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What is the Value of Water? A Complex Question

Introduction

Difficulties in describing the value of water are many. This Arroyo seeks to lay out those difficulties and then examine the concept of water's value from various perspectives. The price of water is addressed first, as that is the first and most obvious aspect of value people in the United States encounter. This section answers the question, "What makes up the price typically paid for water supplied by water providers?" The next section looks into the costs facing water-using sectors that produce their water from groundwater or acquire it from raw water suppliers, such as the Central Arizona Project or the Salt River Project. The third section describes transactions in water, including water rights and long-term storage credits. The following three sections examine estimates of value that have been generated for water in the environment; values associated with effluent and reclaimed water; and the concept of virtual water. After presenting these various perspectives on the economic value of water, this Arroyo provides examples of non-monetary valuation based on water's cultural and spiritual importance. The conclusion calls on readers to appreciate the challenge of understanding the value of water.

Background

Water is both priceless and free. Increased awareness of water scarcity at a global scale has driven efforts to establish a common definition of water's value and to determine a methodology to account for the many components of value. Economists have sought to attach a monetary value to water in its many uses, including its non-consumptive uses. These efforts are very different from the work of other social scientists, who describe water's value in non-monetary

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terms, like religious heritage and community cohesion. Regardless of the perspective, understanding the value of water is critical to developing sustainable approaches to managing the resource.

In 1992 more than 500 participants, including water experts from across the world, gathered at the Conference on Water and the Environment and issued the Dublin Statement on Water and Sustainable Development. The statement, which came to be known as the Dublin Principles, was the first document of its kind to codify the importance of valuing water as an economic good, with the objective of promoting efficient use of water and water conservation.

The Dublin Principles were influential in the establishment of the Global Water Partnership, an international network of organizations created in 1996 to foster an integrated approach to water resource management. A report by the Global Water Partnership in 1998 proposed a method for valuing water that includes multiple component values. A concept of full value based on this method starts with the value of water in its many uses—its use value. Use value includes more than just supply costs, but also the cost of foregoing other uses and other so-called "external costs" left out of the calculations of the water user, such as environmental impacts. In this formulation, the economic value of water is the use value with adjustments for societal values. Then, the "intrinsic" value of water must be included to arrive at the full value of water (see Figure 1). Intrinsic value is difficult to define, but includes notions such as community and spirituality, to which many people do not attach a monetary value. One example could be the value lost to Native peoples by use

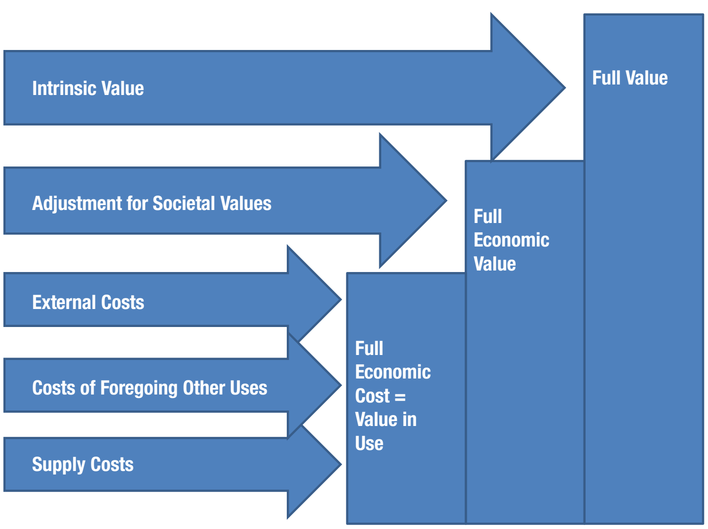

Figure 1. *The conceptual accounting for the full value of water*
Source: Modified from Rogers et al. 1998

of "impure" reclaimed water to create snow on the San Francisco Peaks near Flagstaff, Arizona, which are sacred to many Indigenous Nations, including the Navajo, Hopi and Zuni.

The economic value of water to an industry or sector can be estimated based on the revenues generated by the product or service and its use of water. Other estimates can be made by methods that derive the value of water from observation of economic behavior and by methods that ask people to express their preferences. For example, studies have evaluated the effects of proximity to stream flow or lake clarity on the price of real estate. Monetary estimates have been proposed for the value of water in recreation, based on the economic activity generated. Such indirect measures of value as the contribution of water to economic activity generated by bird watching have been estimated. Researchers have also monetized people's expressed preferences for protection of water in natural systems, even in places they never expect to visit.

To the extent that water's value can be measured in economic terms, it can only be estimated with reference to specifics of time and place. Values range widely depending the factors involved in the evaluation. Where a market exists, it is possible to determine the value of water to certain people in certain places at certain times by observing transactions, such as one farmer selling water to another. However, water markets are rare and only reflect the valuations of those involved in the transactions.

The Price of Water

Water's value depends on multiple, interrelated factors that may or may not be included in its price. The factors often included in the price of water are the costs involved in procuring, treating and delivering water of the appropriate quality to its point of use. Examples of factors frequently excluded from the price of water are costs or benefits to the environment, to future generations, and other intangibles such as contributions to health and well-being.

Many people argue that water should be priced based on its "real value" or "full cost," meaning that excluded costs should be internalized in the price. However, there exists no generally accepted formula to determine such a price. In addition, many consider access to water to be a basic human right that should not be priced out of the reach of the poor.

Instead, the price of water is determined by a complex mix of history, politics, laws and agreements, delivery and treatment costs, and economic pressures. These factors combine in different ways to produce the prices different sectors pay for water in different uses. Although it does not

Key Concepts

Value: Socially determined worth of something; it may be based on economic, social, cultural, and/or symbolic assessments.

