, recreational economy, cultural heritage and rural agricultural communities demands a renewed focus on water conservation, and the restoration and protection of healthy flows in the Colorado River ecosystem.

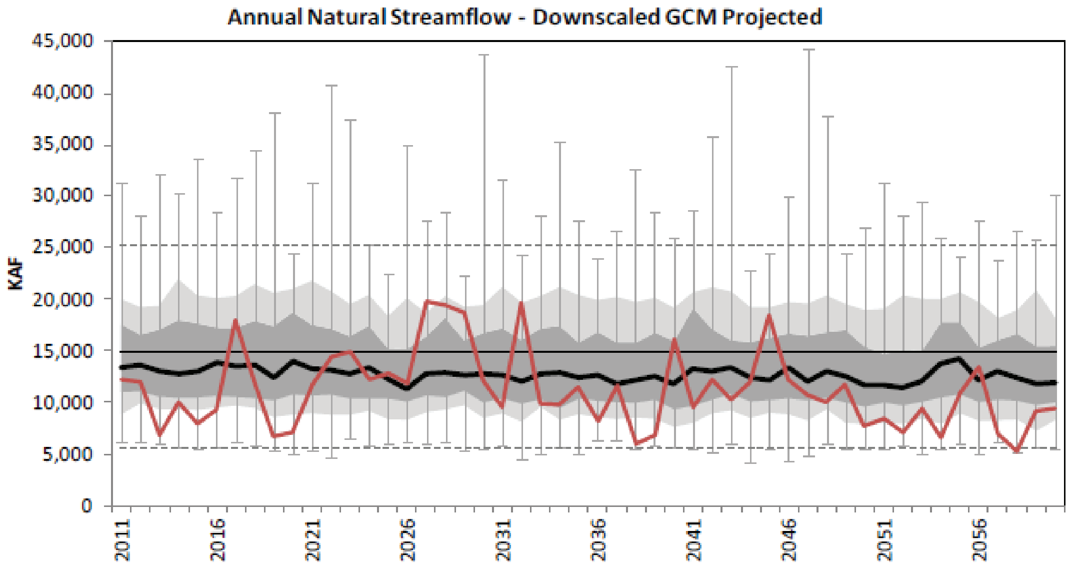
The Colorado River Basin Water Supply and Demand Study

According to the December 2012 Basin Study, the ability of the Colorado River to meet future resource needs is at risk, given increasing demand for water throughout the basin and projections of reduced supply due to changing weather patterns. The imbalance between projected water supply and demand over 50 years time frame is presented in a variety of ways in the Basin Study. However, two critical methods by which to analyze the long-term supply and demand are the mean projected imbalances and the range of projected

FIGURE 1: The Colorado River Basin Study Area

imbalances. Both methods present challenges to water managers, city planners, farmers, businesses, local governments and other stakeholders, all of whom will be forced to plan for the day to day impacts highlighted by these two methods of analysis.

FIGURE 2A: The Basin Study's Projected Annual Natural Streamflow at Lees Ferry, Arizona —Highlights of the Projected Range of Streamflows



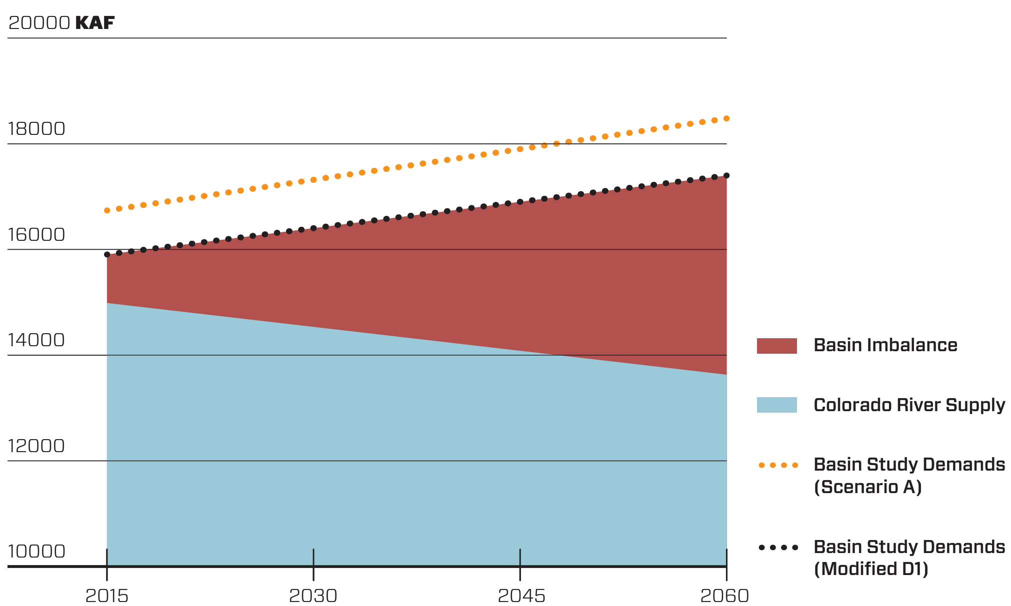
First, Figure 2A highlights the variability or range in projected water supply at Lees Ferry, Arizona, over 50 years as measured by thousands of acre-feet of water each year. While Figure 2A presents an enormous amount of data, several items are critical to note from a water planning perspective. The available water supply decreases steadily over time. Although adjusted to scale, the dark black bolded line in Figure 2A reflects a consistent downward trend as does the dark gray band area reflecting the 25th to 75th percentile projections—i.e. those mostly likely, or "normally" to occur. So, over time, water managers and stakeholders will be required to plan around "normally" decreasing water supplies, as "normal" Colorado River flows will continue to decrease.

However, Figure 2A also presents the daunting challenge of year by year water planning—the fact that water managers and stakeholders are required to plan for and respond to real world water supply shortages as they occur. The light gray band presents the 10th to 90th percentile projections of water supply fluctuations, or those likely to occur about 10 times each 100 years. Note how wide the variations occur in the light gray area. In addition, the individual thin gray lines represent the potential maximum and minimum variations by year, all of which fall notably far away from the projected averages presented in Figure 2A.

Responsible stewardship of water resources requires water managers and stakeholders to plan for the full range of scenarios presented in Figure 2A, as all of these water supply scenarios are supported by the general expectation of more extreme weather events in the Basin Study's modeling projections. Figure 2A summarizes the challenges presented by the broad range of water supply scenarios that water managers and stakeholders must be prepared to address in individual years.

Second, Figure 2B shows the mean (or roughly average) water supply and water demand analyses from the Basin Study. Because of rising demands in the basin states, mean water demands already exceed supply. The projected imbalance between mean supply and projected demand over the next 50 years is presented as the red wedge in Figure 2B. The blue area—supply—also comes from the Basin Study, which projects mean supplies declining be cause of climate change. All of the areas portrayed in Figure 2B represent projected mean (or rough averages).

FIGURE 2B: The Basin Study's Mean Gap in Supply and Demand in the Colorado River Basin



Taken together, the gap between mean water supply and demand could grow to more than 3.8 million acre-feet by 2060 (Figure 2B.)[2] The Basin Study's authors suggested that water shortages affecting agriculture, rural areas and

2 The Basin Study relies upon four main methodologies to produce a range of likely water supply projections. These scenarios are based upon: 1) assumptions that future hydrologic trends will be similar to the past 100 years; 2) assumptions that future hydrologic trends will be similar to the past 1,250 years; 3) assumptions that future hydrologic trends will be similar to a combination of scenarios 1 & 2; and 4) assumptions that future climate trends will continue to warm with regional precipitation and temperature reflecting these climate changes. This white paper bases it projections of the gap between water supply and demand based upon the 4th supply scenario —that climate change will likely impact precipitation and temperature over the next 50 years. This projected 3.8 million acre-feet gap is higher than the 3.2 million acre-feet gap described in the Basin Study because the study's calculation was based on an average of all four water supply scenarios. Assumptions made for the demand analysis in the Basin Study and this white paper are described below in Section V.

cities (including their economic growth potential) as well as damage to the environmental habitats and healthy rivers that support the region's recreation and tourism economy are likely to occur absent strategies that reduce this mean projected imbalance. Figures 2A and 2B combine to highlight the challenges faced by water managers and stakeholders over the next 50 years, both in individual years and over decades. One of the most important achievements of the Basin Study was its comprehensive portrayal of the future challenges posed by this wide range of supply scenarios.

Please note that the Basin Study's projections include an analysis of current and historical demand, and a range of future population estimates submitted by the basin states' local, tribal and state government agencies. Two estimates result: the orange dotted line in Figure 2B represents the Basin Study's current trends scenario, based on demand projections available at the time the Basin Study was performed; the black dotted line is based on more recent population data from Arizona, Nevada and Colorado, and represents more current estimates of future demands.[3]

The Basin Study suggested that addressing the Colorado River's supply and demand imbalances will not be resolved through a single solution. Instead, a wide variety of projects at local, state, regional, and basin-wide levels could help reduce basin resource vulnerability and improve the system's resiliency. The Basin Study contains a wide diversity of potential future water-saving projects that include low-cost, common-sense, "no-regrets" solutions that federal, state and local stakeholders agreed were the best approach for making meaningful change. Ultimately, the Colorado River Basin Study is a call to action to move forward expeditiously on these and other proposed solutions.

Growing Public Concerns

Coupled with this call to action is a growing concern among Western voters that the low levels of water in rivers are a serious problem. In a February 2014 Colorado College poll, 82 percent of western voters said that low water level in rivers is a serious concern. Most voters support conservation over new river diversions and, overall, support for conservation and smart water management in lieu of new water diversions is significantly higher in Colorado (78 percent), Utah (76 percent) and Wyoming (75 percent). The poll results are unequivocal: throughout the basin states, people are concerned that water levels in rivers are a problem.

3 The undertaking of a demand scenario analysis for the Basin States over the next 50 years is both complex and controversial depending upon the assumptions applied. The Modified Environmental Demand scenario (Modified D1 - the black dotted line in Figures 2B & 3) incorporates population projections that are more current than those that were available during the two-year Basin Study stakeholder process. The Modified D1 scenario adjusts estimated population growth for Arizona and Nevada based upon the most recently available population trends in those states, and adjusts agricultural water use and exports in Colorado based upon recently published state documents. Because California's demand for Colorado River water does not vary based on future population estimates for the state, no adjustment was made to the Basin Study's California population projections. Also, no changes in demand projections were made for New Mexico, Utah or Wyoming.

USBR's April 2014 24-Month Study —Short Term Water Supply Concerns and 2015 Projections

Each year the USBR develops an annual operating plan (AOP), based upon a 2007 USBR Record of Decision, that sets the amount of water delivered from Lake Powell and Lake Mead. The AOP's water deliveries are based on water level projections in both lakes from the previous year's 24-month Study, and updated with available data throughout the year. USBR's April 2014 24-month study currently projects a range of runoff in the Colorado River basin, with a minimum inflow into Lake Powell of 8.83 million acre-feet, a most probable inflow of 11.11 million acre-feet, and a maximum inflow of 13.82 million acre-feet. A June 2014 update predicted that on December 31, 2014, Lake Mead's elevation would be 1,083.13 feet.

The 2014 AOP reflects the drought conditions of the previous several years and USBR has already determined that the Lake Powell 2014 annual release volume will be 7.48 million acre-feet, consistent with Section 6.C.1 of the USBR's Interim Guidelines. This means that USBR will reduce Glen Canyon's water releases from Lake Powell in 2014 by 750,000 acre-feet, or the equivalent of enough water to supply 1.5 million homes. This reduction in releases will be 10 percent less than any other time since Lake Powell began operations in 1963.

The 2015 AOP is currently in the early stages of development. However, USBR has closely monitored the runoff from last winter's snowpack and, based on its April 2014 24-Month Study, has determined that the most probable Lake Powell 2015 annual release volume will be 9 million acre-feet. This means that USBR will likely increase Glen Canyon's water releases from Lake Powell in 2015 by 750,000 acre-feet, or restore the 750,000 acre-feet of reduced water deliveries in 2014.

Proposed Solutions for the Colorado River

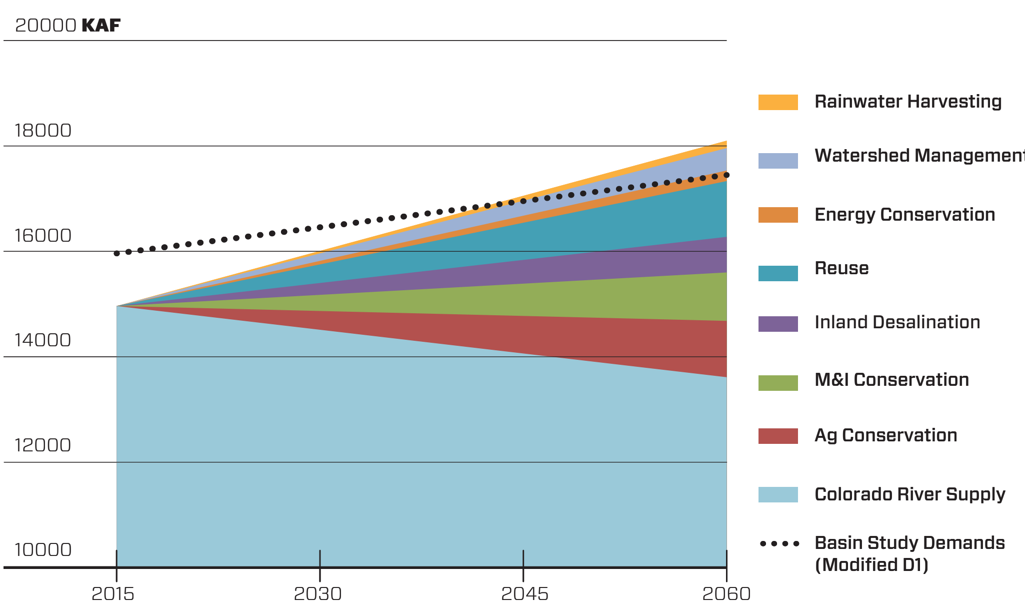
Despite the daunting challenges illustrated in Figures 2A and 2B, there are readily available solutions that can be implemented to close this supply-demand "gap" in future decades. These solutions can be implemented at local, state and federal levels and have the potential to deliver sufficient water supplies without the construction of additional large diversion or storage projects. Figure 3 portrays a water supply and demand scenario that meets the projected needs of the Colorado River basin over the next 50 years while protecting the basin states' economies, agriculture, environmental habitats and recreational activities at the lowest cost. In addition to avoiding costly, impractical and environmentally damaging projects such as massive pipelines from other river systems, these solutions rely primarily upon expanding the use of proven, common-sense tools to meet the challenge. However, these proposed solutions will require a shift away from outdated ways of thinking about supply and demand management. Note that the "gap" illustrated in Figure 3 is based upon mean supply projections over the next 50 years. Many of the proposed solutions can also be scaled up to address the potential range of supply shortages that are shown in Figure 2A. Each policy area in this portfolio of solutions is described in detail below in Sections V and VI.

FIGURE 3: Filling the Gap and Meeting Projected Average Annual Use and Demand

2060 Demands and Solutions

(Values in Million Acre-Feet)

Potential Supply/Demand Imbalance Under the Basin Study's Climate Change Scenario	**3.800**
Proposed Solutions	
Agricultural Conservation (& Water Banking)	1.000
Municipal & Industrial Conservation	1.000
Inland Desalination	.620
Reuse (of Municipal & Industrial water)	1.150
Water for Energy Conservation	.160
Watershed Management	.430
Rainwater Harvesting	.075
Total Water Supply Savings	**4.435**
Potential Excess Supply	**.635**



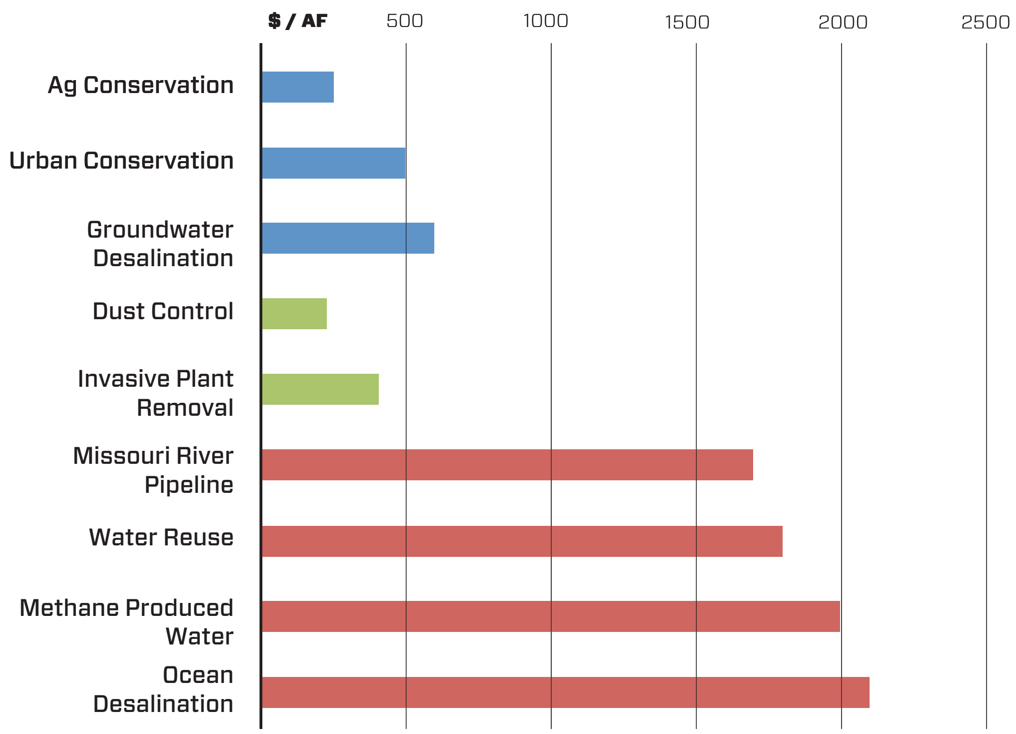
III Benefits of Common-Sense Solutions

An additional supply of 4.4 million acre-feet of water without a large augmentation project could add numerous benefits to the Colorado River basin system. This enormous quantity of water is comparable to the average annual flow of the Green River, a main tributary of the Colorado River.

Cost-Conscious

The first benefit is the avoidance of the high cost of building massive pipelines to augment water supplies from other river systems. Assuming other river systems were willing to sell large quantities of water to the Colorado River basin states (an assumption which may not be politically feasible), the water rate or tax increases associated with building these pipeline systems and treating imported water would be extremely high. The Basin Study estimated that the capital costs associated with the construction of a 700-mile water pipeline to carry 600,000 acre-feet of water to the Colorado Front Range from the Missouri River would be approximately $8.6 billion with an estimated annual cost of $1,700 per acre-foot of water imported, or $1 billion per year for 600,000 acre-feet of water. The Basin Study also estimated that capital costs for a Mississippi River pipeline would be far higher ($14.6 billion) with an estimated annual cost of $2,400 per acre-foot of water imported, or $1.44 billion per year for 600,000 acre-feet of water. Figure 4 portrays a comparison of costs for solutions described in the Basin Study. Many of the proposed solutions described in Figure 3 above represent the lower-cost, more feasible solutions (with the exception of water reuse).

FIGURE 4: Comparison of Annual Costs for Proposed Solutions from the Basin Study per Acre-Foot



Any cost analysis of a Missouri or Mississippi pipeline should also include the full cost of moving water uphill to Denver, Colorado, which would require massive amounts of energy. For example, the largest consumer of energy in California is the California State Water Project, which pumps water from the San Francisco Bay Delta to water users in the Central Valley, the Bay area and Southern California cities including Los Angeles and San Diego. The California State Water Project currently spends more than $192 million per year on energy for pipeline operations. So in addition to huge capital debt repayment responsibilities, taxpayers and ratepayers in the Colorado River basin would be on the hook for maintaining the operations of new massive water pipelines. The Basin Study assumed that low, favorable energy rates will be available for a potential water pipeline, so, some of the potential energy costs are included in the Basin Study's estimates. However, long term, low and favorable energy rates may not be available over the lifetime of a new water pipeline, and, consequently, these energy cost estimates may be understated. Under either energy cost estimate, building and maintaining new water pipelines would incur high costs compared to other water supply solutions as portrayed in Figure 4.

Timeliness

Conservation and improved water management are good solutions because they can be implemented quickly (some, almost immediately) and will not require new infrastructure investments. They rely upon existing technologies and most represent the lower cost solutions evaluated in the Basin Study. The Basin Study, for example, estimates that a Missouri or Mississippi pipeline will take 30 years to design, permit and build. Cities, farmers and businesses would have to wait at least 30 years to see any benefits from a new water pipeline.

Sunk Costs and Adaptive Management

The construction of a large new interstate water augmentation project would require an enormous capital investment 30 years before a single acre-foot of water would be delivered. This large commitment would significantly restrict the potential to redirect funds if such a diversion is not performing as expected. Thus, such an augmentation project can present a significant "sunk cost" risk. By contrast, most of the investments in the proposed portfolio in Figure 3 do not require such a large initial capital investment. As a result, the proposed portfolio of solutions could be managed more adaptively over time, with resources being re-directed to the tools that perform best.

System Reliability and Resiliency

Anyone who has worked at an electric utility or a water company knows that the No. 1 priority is to keep the lights on and/or the water running. When you look at

Lake Powell, UT

the potential gap in supply and demand in Figures 2A, 2B and 3, you can begin to understand that absent a serious commitment to proposed conservation measures, reuse and water management solutions, something has got to give in the supply of water to cities, agriculture, the recreational economy and the environment in the basin states. Current management practices are simply unsustainable. At a July 16, 2013 U.S. Senate Oversight Committee hearing on the Basin Study, water managers testified that future shortages could be addressed by "sharing the pain" among water users. How and when that "pain" would be experienced—whether in the form of less available water or increased costs—was not addressed during the hearing. However, this statement implies that absent changes, water systems will be less reliable and/or more costly for water users.

By implementing the proposed conservation and reuse solutions and potentially adding 4.4 million acre-feet to available water resources, water managers would have far less "pain" (in costs or water reductions) to allocate among water users and the environment. By taking a proactive approach and implementing these proposed solutions, Colorado River basin state and local water systems would be far more reliable and resilient and have more flexibility when shifting water resources to high priority demands during future droughts. After all, the challenge we face is not simply providing more water on average. We must also prepare to manage our water resources in a climate that has always been highly variable from year to year, and will likely be even more variable in the future.

Protecting Priority Headwaters, Tributaries and the Main Stem of the Colorado River

One of the biggest benefits of implementing the proposed solutions is reducing the likelihood of and the need for additional diversions of water from the Colorado River and its tributaries. This package of strategies works by reducing new demands (and thereby the amount of water shortages threatening cities) and eliminating the need for new trans-basin diversions. It also works by compensating water users who forgo diversions temporarily, or those who increase their efficiency and use less water on a permanently. Keeping more water in the Colorado River and its tributaries will improve the health of the environment and help protect the local and regional economies.

Figure 5 presents potential benefits that saving 1 million acre-feet from agricultural conservation would provide to specific locations in the basin. Figure 5 divides the potential savings between the upper and lower basins and lists potential saving by state. The data in Figure 5 are based upon the agricultural conservation estimates in the Basin Study. Existing state and local water laws will make it difficult to translate agricultural conservation water savings into direct benefits for increased healthy river flows. However, Figure 5 demonstrates many of the potential benefits associated with water savings and the resulting additional river flows.

FIGURE 5: Potential Flow Benefits Associated with Agricultural Conservation

Agricultural Conservation

(Thousand Acre-Feet)

Conservation by Basin and State		Tributaries Protected (Includes Flow Restoration)
Upper Basin – 1428 *(Reduced Consumptive Use)*	Colorado – 1278 Utah – 173 Wyoming – 160 New Mexico – 116	Potentially all priority headwaters, tributaries, and the main stem of the Colorado River if the savings are allocated to flows and not the next diverter.
Lower Basin – 1572 *(Reduced Consumptive Use)*	Arizona – 1104 Nevada – 10 California – 1468 *(CA savings not factored into flow benefits)*	Potential benefit for priority rivers and tributaries off the main stem if case-by-case dedication of savings to flows for: • Upper Gila River • Lower San Pedro River • Upper Verde River • Bill Williams River • Muddy River • Virgin River
Mexico	Min 319 – 158*	*This 158,000 acre-feet represents existing water resources available to implement bi-national restoration of the Colorado River Delta from 2012 to 2017

Similarly, Figure 6 lists the potential flow benefits associated with municipal conservation programs in the upper and lower basins of the Colorado River. The specific rivers and tributaries that can benefit are listed by basin and state. These areas will benefit if urban water users achieve conservation levels that do not increase their need for diversions. The flows will also benefit if cities institute programs to not divert the water that their residents conserve.

FIGURE 6: Potential Flow Benefits Associated with Municipal and Industrial Conservation

Municipal Conservation

(Thousand Acre-Feet)

Conservation by Basin and State		Tributaries Protected (Includes Flow Restoration)
Upper Basin – 278 *(Reduced Consumptive Use)*	Colorado – 146 Utah – 68 Wyoming – 13 New Mexico – 46	• Upper Green, Yampa, Gunnison Rivers • Little Snake River • Lower Green, Duchesne Rivers • Upper Colorado River • Gila River • Colorado and Wyoming: Ag sharing and re-use, helps eliminate need for trans-basin water projects • Utah: Wasatch Front avoids need for Bear River and/or Colorado River water
Lower Basin – 727 *(Reduced Consumptive Use)*	Arizona – 291 Nevada – 101 California – 336 (California savings not factored into flow benefits)	• Potential water resources available to support stream flows, system reliability and resiliancy

The Critical Role of Restored and Protected Healthy Flows —Multiple Benefits

A river's natural flows, seasonality, volume, duration, regularity and its rise and fall over time drive many ecological processes and physical conditions that benefit both people and nature. These "healthy, environmental flows" are nature's tools, working to provide clean water, flood protection, groundwater recharge, abundant game and wildlife, healthy riparian forests and recreation. What's at stake is the potential loss of riparian forests and wetlands, spread of invasive species, decline in the abundance of fish and wildlife, and increased water pollution. Cumulatively these impacts result not only in environmental costs, but in economic loss due to decreased recreation value and a decline of ecosystem function and services such as flood mitigation and pollutant breakdown.