Cost: Investment in production or use of something.

Price: Amount asked and/or paid to acquire something.

Fee: Amount assessed for access to something.

Rate: Price per unit to be paid for something.

Market: A place, real or notional, where buyers and sellers interact.

provide a full picture, understanding pricing opens a window on the value of water.

Municipal Water Prices

When residential water consumers pay for water, they are paying an amount estimated to keep the water utility in business. Although some water utilities have other sources of revenue, most, whether publicly or privately owned, cover their operating costs with the revenue generated through their customers. Therefore, anything involved in the costs of operation, such as construction, maintenance, administration and financing, is reflected in consumers' water bills.

Most utilities charge a fixed service fee that is paid regardless of the amount of water used. It may include a quantity of water, but the fee will not vary with the amount of water used. In addition to service fees, utility bills usually include usage charges based on the amount of water delivered to each customer. An EPA survey in 2006 determined that about a third of water utilities in the United States charged their customers a single fixed service fee for their water use. However, volume-based rates have become increasingly popular in the United States, and probably account for a larger percentage of U.S. utilities' pricing structures.

Volume-based rates require meters to measure water use. Meters record every gallon of water used at a location. The cost of installing meters is one reason many small utilities continue to charge a flat fee for water. Where meters are used, the fixed monthly service fee may depend on the size of the meter; larger, more expensive installations are associated with higher service fees. The most common size for a residential meter is 5/8-inch—the size of the pipe from the meter to the house.

Generally, volumetric water rate schedules can take the form of a flat rate per unit of water delivered, an increasing block rate, or a decreasing block rate. An increasing block rate assigns a rate per unit of water delivered for the first increment of water, such as 5,000 gallons, and assigns a higher rate to the next increment, such as 5,001 to 12,000 gallons. The number of blocks varies with the water supplier, but three to five blocks are common in Arizona (see Figure 2). Increasing block rates are intended to encourage water conservation by increasing the per-unit cost for using more water. Decreasing block rates operate in reverse, decreasing the cost per unit, providing no incentive for the customer to use less water.

In Arizona, increasing block rates have become the norm as emphasis is placed on conservation of municipal water supplies. Some utilities have different rates for winter and summer water use. For example, Chandler's block rates increase more in the summer than in the winter. Phoenix has a unique rate schedule that divides the year into three categories: low season (December-March), medium season (April-May and October-November) and high season (June-September). The monthly service charge includes a basic amount of water that varies between the high season and the rest of the year (7,480 gallons and 4,488 gallons). Above the basic amount, customers pay a per-unit rate that increases with the seasons, from low to high.

Many public municipal utilities in Arizona also distinguish in their charges between customers inside the city and customers outside the city, who pay more, sometimes substantially more. In Phoenix, for example, rates for customers outside the city are 50 percent higher than for customers inside the city. Other examples include Chandler, Goodyear and Prescott. In contrast, Tucson customers pay the same whether they are inside or outside city boundaries. Residential rates can also differ by customer class (single family or multi-family) and/or by meter size.

	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5	Tier 6
AZ Water*	0-3,000	3,001-10,000	Over 10,000			
Chandler	0-10,000	10,001-20,000	20,001-60,000	Over 60,000		
Glendale (ccf)	0 – 4,683 (0 - 6.26)	4,690 – 9.356 (6.27 - 12.53)	9,373 – 23,212 (12.53 - 31.03)	23,220 – 30,132 (31.04 - 40.28)	Over 30,139 (Over 40.29)	
Goodyear	0-6,000	6,001-12,000	12,001-30,000	Over 30,000		
Kingman	0-10,000	10,001-40,000	Over 40,000			
Nogales	0-3,000	3,001-8,000	8,001-13,000	13,001-20,000	20,001-35,000	Over 35,000
Prescott	0-3,000	3,001-10,000	10,001-20,000	Over 20,000		
Scottsdale	0-5000	5001-12,000	12,001-40,000	40,000-70,000	Over 70,000	
Tucson (ccf)	748 – 7,480 (1 to 10)	8,230 – 11,220 (11 to 15)	11,970 – 22,440 (16 to 30)	Over 22,440 (Over 30)		

* Arizona Water Company communities:
Superstition (includes Apache Junction, Miami, Superior); Cochise (Sierra Vista); Pinal Valley (includes Casa Grande, Coolidge, Stanfield)

Figure 2. *Block rate tiers for selected communities in Arizona in gallons*

Publicly Owned Water Utilities

Most residential water customers in Arizona are served by publicly owned utilities, which are typically, although not always, run through city governments. They are not operated for profit and generally charge for the cost of service. Revenues may be used to support other city services, but where this is not the case, the cost-of-service rates are designed to generate revenue that matches costs. This is rarely exact, for unexpected costs can arise, costs can be less than expected, or revenues can rise or fall relative to expectations. Reaching revenue sufficiency is essentially reaching a balanced budget, when a utility has managed to cover all of its revenue requirements, including the funding of reasonable reserves.

When revenue deficiency occurs, a utility may have sufficient reserves to make up the difference. Otherwise, it may have to resort to other city funds. Such revenue shortfalls are taken into consideration when rates are next reviewed. At this point, political and economic conditions are likely to affect the potential for rate increases, as city councils weigh costs and benefits.

Private Water Companies

Privately owned water companies (usually investor-owned utilities) are generally overseen by a governing body such as a state Public Utility Commission. In Arizona, this function is carried out by the Arizona Corporation Commission (ACC). The ACC has five publicly elected commissioners who make the final decisions regarding rates, safety and effective operation of a variety of public services, including water. A privately owned utility attempting to set or change its rates must calculate its cost of operation and provide a report to the ACC. The Utilities Division within the ACC conducts its own research into the utility's costs and what rates it should be permitted to charge, and then provides recommendations to the Commissioners, who adjudicate the matter. This process occurs when the company begins operation at a specific location and whenever it wishes to raise rates.