The long-term vision for the Colorado River should focus on maintaining a dynamic river system that provides both economic and environmental services. What is often lost in the discussion is that environmental flow recovery can and should allow for a healthy balance of agricultural, municipal and industrial uses, while supporting native fish recovery and the basin's renowned fisheries. This is because most of the water in the Colorado River that supports recreation and the environment is ultimately diverted for consumptive use elsewhere downstream in the basin. So, it is critical to note that healthy flows in the Colorado River are not the same as consumption of water and, if managed appropriately, river flows can be managed cooperatively with current uses, and not in competition with them.

Achieving the Proposed Benefits —Smart Water Management Principles

This white paper offers the most cost-effective, market-based and common-sense policies to meet current and future water needs and provide benefits to healthy stream flows in the Colorado River. These results can be accomplished by following the smart water policies described below. A longer, more specific set of smart water principles focused primarily on municipal and industrial conservation strategies is attached as Exhibit A.

- Prioritize urban water conservation and efficiency as the top sources of water to meet increased demand, i.e., reducing each person's per capita water use;
- Provide more financial incentives and financing mechanisms for industries, cities (and their residents) and irrigators to conserve and reuse existing water supplies;

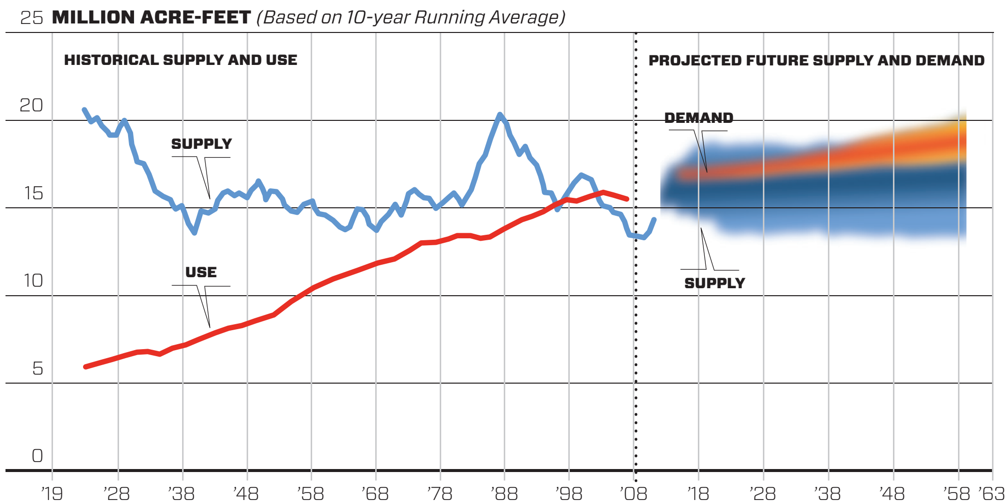
- Emphasize more “sharing” of water between existing users, for example, between farmers and cities, through dry year lease agreements and other voluntary transfers to help address the wide range of future supply scenarios highlighted in the Basin Study. Dry year lease agreements and other short term, voluntary transfers could play a critical role in scaling up (and scaling down) water supply responses to future, more variable climate conditions;
- Balance the coordinated use of ground and surface water supplies in a manner that increases supply reliability;
- Protect rural communities and their access to reliable water supplies;
- Create incentives for cooperation between water providers, including the joint maintenance or operation of water supply infrastructure;
- Invest in infrastructure that expands or rehabilitates existing dams, reservoirs, and structures before building new, costly and potentially damaging projects requiring higher fees and taxes;
- Invest in infrastructure that provides nonconsumptive, healthy flow benefits and improve agricultural sustainability; and
- Recognize the need for water supply projects to conserve, protect and restore healthy flows in the Colorado River for environmental and recreational benefits.

IV Negative Balance: Colorado River Water Demand Exceeds Supply

A COLORADO RIVER BASIN STUDY & WATER SUPPLY ESTIMATES

The Basin Study’s supply projections included one scenario incorporating future climate change impacts on Colorado River water supplies. Although the ability to precisely predict rainfall and water supplies for the next 50 years necessarily includes significant uncertainty, the Basin Study projected that the mean natural flow at Lees Ferry may decrease by approximately 9 percent with a projected average Colorado River water supply of 13.7 million acre-feet. As portrayed in Figure 2A above, this projected decrease in the mean natural flow will also be accompanied by a significant increase in the uncertainty associated with annual stream flows caused by more extreme weather patterns. The Basin Study’s four projected water supply scenarios appear as the shaded blue area on the right side of Figure 7. The darker blue areas represent the study’s projected range of water supplies available over the projected fifty-year time period represented in the chart. Figures 2B, 3 and 7 demonstrate that in the absence of new water management programs and policies, the range of likely future supplies will fall short of future projected demands (demand scenarios are further discussed below), and even fall short of existing uses of the Colorado River.

FIGURE 7: Historical Use and Projected Water Supply for the Colorado River



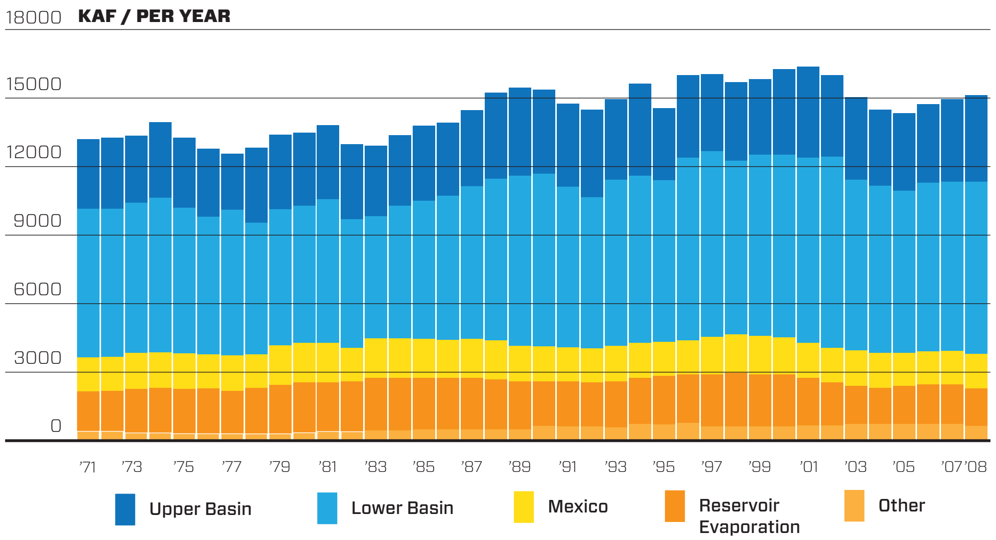
B COLORADO RIVER BASIN STUDY & WATER DEMAND ESTIMATES

The Basin Study conducted over 2,000 complex computer model runs for six different demand scenarios for potential water projections for the basin states over the next 50 years. The range of these estimated demand scenarios are represented by the dark red band in Figure 7 above. Note that many of the scenarios represent demands in excess of historical water use. In other words, some of the future demand estimates represent increases based on projected population growth in the basin and the areas it supplies with water. Please note that projected future uses of water will likely be less than the amount of projected demand as the availability and cost of water has a significant impact on its actual consumption.

To gain some perspective on demand scenarios in the Colorado River basin states, it is helpful to review their actual water use. Figure 8 provides a description of historic use of Colorado River water by region as well as reservoir evaporation (and other current system losses) and deliveries to Mexico. Differences in the "upper basin" and the "lower basin" consumption are influenced by population densities, climate and crop varieties.

It is also helpful to examine the categories of current users of Colorado River water and trends in water use. The Basin Study is one of the first attempts

FIGURE 8: General Use of Colorado River Water by Region (1971–2008)



to present summary data on water consumed by different sectors. Figure 9 lists Colorado River water users by sectors such as agriculture, municipal and industrial water suppliers, the Central Arizona Project (which includes municipal and agricultural uses as well evaporation losses), energy production facilities, mineral extraction activities, a small fraction of fish, wildlife and recreational uses, exports to Mexico and exports to areas outside of the Colorado River Basin.

FIGURE 9: Use of Colorado River Water by Sector and Activity (1971–2008)

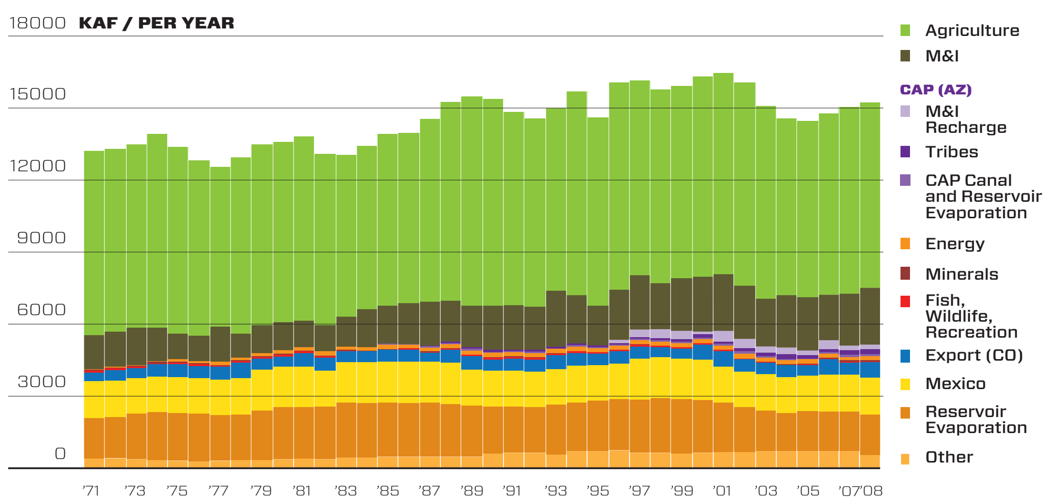


Figure 9 is not a full depiction of the actual requirements of fish, wildlife and recreational uses. This is because the Basin Study only quantified the consumptive portion of wildlife and recreational water demands. Most of the water necessary for river flows that benefit fish, wildlife and recreation is left in the river rather than consumed (and is available for diversions for consumptive use downstream). Consequently, healthy flows in the Colorado River are not the same as consumptive uses of water for fish and wildlife. Managed appropriately, river flows can be managed in tandem with current consumptive uses, not in competition with them.

Figure 9 provides a timeline of historic Colorado River water use over the past several decades, and thus shows the growth of use by municipalities and industrial facilities from 1971 to 2008. This growth in use by municipalities is also reflected in the "Colorado Exports" category, which includes municipal and industrial users outside of the basin. Finally, Figure 9 demonstrates that irrigated agricultural production remains the largest user of Colorado River water.

C A HARD WORKING RIVER—WATER USE AND RELATED ECONOMIC ACTIVITY BY STATE

Keeping a sufficient amount of water in the Colorado River has tremendous economic value. Recreation on the Colorado River and its tributaries supports over a quarter million American jobs and produces $26.4 billion annually in total economic output. The Colorado River plays a critical role in the economy of each of the Colorado River basin states:

ARIZONA—The vast majority of Arizonans depend on the Colorado River for drinking water. Almost 85 percent of Arizona's irrigated agricultural land depends on the Colorado River including the highly productive farm areas near Yuma. In Arizona alone, recreation on the river system supports more than 53,000 jobs and nearly $6 billion in total annual economic output.

CALIFORNIA—California has more people depending upon Colorado River water than any other state. In total about 20 million Californians rely, at least in part, on the Colorado River for their drinking water. Additionally, over a half million acres of agricultural land in California is irrigated by the Colorado River and most of the vegetables consumed by Americans in winter months come from California crops irrigated by the Colorado River.

COLORADO—Colorado is home to the mighty river's headwaters. Nearly all of the state's Western Slope relies on the river for its drinking and agricultural water. On the eastern side of Colorado's Continental Divide, Front Range cities, including Denver, rely on the river for much of their water supply, and many eastern plains farmers also depend on the river's water being shipped in for irrigation. About 61 percent of irrigated agriculture acreage in Colorado depends at least in part on the river. Recreation results in nearly $10 billion in economic output annually and supports nearly 80,000 jobs in the state.

NEVADA—The vast majority of southern Nevada residents depend on the Colorado River for drinking water, despite the fact that Lake Mead is reaching historic lows. The river is also the primary source for irrigation water for the region's small agricultural industry. Recreation on the river and Lake Mead results in more than $2.8 billion in economic output annually and supports more than 25,000 jobs in Nevada.

NEW MEXICO—The Animas, La Plata, Mancos, Navajo and San Juan rivers are all Colorado River tributaries that flow through New Mexico. More than 1 million New Mexicans depend on the Colorado River system for drinking water, and the San Juan River irrigates 100,000 acres of farm land in the state. Recreation on Colorado River tributaries results in nearly $1.7 billion in total economic output annually and supports more than 17,000 jobs in the state.

UTAH—At least 1.2 million Utah residents depend on the Colorado River for drinking water. The river also supports one quarter of all irrigated agriculture and recreation on the Colorado River system supports more than 34,000 jobs and more than $3.3 billion in total annual economic output.

WYOMING—About 100,000 Wyoming residents depend on the Colorado River system for drinking water and the river system supports about one quarter of all irrigated agriculture in the state. Recreation on the Colorado River system supports more than 24,000 jobs and nearly $1.6 billion in total annual economic output.

D MANAGING THE CURRENT SUPPLY AND DEMAND IMBALANCE ON THE COLORADO RIVER

Imbalances in water supply and demand in the Colorado River system (as portrayed in Figures 2B, 3 & 7) are currently managed largely through two massive storage facilities—Lake Powell, which stores 28 million acre-feet (MAF), and Lake Mead (24 MAF). Combined, these two storage facilities are able to safely retain approximately three and a half years of average annual Colorado River flow. However, Lake Mead and Lake Powell currently hold less than 50 percent of their capacity as a result of growing demands, diversions of Colorado River water, the decade-long drought and sedimentation in both lakes. While the reservoirs will continue to help lower basin states manage year-to-year shortfalls in water supply, they alone cannot solve the long term imbalances in the supply and demand for Colorado River water, and, importantly, cannot address the gap in the upper basin.

Today, water demand exceeds supply in the Colorado River basin and this imbalance has been managed by slowly depleting water stored for decades


Dead Horse Point State Park, AZ

in the reservoirs. This situation is inherently unsustainable and without the implementation of the proposed solutions in Figures 3 and 10 is likely to lead to significant water management changes in the coming years.

V Common-Sense Solutions Meet Current Challenges

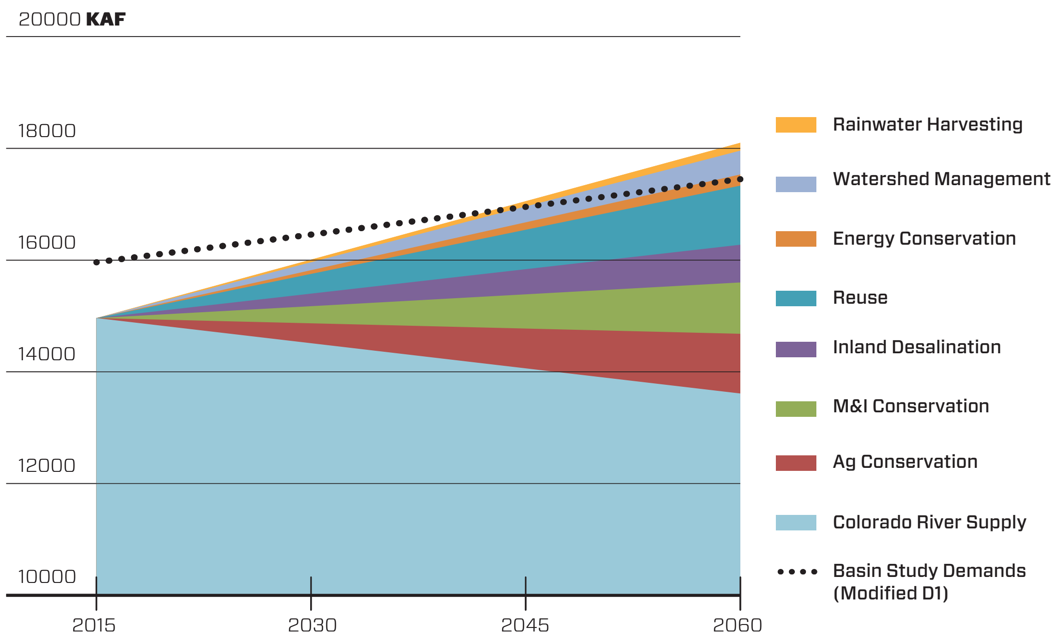
These proposed water supply and conservation strategies account for population growth and continued economic development while helping to restore healthy flows into the Colorado River and its tributaries. These programs can help meet future needs without the large, costly, and environmentally damaging diversions that have been a hallmark of historical approaches to water planning.

FIGURE 10: Demand/Supply Imbalance and Proposed Solutions

2060 Demands and Solutions

(In million acre-feet)

Potential Annual Supply/Demand Imbalance Under Climate Change Scenario	**3.800**
Proposed Solutions	
Agricultural Conservation and Transfers (Including Water Banking)	1.000
Municipal + Industrial Conservation	1.000
Inland Desalinization	.620
Reuse (Municipal + Industrial)	1.150
Water for Energy Conservation	.160
Watershed Management (Dust + Tamarisk)	.430
Rainwater Harvesting	.075
Total Supply	**4.435**
Excess Annual Supply With Proposed Solutions Implemented	**.635**



A MUNICIPAL CONSERVATION

The Colorado River supplies water to millions of people in fast-growing cities such as Las Vegas, Mexicali and Phoenix. Tens of millions of people outside the Colorado River watershed, from Denver, Albuquerque, Salt Lake City, Los Angeles and San Diego and everywhere in between also receive water exported from the Colorado basin. Municipal water supplies include residential, commercial, industrial and landscape irrigation (but not deliveries to agriculture, energy producers, or mining) and comprise approximately 15 percent of total Colorado River use (not including exported water). According to a 2011 Pacific Institute Report, total water deliveries by 100 cities and municipal water agencies that use Colorado River basin water increased from about 6.1 million acre-feet in 1990 to about 6.7 million acre-feet in 2008 (an increase of more than 600,000 acre-feet). Although these 100 cities and municipal water agencies use other sources of drinking water, the Pacific Institute Report illustrates that municipal water supplies are the fastest growing category of Colorado River water use.

Municipal conservation programs are particularly important because the number of people relying at least in part on water from the Colorado River basin increased by roughly 10 million from 1990 to 2008, to a total of approximately 36 million people. Much of this increase occurred in areas experiencing extraordinary population growth: several cities in Arizona and Utah more than tripled in population between 1990 and 2008. The Las Vegas metropolitan area added upwards of a million people, more than doubling in size. Most experts and the Basin Study agree that population growth will continue in the Colorado River Basin states.

Fortunately, municipal conservation programs can help address these population trends. For example, according to the Pacific Institute, agencies delivering water in southern California actually delivered 4 percent less water in 2008 than in 1990, despite serving almost 3.6 million more people. Water conservation and efficiency programs have been proven to work in the Colorado basin (and elsewhere) and represent the lowest-cost option to provide additional water supplies in almost every scenario. Conservation programs can be implemented almost immediately and can be expanded as more water providers adopt their use. Urban water conservation and efficiency can also enhance the production of economic goods, services and jobs while maintaining or even reducing overall water use. Water conservation helps businesses reduce overhead, increase profits, and can create significant numbers of jobs.

Conservation and efficiency measures (also referred to as demand management or water productivity improvements) include: changed behavior by customers, installing efficient appliances and fixtures, better water use metering, improving landscape efficiency techniques such as xeriscaping, and replacing and/or repairing pipes to reduce water loss within the water conveyance and distribution system.

Despite efficiency gains through conservation efforts over the past 25 years, current urban water use in the United States remains generally inefficient. Wasteful fixtures and appliances are still commonplace, particularly in homes built before 1994, and in a range of commercial, institutional and industrial settings. For example, even in a dry and densely populated state like California, where many water agencies have taken the concerns about water supply constraints seriously, far more can be done. A 2003 analysis by the Pacific Institute found that more widespread penetration of existing, cost-effective technologies and policies could reduce California's urban water demand by more than 30 percent. A similar study in Seattle in 2000 found that installing new, water-efficient fixtures and appliances reduced single-family indoor use by nearly 40 percent.

Water service providers and utilities can invest in efficiency improvements through rebate programs or policies that reduce the payback time of installing water-saving devices, such as water rates that incentivize lower water usage. Direct-install programs replace inefficient appliances and fixtures with more efficient models at no cost, or a greatly reduced cost. In addition water service providers can offer rebates for customers to install water efficient appliances or to replace water-intensive landscaping. For example, the Southern Nevada Water Authority offers rebates to homes and residents that replace turf with more water efficient landscapes. So far, this program has led to the removal of more than 155 million square feet of irrigated lawn grass in the Las Vegas area. This type of conservation measure is particularly important as using drinking water for lawns is an inefficient—and perhaps the most questionable—use of a precious resource, and represents almost 50 percent of residential water use in some cities in the Colorado River basin.

Finally, another promising approach is for a municipal water supply system to perform a standardized audit of the entire system. First, the audit establishes where all inventories of water are going. Second, the audit identifies the most cost-effective water efficiency and conservation measures in light of the user base, usage patterns and distribution system. Third, once this analysis is complete, the water system can set efficiency goals. Fourth, once the water efficiency goals are set, the water system can then prioritize investments in order to deliver the results. A number of organizations are working now with municipal water systems to establish standardized audit protocols and procedures, but more work needs to be done.

As indicated in Figures 3 and 10 above, the Basin Study estimated that municipal and industrial conservation programs could save 1.0 million acre-feet of water in the Colorado Basin states. Potential savings may be even higher than the Basin Study estimates. A critical component of these programs is to incentivize reduced water consumption. Water providers and consumers in the Colorado Basin states should be financially rewarded for innovative programs. A list of "Nine Smart Water Principles" published by American Rivers in 2008 to help conserve municipal and industrial water use is attached as Exhibit A. Figure 6 in Section IV above presented some of the potential river flow benefits associated with implementing municipal conservation programs.

MUNICIPAL/URBAN CONSERVATION—MODEL PROGRAMS AND POLICIES INCLUDE:

- **Targeted financial incentives** for consumers to save water:
    - Outdoor: Southern Nevada Water Authority's Cash for Grass Program—Water Smart Landscape Rebate program.
    - Indoor: Denver Water's High Efficiency Toilet program.
    - Indoor: Denver Water's Industrial, Commercial and Institutional Rebate Program for water conservation projects (provides $6,000 per acre-foot of water conserved).
    - Indoor: Irvine Ranch, California—Water District Rate Structure—Since 1991, this program has reduced landscape water use by 43 percent and residential use by 20 percent.
    - Indoor: Report on Water District Rate Structures that reflect consumption.
- **New tap demand offset programs** (water-neutral development—requiring zero additional water use).
    - See Santa Fe's City Water Bank.
    - See East Bay, San Luis Obispo and Santa Cruz County, California
- **Water-use reductio**n goal setting:
    - Utah governor's office goal setting—see 25% by 2025—Governor Gary Herbert's January 2013 conservation goals.
    - California's 2009 Water Conservation Act (SB X7-7 2009) targets a "20

by 2020" water conservation goal for municipal water supplies.

- **"Social norming"** or voluntary consumer conservation—providing customers information about their water use (i.e. more, same, or less than their neighbors)
  - See also: WaterSmart Software.
- **Modernizing state** and local codes/ordinances
  - Outdoor: California Model Landscape Ordinance.
  - Indoor: Georgia Plumbing Code and California Plumbing Code.
- **Public education programs—**Metropolitan Water District of Southern California.
- **Tucson Pilot Program**—The University of Arizona helped create a water and riparian conservation and restoration fund that connects municipal water conservation to local environmental benefits.

B MUNICIPAL/URBAN WATER REUSE

Traditional water sources include rivers, lakes, groundwater, and artificial reservoirs created by dams. In the past few years, however, alternative water sources have played an increasingly important role in supplementing water systems where traditional sources have become harder or more expensive to develop. Such alternative sources include rainwater, storm water, gray water and reclaimed water. Projects to capture these alternative water sources can be implemented by a water utility or at the facility level by households or businesses. This white paper, like the Basin Study, focuses on water reuse activities at the utility-scale; other actions at the home or farm level, such as rainwater harvesting are also viable alternatives.

Broadly, water reuse refers to the process of treating and reusing wastewater for a beneficial purpose. Potential uses include agricultural and landscape irrigation, industrial processing and cooling, dust control, artificial lakes, and replenishing groundwater basins (referred to as groundwater recharge). Treatment levels can be tailored for the intended purpose and the level of human contact, which can help save money and energy when the quality does not have to meet drinking water standards. Water can be distributed from a wastewater treatment facility, or treated and reused directly at the treatment site (such as at an industrial facility).

A growing number of communities across the U.S. are already beginning to move in the direction of encouraging and expanding use of reclaimed water.

According to the USEPA's Clean Watersheds Needs Survey, an investment of approximately $4.4 billion is needed to build, rehabilitate, or replace infrastructure for reclaimed water distribution. In 2004, USEPA estimated total wastewater reuse in the United States at 1.7 billion gallons per day, growing at a rate of 15 percent per year. The same report estimated 32 billion gallons of wastewater are produced each day, of which 12 billion gallons per day are discharged directly to an ocean. These ocean discharges could be recycled and made available for local water users.

Water reuse or the use of highly treated wastewater effluent (also called reclaimed or recycled water) is attracting increasing attention. Many communities have implemented inexpensive water reuse projects, such as irrigating golf courses and parks. These communities have become seen the advantages of water reuse, such as improved reliability and drought resistance of supplies. However, increased reuse of water for household purposes does pose more complex financial, technical and institutional challenges. Some water agencies, including those in Aurora, Colorado, and Orange County, California, have adopted innovative "indirect potable reuse" programs that eventually provide clean water for human use. These water reuse programs have successfully taken on the technical and public perception issues related to treating water.