The owners of a private water utility may structure rates so that they can gradually pay off the costs of their investments, cover their general costs of operation, and make a reasonable rate of return for their shareholders. Before setting prices, however, the operators of an investor-owned utility in Arizona must show that their investments are appropriate and will provide a safe and valuable service to their customers.

Although there is a move toward consolidation, most private water companies operating in Arizona are small, rural companies that serve relatively isolated communities, but private water companies also serve water within cities and metropolitan areas, such as the Anthem, City of Sierra Vista, Paradise Valley, and the Sun City communities. A few large water companies, such as Arizona Water Company and EPCOR Water, operate water utilities in multiple locations. Each location will have an individual rate schedule based on local conditions. According to a 2009 Food and Water Watch Report, in the United States privately owned utilities tend to charge higher rates on average than do publicly owned utilities, but this is not consistently true across Arizona.

Rising Municipal Water Rates

Recent studies have shown that utilities in the United States have been raising their rates over the past few years. Circle of Blue, a non-profit organization focusing on educating the public about water, food and energy concerns, has evaluated the average water rates in 30 major cities around the United States since 2010. To account for various rate schedules, Circle of Blue based its calculations on "medium consumption," which is defined by the U.S. Geological Survey as: "a family of four using 378 liters (100 gallons) per person per day." Circle of Blue found that water

	Service area population (in thousands)	Average monthly bill for family of four using 100 gpd (in dollars)				% change
City		2013	2012	2011	2010	
	Uniform					
Fresno	122	19.75	19.75	19.75	19.75	0
	Uniform Seasonal					
Phoenix	1600	38.75	36.59	36.59	34.29	13
	Increasing Block					
Dallas	1306	42.46	40.28	37.98	37.81	12
Denver	1300	40	39.36	37.33	33.01	21
Fort Worth	625	45.66	45.66	43.72	43.48	5
Las Vegas	2000	41.13	41.13	36.13	32.93	25
San Jose	107	52.26	47.73	42.42	40.93	28
Tucson	775	46.45	39.5	36.32	33.04	41
	Seasonal Increasing Block					
Los Angeles	4000	66.35	59.05	64.8	58.49	13
Salt Lake City	380	26.13	24.92	24.42	22.89	14
Santa Fe	78	153.78	142.1	131.37	121.42	27

Figure 3. *Rising municipal water rates in selected western cities. Table elaborated with data from Circle of Blue.*

rates have been increasing significantly faster than inflation. In 2013 alone, water rates rose an average of 6.7 percent in the cities surveyed. Increases for selected western cities are shown in Figure 3. On average, water rates in these western cities rose nearly 20 percent from 2010 to 2013.

Rates are thought to be going up because of many factors that vary with location. One of the main factors is urban population growth. With growth comes increased infrastructure development. Not only do utilities have to expand in order to reach more customers, but they also may have to invest in renovations to improve efficiency, acquisitions of additional water and/or storage of water for future need. On the other hand, rising rates may also reflect the observed decline in water use across the country, which may be explained by factors such as increased water use efficiency or other conservation practices. Infrastructure costs still must be met, so utilities have been forced to raise rates in the face of declining water use.

Another explanation for rate increases is aging water infrastructure, which is degraded across much of the country, forcing utilities to proactively and reactively replace their pipes, pumps, etc. The Environmental Protection Agency estimates that spending of over $384 billion on water infrastructure will be needed in the 20 years between 2011 and 2031. The American Water Works Association anticipates water and wastewater utilities spending upward of $1 trillion over the next 25 years in order to replace this aging infrastructure and maintain service. Local governments spent over $111 billion on water supply and wastewater management in 2010 alone, including operations and maintenance, as well as capital investments.

Water Costs

Aside from the residential water supplied by public utilities and private water companies, private well owners, agriculture and industry—including mining and power generation—acquire water in different ways and can therefore face very different water costs.

Industrial Water Costs

Industry accounts for about 8 percent of water demand in Arizona. This water is primarily utilized for mining and energy production. The majority of water used for mining is water pumped from wells. Other sources of water for industry include surface streams, Central Arizona Project (CAP) water and treated wastewater. Industrial water users thus face groundwater pumping and distribution costs and/or rates set by privately or publicly owned water providers. Some industries require water of a specified quality, like the ultra-pure water needed by the computer chip industry. These users incur treatment costs as well. To increase water efficiency and save on costs, most industries recycle the water they use several times.

Water for power generation is typically used for cooling and turning turbines (see Arroyo 2010 on the water-energy nexus). Power plants are frequently located near bodies of water such as lakes or rivers in order to have easy access to freshwater for these purposes. The Palo Verde Nuclear Generating Station (PVNGS), west of Phoenix and distant from a convenient lake or river for cooling water, uses reclaimed water from the 91st Avenue wastewater treatment plant for cooling, which reduces its freshwater consumption. Under a pre-2010 agreement, PVNGS paid the plant's owners, the Sub-Regional Operating Group (SROG), about $300 per acre-foot of treated wastewater. (One acre-foot is the amount of water required to fill an acre of land to a depth of one foot and equals 325,851 gallons.) Under the 2010 revised agreement, the owners of PVNGS agreed to pay a total $30 million over the first four-year period of the contract. In addition, they will pay a price per acre-foot increasing from $58 per acre-foot to a maximum of $260 per acre-foot in 2025. From 2026 through 2050, the last year of the contract, prices will be set based on an increasing block-pricing formula that starts at $300 per acre-foot.