Another potential water conservation technique is "rain water harvesting" or storm water collection programs that include bio swales and other forms of storm water retention, permeable pavement, green roofs, and other efforts to reduce impervious areas. For example, local government agencies in Los Angeles, California, and Tucson, Arizona, have implemented pilot programs to disconnect downspouts, rerouting rooftop drainage pipes to rain barrels, cisterns, or permeable areas instead of the storm sewer. Although existing state and local laws may present obstacles to the implementation of similar programs throughout the Colorado River basin region, these programs offer promising results and benefits. Finally, water conservation and reuse also includes water treated and reused onsite at a smaller scale and is often referred to as "gray water." This includes water from clothes washers, showers, and faucets for use on outdoor landscapes or other non-drinking water uses.

As described in Figures 3 and 10 above, the Basin Study estimated that water reuse and storm water management projects can save a minimum of 1.225 million acre-feet in water supply demand for municipal and industrial users. The potential for reuse supplies may higher. The California State Water Resources Control Board has already established a statewide goal of 2.5 MAF for water reuse by 2030, requiring up to 1.2 MAF in new water reuse. The Basin Study estimated new potential reuse water supplies as 1.15 MAF for municipal, industrial and gray water reuse and "rain water harvesting" as 75,000 acre-feet. These water reuse approaches offer a lower cost alternative to other water sources such as building pipelines or new reservoirs. Figure 11 presents the potential river flow benefits associated with water reuse.

FIGURE 11: Potential Flow Benefits Associated with Water Reuse

Water Reuse
(Thousand Acre-Feet)

Impact by Basin and State	Tributaries Protected	What For?
Upper Basin Total – 160 *Municipal Reuse* Colorado, New Mexico and Wyoming – 80 Utah – 20 Potential gray water use – 60	• Upper Green, Yampa, Gunnison Rivers • Little Snake River • Lower Green, Duchesne Rivers • Upper Colorado River	• Provides water for Front Range non-potable uses • Reuse potential by cities in Upper Basin • Utah: Wasatch Front avoids need for Bear River and/or Colorado River water • Colorado & Wyoming: could help reduce potential for trans basin water projects
Lower Basin Total – 1006 *Municipal Reuse* Arizona – 250 California – 600 Potential gray water Use – 156	• Potential increased stream flows - Gila River	• Provides water for non-potable and indirect potable uses • Provides system balance and flexibility

MODEL WATER REUSE APPROACHES INCLUDE:

- Aurora, Colorado, Reuse—Prairie Waters Project
- Orange County Water District, California, Groundwater Replenishment System
- Inland Empire Utilities Agency, California, recycled water system—Wastewater District with water supply, compost and natural gas district components
- Reuse requirements for new construction projects or federally financed construction

C AGRICULTURAL WATER EFFICIENCY AND CONSERVATION

Under current water policy, many experts predict that transfers of agricultural water rights will increase to satisfy the rising municipal and industrial water demands. This is because transferring water from existing agricultural uses is typically less expensive than other sources available to cities. Several basin states have indicated their support for alternatives to traditional water transfers that result in the permanent dry-up of farmlands to minimize the negative socioeconomic impacts to rural communities that can result from permanent transfers. Water banking and alternative water transfers are important potential water management and conservation tools in the basin states; they are discussed in Section VI (D) below. Voluntary, market-based transfer mechanisms are a critical component for agricultural water conservation strategies.

Agriculture is the largest user of water in the world, our nation and the Colorado River basin. Irrigated agriculture extends across some 3.2 million acres of land within the Colorado basin (including the Salton Sea watershed in the U.S. and Mexico) while water exported from the basin helps irrigate another 2.5 million acres in Colorado, Utah, New Mexico and Southern California. Irrigated agriculture consumes more than 70 percent of the water supply within the Colorado River basin (exclusive of exports and reservoir evaporation). According to the Basin Study and a recent Pacific Institute report, potential water savings in irrigation agriculture may save 1.0 MAF in the Colorado River basin without taking land out of production. These potential water savings are based on various conservation scenarios involving irrigation efficiency, regulated deficit irrigation, rotational fallowing, crop shifting and advanced irrigation technologies and vary significantly between the upper and lower basins.

A 2008 study by the Colorado Agricultural Water Alliance listed five ways that consumptive water use can be decreased in the agricultural sector: (1) irrigated crop acreage is decreased; (2) crop selection is changed from a summer crop to a cool seasonal crop; (3) crop selection is changed to require a shorter growing season; (4) deficit irrigation is practiced, applying some of the less-than-full evapotranspiration (ET)[4] requirements over the growing season; and (5) evaporative losses from the field are reduced as a result of conservation tillage, mulching, efficient irrigation and/or drip irrigation. Although the agricultural landscape in the lower basin is much different from the upper basin, these five opportunities apply across the Colorado River basin. In addition, there are other conservation opportunities in the lower basin such as switching to sprinkler systems rather than flood irrigation and using greenhouses for certain crops. If nothing is done to protect agriculture, future shortages of water could force some productive farms areas to be permanently retired from agricultural production.

4 Evapotranspiration is the loss of water from the soil both by evaporation from the soil surface and transpiration from the leaves of the plants growing on it. Factors that affect the rate of evapotranspiration include the amount of solar radiation, atmospheric vapor pressure, temperature, wind and soil moisture. Evapotranspiration accounts for most of the water consumed and lost from the soil during the growth of a crop and is thus a critical factor for planning irrigation methodologies.

Financial Incentives for Agricultural Conservation

Under current water policy, many experts predict that transfers of agricultural water rights will increase to satisfy the rising municipal and industrial water demands. This is because transferring water from existing agricultural uses is typically less expensive than other sources available to cities. Several basin states have indicated their support for alternatives to traditional water transfers that result in the permanent dry-up of farmlands to minimize the negative socioeconomic impacts to rural communities that can result from permanent transfers. Water banking and alternative water transfers are important potential water management and conservation tools in the basin states; they are discussed in Section VI (D) below. Voluntary, market-based transfer mechanisms are a critical component for agricultural water conservation strategies.

Irrigation Efficiency

Although great advances in agricultural water efficiency have been made, improved water management techniques can produce even more gains through reduced water loss and, in some cases, they can improve crop quality and yield. They include improved irrigation technologies and scheduling, reducing erosion, lining canals, increasing pump efficiency, restoring riparian areas, recycling excess water on-farms, and constructing spill reservoirs at the water supplier scale. A study in the upper Rio Grande River basin found that efficiency improvements could have a variety of beneficial impacts, including increases in gross revenue and crop production, and decreases in total water use. Total system-wide water savings from more efficient irrigation systems are difficult to calculate and must consider the loss of return flows which are often a valuable downstream water supply source. Not all of these techniques reduce net water use; nevertheless, irrigation efficiency has the potential to reduce consumption in the agricultural sector in the Colorado basin. In addition, some irrigation efficiency programs can provide non-consumptive healthy flow benefits by reducing conveyance losses in irrigation systems and thereby allowing more water to remain instream.

Precision Irrigation

Farmers are constantly implementing new technologies and management practices to improve their products. In many cases, water savings occur when farmers use techniques that decrease input costs or improve crop quality. One such practice is replacing flood irrigation with precision irrigation, which today occurs on almost 39 percent of irrigated land in the United States. Precision irrigation has been shown to decrease input costs and improve quality, and, according to the U.S. Census of Agriculture, flood irrigation declined 5 percent nationwide between 2003 and 2008, replaced by more precise sprinkler and drip irrigation. Continued efforts to shift from flood irrigation to sprinkler and/or precision irrigation may yield additional water conservation savings in the Colorado River basin.

Regulated Deficit Irrigation

The traditional irrigation strategy supplies crops with ample water throughout the season. However, water scarcity has innovated new approaches that reduce crop water use including deficit irrigation (which is watering slightly below full crop requirements), tail water recovery, and soil management practices that increase soil moisture retention. All these practices can be effective tools to reduce applied water and increase revenue. Regulated deficit irrigation (RDI) is a voluntary irrigation management practice implemented during stress-tolerant growth stages in order to conserve water while minimizing negative impacts on yield. Because response to water stress can vary considerably by crop, a clear understanding of crop behavior and ecological conditions is required to maintain yields. Water savings associated with RDI depends on many factors, including the crop type and the sensitivity of growth stages to stress, climatic demand, stored water, spring-summer rains and the particular irrigation method.

RDI is practiced widely on wine grapes to improve crop quality and has been used successfully on several crops in the Colorado River basin, including alfalfa. To implement RDI across the Colorado River basin, other interests—such as municipal water agencies, water trusts or wildlife agencies—would need to compensate irrigators for their reduced crop yields, so total costs would need to be negotiated and would presumably include incentive payments to irrigators.

Crop Shifting

Crop shifting refers to converting from one type of crop to another. A variety of factors limit producers' ability to shift crops, from physical constraints such as soil conditions, climate and water availability, to market considerations and other less tangible factors. In the upper basin, the crop mix (predominantly pasture and forage) has been stagnant for many years, at least partly due to these factors. In the lower basin, farmers have demonstrated much greater ability and willingness to shift between crops. Although any specific decision to shift crops will be grounded in a set of factors particular to that location, crop shifting could be implemented in the context of projected water shortages, incentivizing willing producers to plant less water-intensive crops that, in many cases, have higher market values, and transfer a portion of the water savings to improve supply predictability or to benefit overall stream flows.

Water Measurement and Reporting

The federal government is closely linked to agricultural water supply as the U.S. Bureau of Reclamation provides irrigation water to approximately 1 out of every 5 farmers in the nation. In some cases, the Bureau has encouraged water conservation through measurement and reporting. Most often, agricultural water efficiency is driven by state and local efforts, particularly in areas that experience frequent droughts. For example, California recently passed the Water Conservation Act of 2009, which, for the first time, requires that large irrigation providers measure the quantity of water delivered to customers and begin to charge their customers based on their water use (known as volumetric pricing). Volumetric pricing is intended to send better price signals to agricultural water users thereby encouraging efficiency.

As presented in Figures 3 and 10 above, the Basin Study estimated that agricultural transfers and conservation could save 1.0 MAF of water in the Colorado Basin states and a recent Pacific Institute report indicated that conservation savings may be even higher.

As described in Section V (D) below, agricultural water conservation savings and transfers should be driven by voluntary, locally designed and controlled market-based incentive programs in tandem with appropriate federal, state and local entities that provide irrigators with financial incentives and low transaction costs for their participation. Although some successful models exist, there is both a great deal of opportunity and work to be done in this evolving area. Figure 5 in Section IV above presented some of the potential river flow benefits associated with implementing agricultural conservation programs.

OTHER MODEL AGRICULTURAL CONSERVATION APPROACHES INCLUDE:

- Palo Verde Valley, California—Land management, crop rotation and supply program Imperial Irrigation District, California—System efficiency upgrades
- Three Sisters Irrigation District (Bend, Oregon)—Oregon's conserved water statute allows for piping, pressurization and low head hydro projects that increase water reliability for district irrigators; saved water is dedicated to in-stream flows.
- Metering and volumetric pricing for U.S. Bureau of Reclamation-delivered water
- New financing mechanisms for agricultural infrastructure upgrades
- California Farm Water Success Stories—Pacific Institute's case studies of successful agricultural water conservation projects

D WATER BANKING

For most of us, traditional banking is a familiar concept. People store their resources in a collective location, with the ability to access their property whenever they need to. The bank itself can lend and benefit from the large "pot" of pooled resources, benefitting those who want a safe place to store assets when they are aren't needed. Banking encourages savings and gives participants access to loans when they need support. Water banking is a similar concept.

A water bank is an institutional mechanism designed to facilitate transfers or exchanges of water on a temporary, intermittent or permanent basis through voluntary, market-based transactions. Specifically, water banks are generally established to accomplish one (or more) of the following goals: a) create a more reliable water supply during dry years; b) stockpile water supplies for future water needs; c) promote water conservation by encouraging water users to conserve and deposit conserved water into the water bank; d) facilitate more active water market trading and purchasing activity; e) resolve supply and demand issues between groundwater and surface-water users; and f) ensure compliance with intrastate agreements regarding instream flows and with interstate compacts. Water banks range in geographic scale from involving local water users in a specific urban area or a county to offering services across broad regions, sometimes including several states (for example, the Arizona Water Bank also serves Nevada and California).

The core principal of a water bank is to voluntarily use market mechanisms to facilitate flexibility in an otherwise rigid water rights system. In the upper Colorado River basin, ranchers and farmers would be compensated for reducing their consumptive use of irrigation rights, allowing that water instead to flow into Lake Powell. While much remains to be explored about how exactly such a bank would operate within the 'Law of the River' and state water laws, the central purpose of such a bank would be to prevent a compact compliance call by the lower Basin states. Such a call has never happened before. There is widespread agreement that a call could cause economic and environmental havoc in the upper Basin states, and, the looming threat of a call introduces great uncertainty for water users. Appropriately structured, water banking could provide solutions throughout the Colorado River basin for urban water providers, agriculture and the environment. To the extent that an upper Basin water bank would shepherd conserved water down to Lake Powell for storage and ultimate release to the lower Basin, the bank would prevent the conserved water from being re-diverted in the upper Basin and thereby result in flow protection for priority headwaters, tributaries and mainstems.

One of the most attractive characteristics of a functioning water bank is the ability to scale up (and subsequently scale down) water conservation activities in response to short term water shortages. While a massive pipeline to divert large volumes of water from another river system would take decades to design, finance, permit and construct in order to alleviate shortages, a water bank could provide stored surplus water almost immediately. In addition, unlike a massive water pipeline which would cost an enormous amount of money to finance and maintain even during wet periods, a water bank can be scaled back down when a drought period ends and sufficient water resources become available. Given the Basin Study's findings that projected water supplies will be more variable in the future (See Figure 2A above), the flexibility and scaling advantages of water banking will likely prove to be particularly attractive. In addition, water banking will help to avoid the construction of costly infrastructure.

As described in Figures 3 and 10 above, the Basin Study has already estimated that agricultural transfers and conservation can save 1.0 MAF in the Colorado basin states. The development of water banks and streamlined water transfer rules will help facilitate these savings and provide flexibility to farmers and ranchers who conserve water.

There may be additional water savings by eliminating the need for existing water rights holders to "use or lose" their water supplies. By allowing water rights holders to make voluntary, temporary transfers to meet short-term variations in water supplies, benefits would accrue to both parties and increase system reliability and resiliency. However, significant federal, state and local legal issues would need to be reformed and modernized to establish low-transaction cost water transfer and water banking mechanisms for these types of short-term and long-term agreements. The water banking approaches listed below have not yet overcome all of these existing legal obstacles. The establishment of robust and transparent water markets and a shared water bank in some or all of the basin states will help farmers and ranchers conserve water while potentially boosting revenues. Agricultural communities in the Colorado River basin states should be provided financial incentives to increase water efficiency and conserve water while lowering the transaction costs associated with transfers of conserved water.

MODEL WATER BANKING AND WATER TRANSFER APPROACHES INCLUDE:

- Arizona Water Bank
- Lower Colorado River intentionally created surplus (Arizona, California, Nevada)

Hoover Dam, NV

- Deschutes groundwater mitigation program and the Deschutes Water Alliance water bank, Deschutes River Conservancy, Oregon
- Colorado Water Trust, Denver, Colorado—voluntary transfers

E WATER USE FOR ENERGY

Thermoelectric power plants consume substantial amounts of water each year, impacting the Colorado River basin states' valuable rivers, lakes and groundwater aquifers. In the Colorado River basin, power plants consume more than 167,000 acre-feet of water each year. Figure 12 lists the fossil fuel plants in the Colorado River basin states and the amount of water consumed at each generating facility. Coal plants could consume even more water if they become operational.

Fortunately, energy efficiency and many forms of renewable energy use negligible amounts of fresh water. Adopting energy efficiency policies and developing more renewable energy sources can help to meet the basin states' future energy and water demands at the same time.

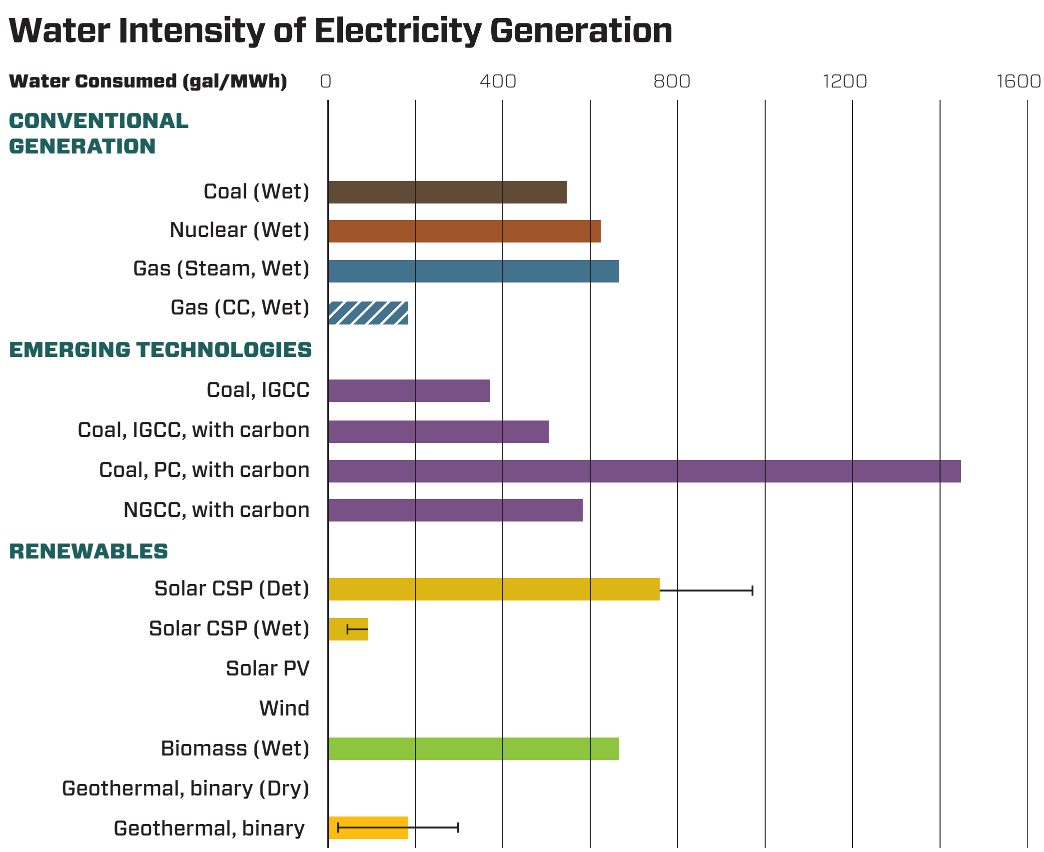
FIGURE 12: Water Consumption by Power Plants in the Colorado River Basin

Map #	State	Plant	Primary Fuel	Cooling Water Source	Average Annual Consumption (AF/yr)
1	AZ	Desert Basin	Gas	Central Arizona Project Canal Water	1,614
2	AZ	Navajo	Coal	Lake Powell	26,274
3	AZ	South Point Energy	Gas	Colorado River	1,954
4	CO	Craig	Coal	Yampa River	14,331
5	CO	Hayden	Coal	Yampa River	2,823
6	CO	Nucla	Coal	San Miguel River	1,592
7	NM	Four Corners	Coal	San Juan River	24,826
8	NM	San Juan	Coal	San Juan River	19,977
9	UT	Bonanza	Coal	Green River	7,672
10	UT	Carbon	Coal	Price River	3,112
11	UT	Hunter	Coal	Cottonwood Creek	18,746
12	UT	Huntington	Coal	Huntington Creek	12,377
13	WY	Jim Bridger	Coal	Green River	25,333
14	WY	Naughton	Coal	Hams Fork River	6,080
		Total			**166,711**

In comparison to fossil fuel plants, many renewable sources of energy such as wind, solar PV, geothermal and certain concentrated solar power technologies consume negligible amounts of water. The water needed to produce various sources of electricity and power is displayed at Figure 13.

One option for reducing water use for power production is to use air-cooled steam condensers instead of cooling water. In the United States, only about 1 percent of electrical generating capacity uses air-cooling, which is a relatively expensive option. Use of this technology may expand in the future as water availability increasingly constrains power generation options. A second option is hybrid cooling systems, which use both wet and dry cooling, depending on water supplies and weather conditions. Xcel Energy's Comanche Unit 3 plant in Pueblo, Colorado, uses a hybrid cooling system that will save about 50 percent compared to a conventional re-circulating system. A third option is to use recycled or reused waste water for cooling towers.

FIGURE 13: Water Consumption by Generating Source



In contrast to thermoelectric technologies, wind power and solar photovoltaic panels use no water during operation. Similarly, micro turbines that generate power from methane gas captured at landfills or wastewater treatment plants consume no water. Geothermal power plants typically use negligible amounts of fresh water. The water saved with renewable energy or energy efficiency can be substantial. For example, replacing just one 500-MW pulverized coal plant with wind turbines capable of producing an equivalent amount of energy saves nearly 6,200 acre-feet of water—the annual domestic, consumptive water needs of approximately 55,000 people.

As water in the basin states becomes scarcer, its value will undoubtedly rise. Today, most electric utilities do not adequately value water when they create their future permitting and resource plans despite the fact that most regulators in western states have the authority to value water in evaluating a resource plan. Evaluating the value of water both today and in the future is a critical step forward toward the better integration of water supply issues in electric resource planning. At a minimum, state and local regulators should require that electric generating utilities plan and account for future water consumption needs and costs in their planning and permitting processes. As described in Figures 3 and 10 above, the Basin Study estimated that power facility conservation programs can save 160,000 acre-feet of water. This would require a shift to using recycled water or air cooling at fossil fuel plants and/or a transition to renewable power sources such as solar, wind and geothermal over the next 50 years. Figure 14 lists potential flow benefits associated with water for energy conservation.

FIGURE 14: Potential Flow Benefits Associated with Water for Energy Conservation

Water for Energy Conservation

(Thousand Acre-Feet)

Conservation by Basin and State		Tributaries Protected (Includes Flow Restoration) and Related Power Plants
Upper Basin - Total 160 *(Reduced Consumptive Use)*	Colorado – 18 Utah - 40 Wyoming - 30 New Mexico – 42 Arizona - 25	• Yampa River (Craig and Hayden Plants) • San Juan River (San Juan and Four Corners Plants) • Green River (Jim Bridger, Hunter, and Huntington Plants) • Hams Fork River (Naughton Plant) • Colorado River mainstream (Navajo Generating Station)

WATER CONSERVATION FOR ENERGY—MODEL APPROACHES INCLUDE:

- **Adopting high levels** of energy efficiency
    - Arizona Public Service—Implemented an energy demand reduction program with a $140 million investment in 2012 to achieve a 1.8 percent net energy savings. More information at: http://www.swenergy.org
- **Promoting water-efficient** renewable energy

- Policies to advance this include renewable energy standards or other state-based incentives. Colorado has set a 30 percent renewable energy standard by 2020.
- 26 states have Renewable Energy Standards

- **Retiring water-intensive** coal-fired power plants:
    - Colorado's Clean Air-Clean Jobs Act required Xcel Energy to retire 900-MW of coal units and replace them with energy efficient natural gas and other cleaner power sources. The act will save 5,200 acre-feet of water in the Denver area.
    - Arizona Public Service has proposed retiring Four Corners Units 1–3, which draw water from the San Juan River.
    - NV Energy's proposal to retire Reid Gardner Station and its share of Navajo Generating Station (both of which draw water from the Colorado River Basin)
- **Incorporating water** into long-term energy resource planning and investments:
    - Arizona Public Service—Evaluates water use for different energy portfolios over time and the potential value of that water
- **Adopting dry cooling** for new power plants:
    - Nevada and Arizona both encourage dry cooling for new natural gas plants. Arizona has indicated that water use is a significant factor in permitting decisions.
- **Relying on recycled wastewater** for power plant cooling systems:
    - San Antonio Water System—100 percent reclaimed water for CPS Energy facilities.
    - Denver Water System—100 percent reclaimed water for Xcel Energy's Cherokee Station facility
    - Palo Verde, Arizona—100 percent reclaimed water for the Palo Verde Nuclear Generation Station.

VI Innovative Water Opportunities

A number of water conservation and water management techniques hold the promise to augment the supply of water in the Colorado River basin states and to improve management flexibility during droughts. Each of the options described below—the removal of invasive tamarisk plants from Colorado River banks, the improved management of dust on snow in the Basin States and the targeted deployment of inland desalination projects—offer ways to increase the supply of Colorado River water at a cost that is much lower than other supply augmentation options.

A TAMARISK REMOVAL

Riparian lands in the Western United States have been severely impacted by many human-related actions including the introduction of tamarisk, an invasive and non-native plant. Tamarisk plants hoard light, water and nutrients, and can destroy native wildlife habitat. The Colorado River basin is an ecosystem in which tamarisk has spread to such an extent that it has effectively altered the natural functions and processes of the ecosystem. Tamarisk issues are widespread and complex, and there are no easy solutions for its eradication. Any tamarisk removal project should also include native plant restoration measures to avoid negative environmental and habitat impacts.