Agricultural Water Costs

Agriculture accounts for about 70 percent of the water demand in Arizona. Farmers in the state use water primarily to irrigate their crops. Water supply for agriculture in the state comes from the Colorado River, other surface water and groundwater. Many farms, especially larger ones, operate along the state's western border and use Colorado River water. Farms in this area use approximately 1.2 million acre-feet of Arizona's 2.8 million-acre foot Colorado River water allocation.

According to the U.S. Department of Agriculture's (USDA) 2008 Farm and Ranch Irrigation Survey, 30.5 percent of irrigated farms in Arizona used groundwater that year. The costs typically associated with groundwater use are those that go into maintaining and operating irrigation wells and pumps, an amount that varies depending on the price of energy and depth to groundwater. The main costs of using groundwater for agricultural irrigation are energy expenses of pumping. The energy prices that farmers face are influenced by a number of factors, including market forces and taxes, and many benefit from relatively low-cost hydropower allocations. For Arizona farms with wells and pumps, the average energy cost for pumping in 2008 was $26.31 per acre-foot of water compared with the average cost of $44.94 per acre-foot for the 17 western states studied (Figure 4). For reasons of climate, soil and cropping choices, Arizona irrigators typically use more water per acre than those in other states, therefore their average per acre cost for pumping is greater ($102.34 per acre versus $63.37 per acre). Irrigation and maintenance costs for farm irrigation systems, on the other hand, were relatively consistent across states, with farmers in Arizona paying $21.08 per acre on average and Western states in general paying $18.35 per acre on average.

Farms using surface water face different kinds of costs for their water. In 2008, 57.3 percent of irrigated farms in Arizona were using off-farm surface water and 23.3 percent were using surface water sources located on their land. The farmer with a right to divert water from these on-farm sources does not need to pay a purveyor and can therefore use the water at little or no cost beyond construction and maintenance of irrigation systems. Off-farm surface water is the water acquired by a farmer from outside of his or her land's boundaries, such as CAP and other Colorado River water. Water user organizations such as irrigation districts typically supply this water, but it can also be diverted by ditch companies or from commercial or municipal water systems. The average cost, including energy costs, for farms using off-farm surface water in Arizona was $122.54 per acre in 2008. Based on an average delivery of 4.83 acre-feet per acre, this comes out to $25.38 per acre-foot. Of course, the average does not show the range of costs farms may face.

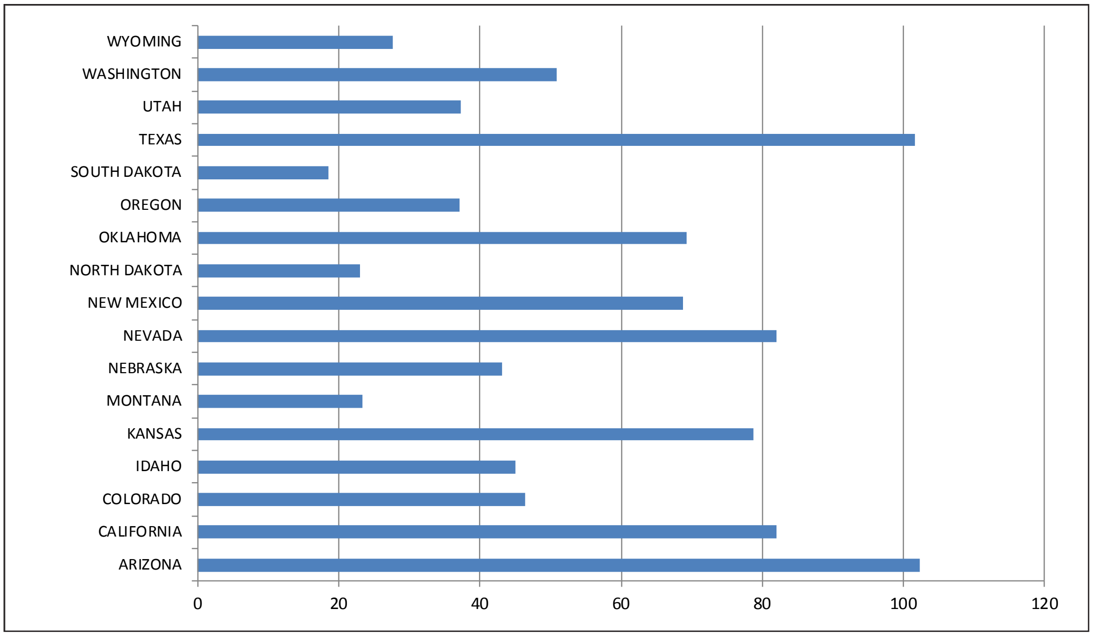

Figure 4. *Average energy cost per acre for pumping water for farms and ranches in Western states Source: Farm and Ranch Irrigation Survey (2008), National Agriculture Statistics Service, U.S, Department of Agriculture. Data were summarized by the Economic Research Service, USDA.*

The amount irrigation districts charge for water reflects district capital improvement, operations and maintenance costs. Depending on the district, charges to farmers for irrigation water can be very low on a per acre-foot basis. For example, the Yuma Mesa Irrigation and Drainage District charges its customers $85 per acre and allows up to 9 acre-feet of water application per acre. This comes out to $9.44 per acre-foot of water used, if all nine acre-feet are used.

U.S. Bureau of Reclamation Project Cost Recovery

The U.S. Bureau of Reclamation (Reclamation) serves water users with rights to use Colorado River water. Reclamation delivers wholesale water to locally organized water user associations, including irrigation districts and conservation districts, and also delivers water for municipal, industrial, tribal, and environmental purposes. Since 1902, Reclamation has developed water projects throughout the West that provide multiple benefits, including hydropower, flood control and recreation, in addition to water supplies. Irrigators were expected to repay a portion of the project development costs. The non-reimbursable portion includes all project costs attributed to public benefits, such as recreation. Irrigators were not required to pay interest on the construction debt, and some repayment obligations were reduced based on ability to pay or due to federal policies for water provided to Indian tribes in water rights settlements.

The long-term contracts with irrigation districts specify charges for repayment of the construction debt. Reclamation uses a consistent method for allocating construction costs throughout the West; however, irrigation districts across the region may face different water charges due to the wide range of costs associated with the magnitude of different projects, the types of facilities, and when the facilities were built. For example, Salt River Project has already repaid construction costs and there is no longer a capital component in its payment structure. Along the Colorado River in Arizona, for those with minimal Reclamation project cost repayment obligations, charges are particularly low. In addition, multipurpose Reclamation projects that generate electricity can subsidize water costs through power revenues. Salt River Project, for example, subsidizes its water charges with energy revenues. Revenue from surplus power sales from the Navajo Generating Station is applied to CAP's annual repayment obligation, which influences the capital charge assessed to Municipal & Industrial (M&I) subcontractors.

Salt River Project (SRP) Water Allocation Pricing

The Salt River Project supplies water as it has since 1903, when it organized as the Salt River Valley Water Users Association to contract with the U.S. government for one of the nation's first multipurpose reclamation projects authorized under the National Reclamation Act. Association member lands were allocated water subject to assessments to repay the federal government's capital investment, and for operation of the project. Today most of the original agricultural lands have been converted to municipal uses, such as residences and businesses, but SRP's assessments are still based on the same principles—all shareholders are treated the same and each receives an allocation of water per acre of member lands, which is set each year by the Association's Board of Governors. The Board also sets the assessment and fees for water delivery, and the accounting fee. In 2013, the assessment was $30 for each acre of member land. In normal years, the assessment entitles a shareholder

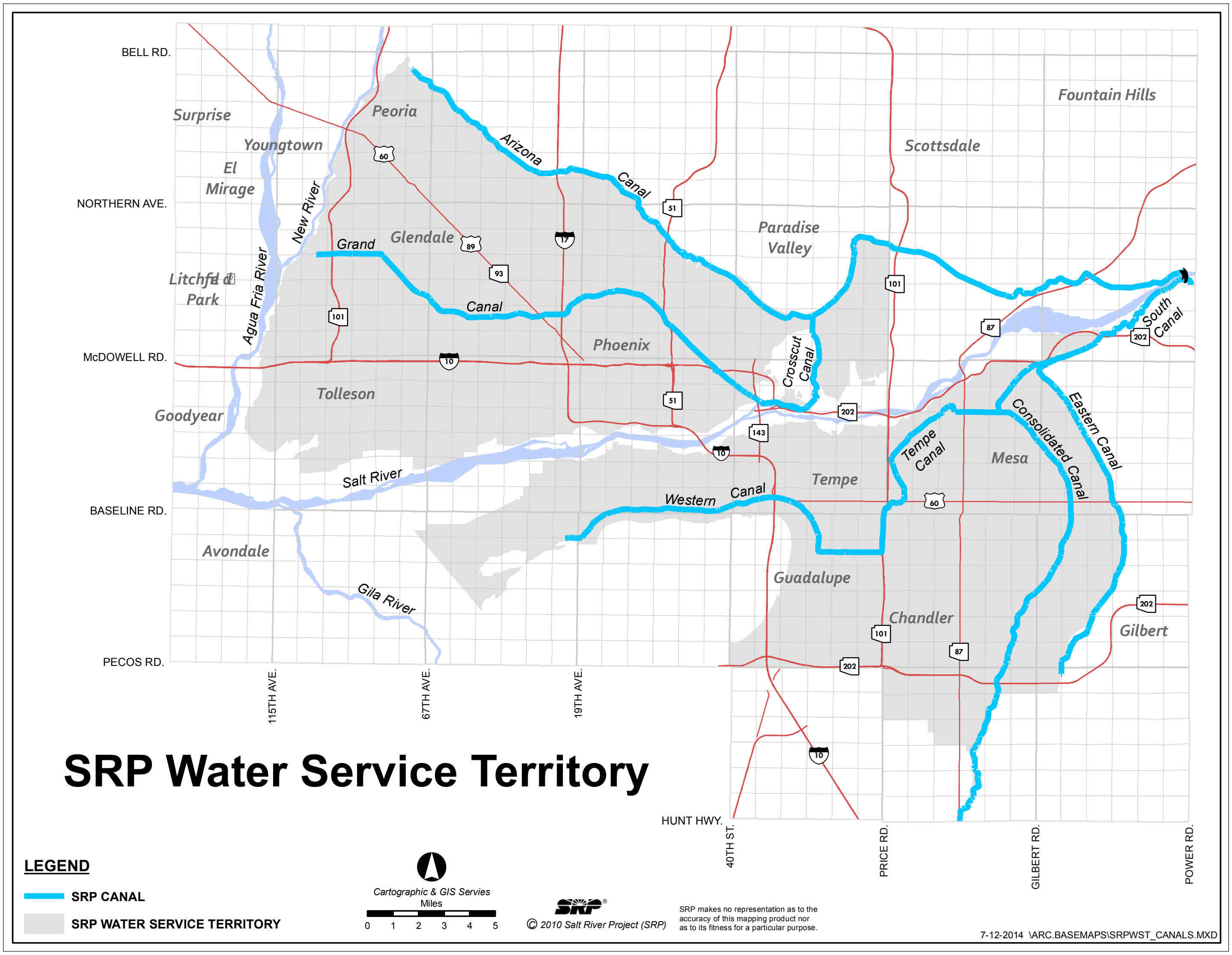

Figure 5. *Salt River Project's (SRP) Irrigation Service Territory. Source: SRP*

to 2 acre-feet of water per acre. In 2013, a third acre-foot was available to be delivered for an additional $15. Certain member lands are also eligible to receive additional water for $46.00 or $64.00 per acre-foot, depending on the category of water purchased. In 2013, the accounting fee was $59.40 per active account.