Tamarisk (or salt cedar) is a deciduous shrub or small tree from Eurasia that can grow as high as 25 feet tall. Tamarisk has displaced native vegetation on close to 1.6 million acres of land in the western United States and continues to spread. Water use by tamarisk varies depending on depth to groundwater, water quality, plant age and length of growing season, but it is much higher than native plants because of its ability to tap into deeper groundwater, spread onto areas much

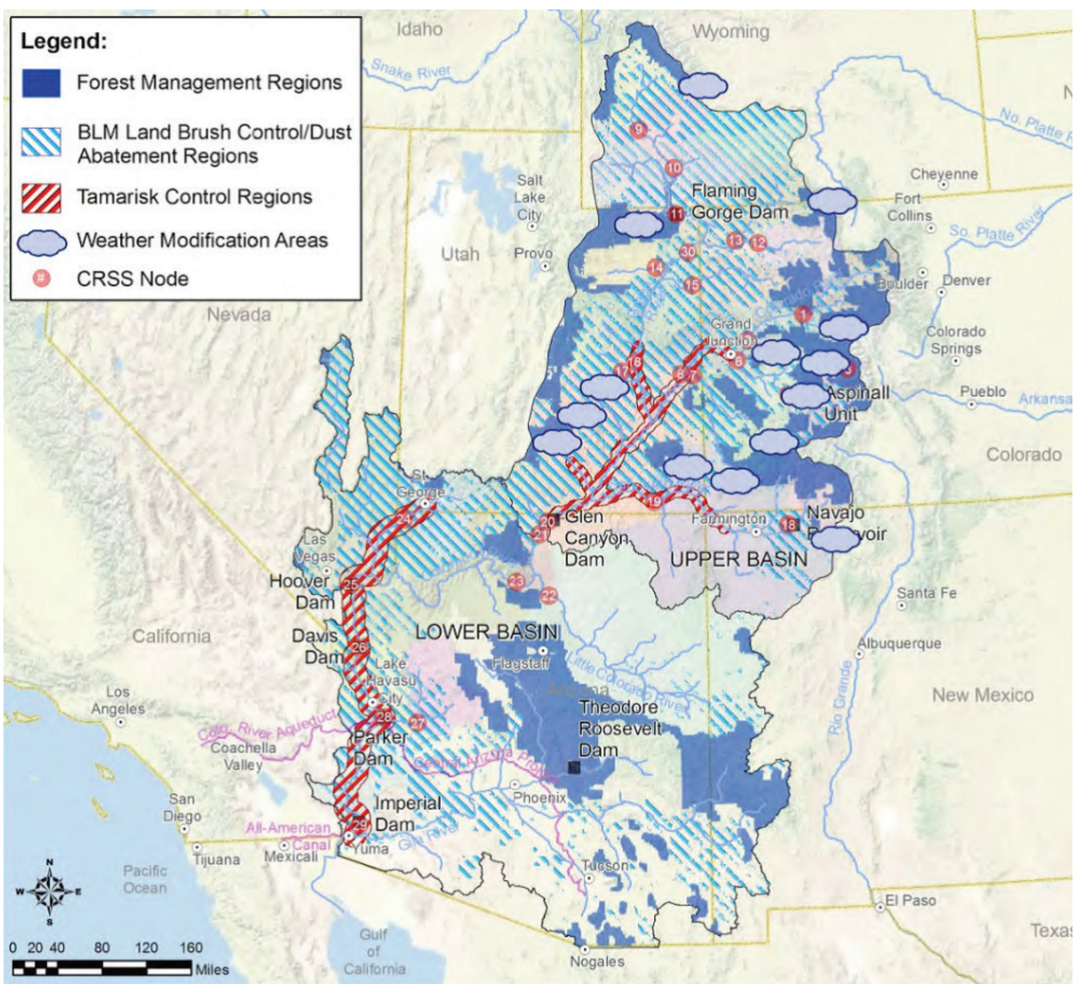
PHOTO 1: Tamarisk along the Colorado River near Moab, Utah

farther from the Colorado River and grow much denser than native plants.

In 2009, the University of California Santa Cruz convened a peer panel of scientists to analyze the tamarisk problem and develop recommendations for the Colorado River basin. The purpose of their assessment was to provide enough information for the basin states to make informed decisions about the cost-effectiveness of large-scale tamarisk removal/management.

The panel's December 2009 report concluded that although costs and potential water savings are strongly dependent on site-specific factors, there is an opportunity to save water within the Colorado River system at a relatively low cost per acre-foot. The panel suggested that the greatest potential for water savings is by managing tamarisk on upland sites adjacent to rivers, where the plant would be controlled, and depending on conditions, sites would be re-vegetated with native species. A report by the USGS in 2009 reached the same conclusion.

FIGURE 15: Basin Study Map of Tamarisk Infestation in the Colorado River Basin (in Red)



The panel found potential water savings from tamarisk management would range from 50-60 percent of the amount of water currently used by tamarisk. For a representative site within the Colorado River basin that has 60 percent tamarisk canopy cover, of which 75 percent of the area would be re-vegetated with native xeric vegetation, the panel estimated that approximately 1 acre-foot can be saved for each 1.85 acres of tamarisk managed, or 0.54 acre-feet per acre. Most encouraging, the report concluded that the costs for a tamarisk management effort and subsequent water savings are competitive with other water supply augmentation approaches.

Normalized unit costs of water saved by tamarisk management for sites within the basin range from $260 to $1,050 per acre-foot. Using a suite of available and common techniques, tamarisk management costs are estimated to be less than $400 per acre-foot. In addition, the panel noted that other environmental benefits will generally accrue to aquatic and terrestrial habitats, reducing wildfire threats and improving cultural and recreational uses.

As described in Figures 3, 10 and 16, the Basin Study estimated that tamarisk conservation programs can save a minimum of 30,000 acre-feet of water in the Colorado basin states. Currently some funding is available from state and federal government agencies for pilot projects. These funds should be expanded and allow successful pilot projects (with demonstrated and monitored water savings) to be compensated for the additional water made available to the Colorado River streambed. Figure 16 lists potential flow benefits associated with tamarisk removal.

FIGURE 16: Potential Flow Benefits Associated with Tamarisk Removal

Tamarisk Removal
(Thousand Acre-Feet)

Basin	Tributaries Protected
Upper Basin Tamarisk–7.5 (1/4 of 30)	• Colorado River (Main stem—Glen Canyon) • San Juan River • Green River • Escalante River • Dolores River
Lower Basin Tamarisk–22.5 (3/4 of 30)	• Colorado River (Main stem—below Lake Mead) • Bill Williams River

MODEL TAMARISK REMOVAL APPROACHES INCLUDE:

- Paradox Valley Tamarisk Control Project, Montrose County, Colorado
- San Pedro River Partnership—Southern Arizona

- Tackling Tamarisk on the Purgatory River Watershed, Southeast Colorado
- Virgin River (Utah, Arizona, Nevada)

B DUST ON SNOW MANAGEMENT

White snow reflects the sunshine; snow that is covered with dust is darker and absorbs the sun. When snow gets dusty, more of it evaporates. The mountain snowpack of the Colorado River basin has historically functioned as the largest "reservoir" in the region, storing the snow in the winter and releasing it through snowmelt in the spring. Human settlement generates dust because our animals, vehicles and construction projects disturb the soil. Dust storms and the general deposition of dust have increased in the west along with population. As a result, the level of dust on snow in the mountains of the Colorado River basin has increased.

In 2003, researchers with NASA's Jet Propulsion Laboratory used an advanced hydrology model to simulate water entering into and flowing out of the upper Colorado River basin. The modeling results indicated that the current (2003-08) dust on snow levels accelerate the timing of snowmelt by up to 30 days across the basin varying with total snow accumulation and forest cover. The NASA research found that the timing of the runoff peak at Lees Ferry, Arizona—reflecting the inflows from the entire upper basin—is now three weeks earlier under the current dust scenario and the annual runoff at Lees Ferry is reduced by 5 percent. The modeling indicated that the lost flow under the current dust scenario varies year to year from a low of 2 percent to a high of more than 7 percent. Similar research at the National Oceanic and Atmospheric Administration's Institute for Research in Environmental Sciences at the University of Colorado in Boulder has found that the snowpack is melting six weeks earlier than it did in the 1800's.

This excess dust on snow may rob the Colorado River system of an average of 800,000 acre-feet of water annually, yet runoff loss caused by excess dust may be reversible because the primary causes of excess dust are disturbances from land uses such as grazing, oil and gas drilling, dry land agriculture and off-road vehicle use. Changes in land management to promote soil stabilization and re-vegetation in those areas could decrease dust loading and its hydrologic impact.

As described in Figures 3, 10 and 17, the Basin Study estimated that dust management programs can save a minimum of 400,000 acre-feet of water in the Colorado Basin states. These programs will need to be financed through demonstration programs, but offer significant potential benefits in the basin states. Figure 17 lists potential flow benefits associated with dust on snow prevention.

FIGURE 17: Potential Flow Benefits Associated with Dust on Snow Management

Dust on Snow Management
(Thousand Acre-Feet)

Basin	Tributaries Protected
Upper Basin • Dust on Snow—400	• Colorado River (Main stem—Glen Canyon) • San Juan River • Green River • Escalante River • Dolores River

EXISTING DUST ON SNOW PREVENTION APPROACHES INCLUDE:

- Identification and treatment of high dust source areas
- Improved enforcement of grazing guidelines, particularly during drought periods

C INLAND DESALINATION—GROUNDWATER AND SURFACE WATER TREATMENT

With supplies of clean water becoming scarcer in certain areas and water demand increasing, desalination is on the rise in the United States. According to a June, 2006, Pacific Institute study, "Desalination: With a Grain of Salt", there were roughly 2,000 desalination operations larger than 300,000 gallons per day in the United States, including industrial plants. According to a 2012 International Desalination Association (IDA) Report, between 2000 and 2010, 117 municipal desalination plants were constructed, bringing the total to 324 plants built since 1971.

Desalination grew significantly because of improved technology, a decline in cost and dwindling supplies of water in the face of heightened demand. Most of the new plants cited in the IDA study are small or medium scale, and many water managers now believe that inland desalination of brackish groundwater and surface water should be one option to consider depending on the location. However, full-scale ocean desalination must consider its relatively high costs, intensive energy use and potential negative environmental impacts, both from facilities that run on fossil fuels generating greenhouse gases, but also the from the disposal of concentrated brine in the ocean.

Inland desalination plants can provide a secure source of water, albeit salty water, for environmental purposes. Salt tolerant wetlands plants can thrive on concentrate from inland desalination and provide an ecosystem supporting marsh birds and other wildlife. An Oxnard, California, Concentrate Treatment Wetlands pilot project demonstrated the ability of an engineered natural treatment system to utilize concentrate for environmental benefit. The pilot employed salt-tolerant, brackish marsh species to remove nutrients and heavy metals and to provide volume reduction. Any analysis of the environmental costs and benefits associated with an inland desalination project will vary by geographic location, and should be evaluated on a case by case basis. However, more water system managers are considering inland desalination as one tool to meet rising demands and add resiliency to their water supply systems.

As described in Figures 3 & 10, the Basin Study estimated that inland desalination projects could provide up to 620,000 acre-feet of water supply demand in the lower Colorado River basin states. These desalination programs will pose a challenge for financing and waste brine disposal but may increase the water supplies available to households and businesses.

MODEL INLAND DESALINATION PROJECTS AND APPROACHES INCLUDE:

- Western Municipal Water District, Arlington, California—Inland Desalter
- Desalination Projects in Israel

VII Proven Solutions, Progress We Can See

The landmark Colorado River Basin Study served as a call to action for federal, state and local stakeholders to move forward with low-cost, feasible, common-sense solutions to future water shortages in the Colorado River. Many stakeholders are already moving forward and there are four potential areas for immediate policy and project development:

Federal Actions

BASIN STUDY WORKGROUPS—The follow up to the Basin Study included the formation of three multi-stakeholder workgroups representing federal, state, tribal, agricultural, municipal, hydropower, environmental and recreational interests. These workgroups are investigating potential action items in: 1) Municipal and Industrial (M&I) Conservation and Water Reuse, 2) Agricultural Conservation and Water Transfers, and 3) Environmental and Recreational Flows. USBR has asked these workgroups to identify specific programs and policies to jump start conservation and research efforts. The workgroups should be encouraged to produce specific, actionable plans as soon as possible that can meet the short- and medium-term water conservation goals outlined in the Basin Study. Federal agencies should move forward quickly with the activities of the workgroups and help organize and staff their efforts for the next three years. Congress should increase funding for federal agency programs that promote the solutions developed by these workgroups including water conservation and efficiency, such as *WaterSmart* and other related programs. This will help the Basin Study workgroups achieve their planning and implementation goals.

MODELING WORK ON HEALTHY FLOWS—The Basin Study took a large step forward by considering healthy flows in the Colorado River as an important component of the health of the river system and the economy of the region including the businesses and industries that rely on outdoor recreation and tourism. Important scientific modeling will be required beyond the conclusion of the Basin Study workgroup on healthy flows to help define when and where flows are needed to keep the Colorado River system healthy. Congress should fund research on healthy flows to protect the river and the recreational economy.

COORDINATED FEDERAL APPROACH—Numerous federal programs at different departments and agencies engage in various aspects of water management in the Colorado River basin. A more coordinated approach that unites programs at the Departments of Interior, Agriculture and Energy, as well as the Environmental Protection Agency, could leverage scarce federal resources into a more effective approach to water management.

FEDERALLY-SPONSORED COLLABORATIVE R&D ON WATER SAVINGS IN AGRICULTURE—Around the world, innovations that reduce water use in agriculture have emerged that sustain profitable agribusiness. Many of these solutions are geographically specific, tailored to local water, soil and market conditions. The Colorado River basin needs research and development of geographically appropriate water conservation and efficiency programs that will help farmers, ranchers and agriculture thrive in this region as water supplies become increasingly scarce. Federal coordination and support for state and university programs is critical.

REPORTING, DATA AND TRANSPARENCY—The Basin Study was the collection of an immense amount of data and information on the Colorado River and how related water resources are consumed in the basin states and Mexico. The federal government should continue to collect, publish and organize data from the various state, local and federal agencies that already maintain water records and scientific data on the Colorado River. Standards and practices should be developed to ensure consistency between and within basin states to allow for more accurate interstate accounting and streamlined water transfer programs. As water becomes a resource that is increasingly scarce in the Colorado River basin, farmers, ranchers, local water planning agencies, citizens, taxpayers and small businesses in the recreation industry all have a greater need for more transparent and accessible information on available water resources. Congress and the federal government have an important role to play in filling this growing need for information on water and water conservation.