As lands within the SRP urbanized, the water for those lands was most often delivered to the city responsible for serving those lands. The city treats the water and delivers it to the Association's members in the Phoenix area as domestic water. A water utility, such as the City of Phoenix, pays the assessment and water delivery fee for each acre of member lands it serves. By contract, the cities must deliver that water only to lands with rights to that water. With urbanization, the SRP has become one of the main sources of water for the urban uses that replaced agriculture in the Salt River Valley (Figure 5).

Central Arizona Project (CAP) Rate Structure

In Arizona, more than 1.5 million acre-feet of water from the Colorado River is guided and pumped through the CAP across the state to provide Maricopa, Pinal and Pima Counties, which account for more than 80 percent of the state's population, with a reliable source of fresh water. The delivery system is 336 miles long and lifts the water 2,900 feet to its final stop just south of the City of Tucson. As it snakes through the state, a wide variety of customers are served, including municipal and industrial (M&I) users, non-Indian agricultural users, Native American tribes and communities, and the Arizona Water Banking Authority (AWBA).

The Central Arizona Water Conservation District (CAWCD), which operates the CAP system, has several revenue sources. These include an ad valorem tax on all property within the three-county service area, regardless of whether the land owners have access to CAP water or not. The tax is set by the publicly elected CAWCD Board of Directors and may be used for any authorized purpose of the district. For many years CAWCD collected the maximum tax rate allowed by state law: 10 cents per $100 of assessed valuation. After CAWCD and the United States reached a settlement of their dispute over the CAWCD's repayment obligation for the CAP in 2000, the Board reduced the rate from 10 cents to 9 cents. The Board again reduced the tax to

Delivery Rates for Various Classes of Water Service Units = $/ acre-foot			
(The Letter Designations in the Formulas Refer to the Rate Components Shown Below)			
	2012	2013	2014
Long Term Subcontract (B+C)[1]	$122.00	$129.00	$146.00
Non-Subcontract (A+B+C)	$137.00	$144.00	$166.00
Federal (B+C)	$122.00	$129.00	$146.00
Agricultural			
Settlement Pool (C)[2]	$49.00	$53.00	$67.00
Agricultural Incentives			
Meet Settlement Pool Goals	$ (4.00)	$ (6.00)	$ (14.00)
Meet AWBA/CAGRD GSF Goals	$ (1.00)	$ (1.00)	$ (2.00)
Meet Recovery Goals	$ (1.00)	$ (1.00)	$ (2.00)
RATE COMPONENTS			
Capital Charges			
(A) Municipal and Industrial – Long Term Subcontract[3]	$15.00	$15.00	$20.00
Delivery Charges			
(B) Fixed OM&R[4]	$73.00	$76.00	$79.00
(C) Pumping Energy Rate 1[5]	$49.00	$53.00	$67.00

NOTES:

1 - Does not include the Capital Charge.

2 - Rate is the Pumping Energy Rate 1 component. Incentives may be earned for meeting delivery goals in three areas. Any incentives earned are applied to Settlement Pool deliveries.

3 - For M&I subcontract water, the Capital Charge is paid on full allocation regardless of amount delivered and not included in delivery rates.

4 - Fixed O&M costs divided by projected total water volumes plus components to fund capital replacements and a rate stabilization reserve. This amount is collected on all ordered water whether delivered or not.

5 - Applies to all water deliveries. The calculation is pumping energy costs divided by projected volumes. This amount is collected only for water actually delivered as opposed to scheduled.

Figure 6: *CAP Water Rate Schedule (abridged). Source: Central Arizona Conservation District*

8 cents in 2003, and to 6 cents in 2007. However, in 2013 the Board increased the tax back to 10 cents due to uncertainties related to the Navajo Generating Station, which supplies most of the power used to move water through the CAP canal system. In addition, the CAWCD Board can levy another ad valorem tax of up to 4 cents per $100 of assessed valuation that may be used for CAP repayment or annual CAP operations and maintenance (O&M) costs. If the Board determines that revenues from the 4-cent tax are not needed for CAP purposes, then the unneeded funds are deposited into the Arizona Water Banking Fund for use by the Arizona Water Banking Authority.

With the exception of certain agricultural users, all CAP customers pay the same water delivery rate, which includes a fixed Operation, Maintenance and Replacement (OM&R) component and an energy component. In 2013, the fixed OM&R component was $76.00 and the energy component was $53.00 per acre-foot. Delivery rates are uniform across the system ("Postage Stamp") regardless of distance or elevation gain from the Colorado River.

Users who hold M&I subcontracts with CAWCD, such as the cities of Phoenix and Tucson, have service rights for high-priority CAP water. In addition to paying the delivery rate for the CAP water they use, the M&I subcontractors pay a capital charge based on the full allocation in the subcontract, regardless of how much water is actually taken. Capital charges are used to assist in CAP repayment.

The CAP also delivers water pursuant to long-term contracts that nine of Arizona's Indian tribes and communities entered into directly with the United States. The standard CAP water delivery rate applies to water delivered under these contracts, but the federal government is responsible for payment for these deliveries. A capital repayment charge does not apply to these contracts.

CAP water that is available after satisfying tribal and M&I contracts is classified as "Excess" CAP water and is distributed annually based on a secondary priority system. The Agricultural Settlement Pool (Ag Pool) has the first priority for Excess CAP water. At 400,000 acre-feet per year in 2014, the Ag Pool steps down in volume through 2030. The Ag Pool was established as part of an arrangement in which CAP non-Indian agricultural subcontractors relinquished their long-term entitlements to CAP water. In exchange, they received partial forgiveness of their debt from federal loans for construction of the irrigation and distribution systems needed to take CAP water, and an energy-only rate for the water they take from the pool. In recent years the CAP Board has reduced the cost of Ag Pool water further through incentive programs to meet specific policy objectives.

Excess CAP water that is available after satisfying the Ag Pool is made available to a variety of users. These customers pay the standard CAP water delivery rate (fixed OM&R and energy), plus a component that is equivalent to the M&I capital charge. Figure 6 shows CAP charges in a table format.

Water Transactions

The act of buying and selling the right to take and use a one-time fixed amount of water or an annual amount of water is considered a water transaction. Observing the several types of transactions that take place in Arizona provides a glimpse at the value of water from a market perspective.

Purchase of Groundwater Storage Credits

Historically, groundwater in Arizona has been pumped faster than it can be naturally replenished. This condition—known as overdraft—lowers groundwater levels, increasing well drilling and pumping costs. In 1980, Arizona passed the Groundwater Management Act (GMA) in order to preserve groundwater resources. The statute identified and designated Active Management Areas (AMAs) where groundwater use is regulated by the Arizona Department of Water Resources (ADWR). The current AMAs are Phoenix, Pinal, Prescott, Santa Cruz, and Tucson (Figure 7). Groundwater pumping outside of AMAs is not regulated.

In 1986, Arizona passed the Underground Water Storage Act, which allows the storage of water underground for future recovery and use. The Underground Water Storage, Savings, and Replenishment Act, enacted in 1994, further defined the recharge program. Long-term storage credits can be accrued by an entity that stores a renewable water supply—principally CAP water and reclaimed water—in a permitted recharge facility. Recovery of long-term storage credits can occur almost anywhere within the same AMA. Therefore, use is not limited by the need to transport the actual water between the recharge facility and the place of recovery within the AMA. Long-term storage credits may be sold to another entity, and long-term storage credit accounts are maintained by ADWR.

A principal purchaser of long-term storage credits is the Central Arizona Groundwater Replenishment District (CAGRD). The CAGRD is not a separate governmental entity, but is a responsibility of the CAWCD. CAGRD purchase agreements for long-term storage are available for public view, while records of private sales generally are not. Established in 1993, the CAGRD provides a means for property developers and water providers operating within the Phoenix, Pinal and Tucson AMAs to comply with GMA regulations that require any new M&I water use to be consistent with the AMA water management goal. For most AMAs, in addition to demonstrating a 100-year assured water supply, developers and water providers must have access to renewable water supplies, such as surface water, or show membership in the CAGRD. Provided the water is physically, legally and continuously available for 100 years, members of the CAGRD may pump groundwater, a defined portion of which must be replenished by the CAGRD. The CAGRD is obligated to obtain sufficient water supplies for this purpose. The 2010 CAGRD replenishment obligation

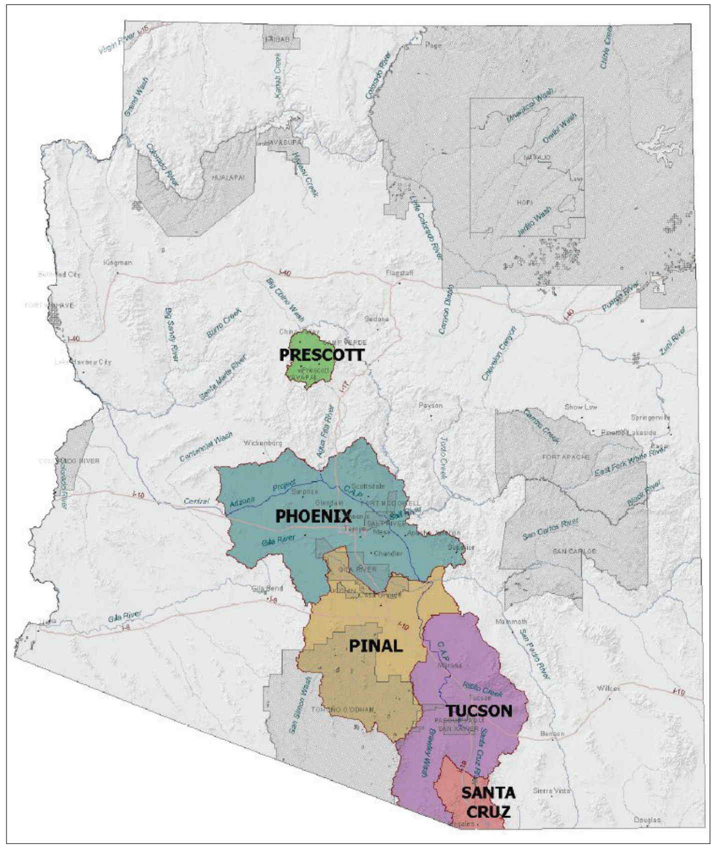

Figure 7. *Arizona's Active Management Areas (AMA). Source: Arizona Department of Water Resources (ADWR)*

was estimated at 23,200 acre-feet, but CAGRD projected in 2013 that its replenishment obligation for members expected to enroll during the current Plan of Operation (which ends in 2015) will be 136,500 acre-feet annually as of 2035.