State Actions

REPORTING, DATA, TRANSPARENCY AND PLANNING—As noted above, one of the greatest achievements of the Basin Study was the collection of an immense amount of data and information on the Colorado River and how water is consumed. State governments should collect, publish and organize data from local agencies responsible for maintaining water records and scientific data on the Colorado River. Standards and practices should be developed among the states to ensure consistency between basin states to allow for more accurate interstate accounting and streamlined water transfer programs. In addition, Utah, Colorado, New Mexico and California are all engaged in state water resource planning efforts. These state-based planning efforts should be encouraged and supported and perhaps expanded into more robust regional planning efforts.

WATER BANKING—Water banking and alternative agricultural water transfers offer some of the most important potential water management and conservation tools in the basin states. The logical first step for building low transaction cost methods to allow farmers and ranchers to make market-based, voluntary water transfers is to reform state laws. Each state in the Colorado River basin should undertake efforts to implement reforms that facilitate the establishment of state and regional water banking mechanisms. All stakeholders should work with farmers and ranchers to develop the appropriate financial and legal mechanisms to help them conserve water. Perhaps the greatest opportunities for water banking occur in the upper basin. The federal government should also work with and encourage states to implement water banks and water transfer mechanisms in the basin.

MODEL PROGRAMS/MODEL CODES—As described in Sections VI and VII above, there are model programs and projects in municipal and agricultural water conservation, water reuse and river management that have proven successful in the Colorado Basin and across the country. Each state in the Colorado River basin should begin adopting some or all of these model programs where appropriate in their state. Recent legislative initiatives during the 2014 legislative session in Colorado may serve as promising examples.

REGIONAL COLORADO RIVER WATER CAUCUS—To build upon the success of the Basin Study workgroups, state and local elected officials should form a "Colorado River Water Caucus" to help marshal federal, state and local funding for research and pilot conservation programs. The Colorado River Water Caucus might be particularly effective in educating congressional representatives from basin states on federal funding and research opportunities, while also encouraging the federal government to play a unique role and work with state and local stakeholders to identify priority projects and programs to address the water supply and demand issues.

Local Government/Water Agency Actions

MODEL PROGRAMS/MODEL CODES—As described in Sections VI and VII above, there are model programs and projects in municipal and agricultural water conservation, water reuse and river management that have proven successful in the Colorado basin and across the country. Each municipality and local water agency in the Colorado River basin should begin adopting some or all of these model programs where appropriate for its own metropolitan area. A list of nine "Smart Water Policies" is attached as Exhibit A to this report.

TUCSON, ARIZONA, CONSERVATION AND RIPARIAN BENEFITS PROGRAM—One promising approach is to allow local, voluntary water conservation efforts to benefit in-stream flows in local waterways. In this way, local residents are able to see and enjoy immediate riparian benefits as a result of their conservation efforts. Local governments are uniquely situated to manage these types of "win-win" programs. In Tucson, the Sonoran Institute, Watershed Management Group, The University of Arizona Water Resources Research Center, the City of Tucson, and Tucson Water have partnered to pilot a voluntary model conservation program that provides direct riparian benefits.

Non-Profits and Private Landowners

COLLABORATIVE PROJECTS—By combining private and public dollars to concurrently meet both the water needs of people and nature, non-profits can develop innovative new technologies and infrastructure solutions to address what are seemingly unsolvable water shortage issues. Non-profits see a future for the arid west and its rivers that may include collaboration between private and public interests, development of smart science, technical tools, and infrastructure; and a commitment to simultaneously address the water needs of all water sectors through informed decision-making. For one sample collaborative Project, see Exhibit B.


Near Rocky Mountain National Park, CO

EXHIBIT A

Nine Smart Water Policies for Municipal and Industrial Conservation

(From American River's Hidden Reservoir)

Stop Leaks

Aging, broken pipes lose large quantities of precious clean water through leaks. It is estimated that in the U.S. over six billion gallons are lost each day or 14% of total water use. To address this problem, communities should:

- Reduce leaks to as close to zero as possible.
- Conduct self-audits to identify and fix system leaks and eliminate unmetered uses.

Price Water Right

Water must be priced to cover costs and to encourage efficiency. Pricing water right can yield a 15% reduction in water consumption for only a fraction of a penny per gallon increase in price. Utilities should adopt a two part fee system which establishes:

- A flat service fee that covers all utility fixed costs, such as pipe maintenance and pump station operations.
- A variable fee for the volume of water consumed, charging significantly higher rates as water consumption increases to discourage water waste, and lower rates for conserving households and low-fixed income customers.
- Higher fees associated with water waste should fund conservation incentive programs and alleviate the increased cost to lower and fixed income customers.

Meter All Water Users

Most apartments, condos, and commercial buildings include a flat rate for water in the rent or monthly fees effectively eliminating any market signals to encourage water efficiency.

- Water meters should be installed on all new homes, multi-family apartment buildings, and businesses.
- Incentives should be provided to retrofit existing multi-family and commercial buildings.

Retrofit All Buildings

Outdated appliances and fixtures waste a lot of water. Installing water efficient fixtures and appliances can yield a 35% savings in household consumption alone." If all U.S. households installed water-efficient fixtures and appliances, the country would save more than 8.2 billion gallons per day. This savings equals approximately 20% of the total U.S. public water supply. Communities should:

- Invest in voluntary incentive programs that provide rebates, swap-outs, or direct installations to retrofit wasteful water fixtures and appliances.
- Mandate retrofitting of antiquated fixtures and appliances upon resale of homes or establishment of a new water account.
- Provide free audits for all customer sectors to assess where the most cost-effective and water efficient savings can be secured.

Landscape to Minimize Water Waste

Homes in the Southeastern U.S. consume on average 30% of their Evian quality drinking water outdoors watering lawns, plants and trees. Tampa, Florida's smart sprinkling education and

landscape incentives programs have secured a 25% reduction in outdoor water use. Communities should follow Tampa's lead and:

- Require dedicated irrigation meters for large landscapes (such as office parks, hospitals,
- school campuses) and create a significantly higher water rate for irrigation water.
- Require moisture or rain sensors for all irrigation systems.
- Provide free irrigation system audits.
- Promote different landscape models to reduce water-intensive plantings.

Increase Public Understanding

Most people in the U.S. know very little about their water supply, having no idea what their water costs or where their water comes from. This leaves water users uninformed and disengaged. Communities should take simple, but powerful steps to:

- Create an outreach campaign about smart, simple, cost-effective water efficiency.
- Demystify the water bill by billing in gallon increments on a monthly basis and sharing
- historical data to compare use from month to month and year to year.
- Designate a staff member to coordinate water efficiency, conservation and reuse programs.

Build Smart for the Future

In the U.S., 50% of the homes that will exist in 2030 have not yet been built. With global warming and growing populations in mind, the current trends of water waste in new developments need to be reversed to stress cost-saving water efficiency. Communities should:

- Enact policies that promote the use of alternative sources of water, such as gray water and rainwater, for uses that do not require drinking-quality water.
- Design homes and neighborhoods to capture and reuse storm water on site.
- Require "dual plumbing" for new homes and businesses.
- Regularly update building codes and ordinances to support or require the use of the most water efficient technologies.

Return Water to the River

Lack of water compromises the health of a river as well as its ability to sustain its human and natural communities. To maintain healthy flows, a portion of water efficiency "savings" should be returned to the river to serve as a "savings account" for a not so rainy day. State level policy should be adopted that requires that river and community "water budgets" be developed for every river, estuary, and aquifer in the state. Water budgets should provide:

- An assessment of the ecologically sustainable flow for a healthy river;

- A determination of how much water can be sustainably ‘harvested’ from the river; and
- An assessment of community priorities that establishes how the public’s shared water resource should be used.

Involve Water Users in Decisions

Opportunities for significant water savings can be overlooked without having all the stakeholders at the table. Involving water users in these discussions encourages higher rates of efficiency. Communities can involve water users by:

- Creating a standing advisory board, with representatives from all sectors including industrial, commercial and residential, to provide ideas, guidance and assistance with water supply policy and programs.
- Hosting town hall meetings about policy and rate changes to engage questions and develop support for rate changes, outdoor water regulations, and efficiency programs.

EXHIBIT B

A Sample Collaborative Public/Private Partnership—the San Pedro River

Northern Mexico & Southern Arizona

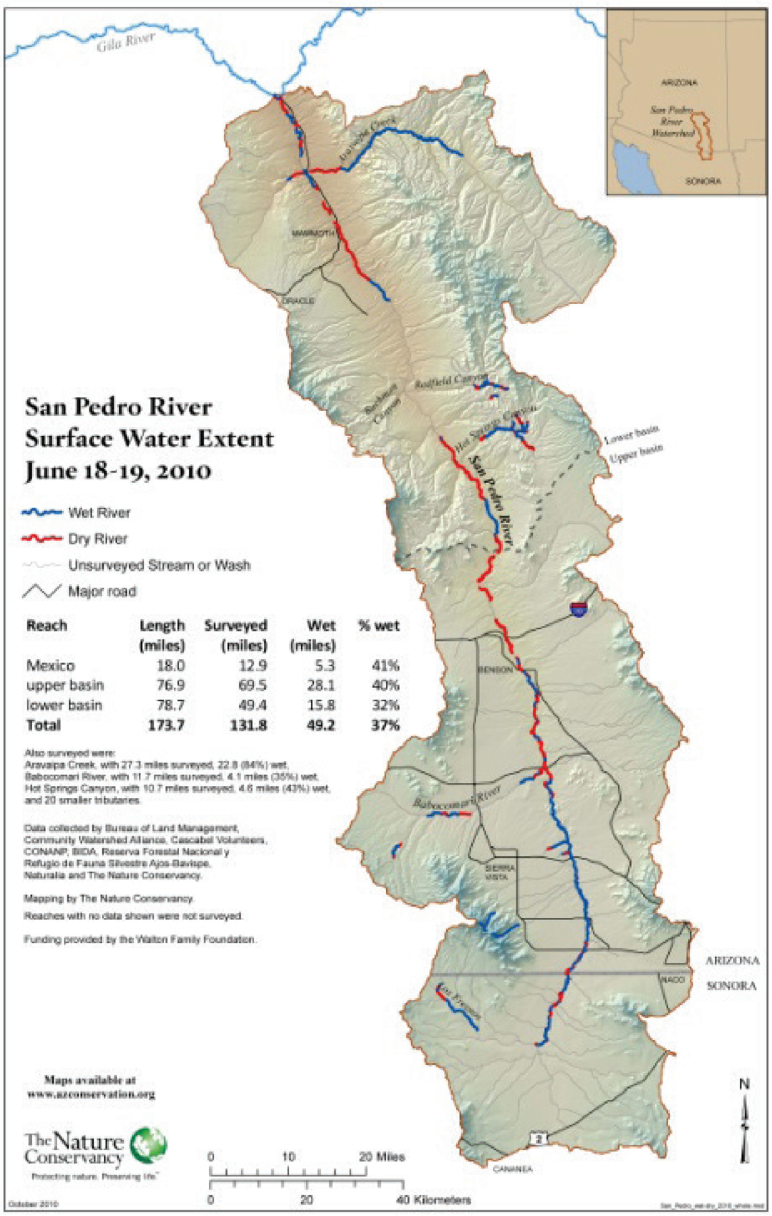
While the Basin Study considered basin-wide solutions, Colorado River communities must also be creative in finding local solutions. Smaller scale projects in the Basin demonstrate that the needs of people and nature do not have to be mutually exclusive. For example, consider the San Pedro River.

The San Pedro River starts in Mexico and flows north into Arizona near the City of Sierra Vista, southeast of Tucson. The region includes two significant national assets: a major U.S. intelligence and communications testing installation at the Army's Fort Huachuca and the BLM's San Pedro Riparian National Conservation Area. It provides critical riparian habitat to millions of migratory birds, many vulnerable animal species and an endangered aquatic plant. The combination of prolonged drought, increasing human water demands, and other factors have reduced the river's flows in many locations, which has adversely affected wildlife and fish as well as the long-term reliability of water supplies for area residents.

Finding a solution for the San Pedro started with good science and a better understanding of the river. Every June, The Nature Conservancy (TNC) works with more than 100 community members in the United States and Mexico to map more than 270 miles of the river and its tributaries to define the extent of surface water, specifically where the river continues to flow during the very hottest and driest time of the year. TNC then developed a computer simulation model with local, state and federal partners to better understand underground groundwater flows in the aquifer that help sustain the river. Using this information, TNC was able to identify the best locations for groundwater recharge projects that enhance stream flows in the San Pedro by improving the aquifer where it is needed the most.

In partnership with the Department of Defense, the Nature Conservancy has acquired key lands from willing sellers and is now designing aquifer recharge projects in conjunction with our partners, including Cochise County, local developers, private foundations and Natural Resource Conservation Districts. By combining private and public dollars to concurrently meet both the water needs of people and nature, TNC developed innovative new technologies and infrastructure solutions to address what were seemingly unsolvable water shortage issues. This is the future that TNC and its partners see for the arid West and its rivers: collaboration between private and public interests, development of smart science, technical tools, and infrastructure; and a commitment to simultaneously address the water needs of all water sectors through informed decision-making. Water issues do not have to be focused on conflict.

Map of the San Pedro River in SE Arizona



Lake Powell, UT