Records of recent transactions indicate that in 2013 the CAGRD paid approximately $140 per acre-foot of long-term storage credits, and it anticipates the price will rise. In these transactions, the price per acre-foot for water credits was roughly equivalent to the amount an M&I subcontractor would pay the CAP for water delivery, which also is rising. Other entities, such as the Town of Marana, have purchased long-term water storage credits to keep up with growth in water demand.

Investors have entered the water credit market in Arizona on the basis of projected future demands. As of 2013, Vidler Water Company—a subsidiary of Pico Holdings—held 427,351 acre-feet of water in Arizona, for which it paid an estimated average price of $78 per acre-foot. Vidler is holding its long-term storage credit for sale in the future when the price is anticipated to rise.

In 2007, the Town of Prescott Valley was able to auction long-term storage credits in the amount of 1,103 acre-feet per year for a price of $24,650 per acre-foot. The buyer, Water Property Investors, LLC, has the option to purchase up to 2,724 acre-feet per year for the same price, up to a total of $67 million. The town created the credits by storing treated wastewater underground.

Long-term storage credits must be recovered in the same AMA in which the water is stored. Groundwater outside

AMAs is not limited as to quantity or use (as long as the use is beneficial), but it may not be transported outside the groundwater basin except under conditions specified in statute. Limitations on recovery and transportation reduce the demand and therefore reduce market activity.

Transactions in Water Rights

Very different from the purchase of a quantity of water or its equivalent in credits, is the acquisition of a water right: the right to use a quantity of water every year in perpetuity. Rights to certain types of water in Arizona may be transferred between willing buyers and sellers, but these transactions can be very difficult to effect. This is true both inside and outside AMAs. While transfers of surface water have occurred, for example the transfer of the water rights in the Chino Valley Irrigation District to the City of Prescott, there are few such transactions to use as a gauge for the value of a water right.

Since the State Water Code came into existence in 1919, acquisition of a surface water right was essentially free, with the only associated cost being a filing fee. An appropriator needed to post his intent to divert water from a stream for a beneficial use and make good his intent within a reasonable amount of time in order to establish a right. The quantity of water diverted and put to beneficial use determined the amount of the right. As Arizona's population increased, legal and administrative institutions attempted to bring order to this system, and today surface water rights defined by location, quantity and type of use are administered by ADWR. Would-be appropriators must now pay administrative fees, but because of major on-going litigation, it is unknown how much water, if any, is left to appropriate.

Certain rights to use groundwater are bought and sold in AMAs, where the GMA created categories of groundwater rights in order to promote conservation and curtail unsustainable growth in groundwater use. These rights grant the holder use of a certain amount of groundwater per year. There are three main types of groundwater rights within the AMAs: irrigation grandfathered rights; Type 1 non-irrigation grandfathered rights; and Type 2 non-irrigation grandfathered rights. Irrigation grandfathered rights were based on irrigation water use between 1975 and 1980—the date of the GMA and are appurtenant to the land that was historically irrigated, remaining so if and when the land is sold. The amount of the right is based on a water duty determined by ADWR. Type 1 rights are associated with land permanently retired from agriculture and may be conveyed only with the property. The maximum amount of a Type 1 right is 3 acre-feet per acre per year.

Figure 8. *Water in Oak Creek enhances real estate values in Sedona, Arizona. Source: Ken Thomas, Wikipedia Commons*

Type 1 rights have limited value since they may be used only on the acre or group of contiguous acres to which the right is appurtenant. Type 2 rights are not appurtenant to any land and may be sold or leased. Although the market for these rights is also limited, quite a few transactions in Type 2 right have taken place over the past three decades. By 2007, Type 2 rights were trading at an average of $1,000 to $4,000 per acre-foot between private buyers and sellers. Type 2 rights traded for higher prices in Tucson than Phoenix, and prices were highest in Prescott. As in real estate, location is a prime determinant of price. In the fast growing Prescott AMA, which has extremely limited access to renewable water resources, water rights are able to demand a premium.

The *Water Strategist*, the best source of information on water transactions, listed transactions for Arizona. Since 2000, most of these have been assignments or reassignments of CAP water allocations, sales of reclaimed water by Tucson and Flagstaff, and purchases of Type 2 non-irrigation rights. A survey of the *Water Strategist* from 2001 to 2007 found 90 transactions listed.

Home Value^	Increase in Value	Percent Increase	Distance in Miles*
$ 181,466.00			1.5
	$ 1,593.00	0.9 %	1
	$ 4,317.00	2.4 %	0.5
	$ 6,324.00	3.5%	0.3
$ 192,107.00	$ 10,641.00	5.9 %	0.1

^ 2,000 square-foot, one-car garage, 15-year-old home on ¼ acre
* Distance from the centerline of riparian corridor

Figure 9. *Real estate sales according to distance from riparian area in northeast Tucson, Arizona. Source: Data from Colby and Wishart, 2002, UA Department of Agriculture and Resource Economics*

The Value of Water in the Environment

The value of water in the environment has been assessed in various ways, including evaluating the impact on real estate of proximity to bodies of water or riparian corridors. The value of the water amenity can be inferred from real estate prices. For example, a survey of real estate professionals in Sedona, Ariz. and three other riverside communities in the West found that reductions in river flows would cause significant drops in property values (Figure 8).

A study published in 2002 by Colby and Wishart analyzed real estate sales in northeast Tucson of homes located within 1.5 miles of riparian corridors proposed for protection. It identified a relationship between distance from riparian area and property values that places a premium of 3 to 6 percent for location within half a mile of the studied riparian corridors, after accounting for such factors as lot size and home size (Figure 9).

Frequently, the value of water in the environment is demonstrated by purchase of existing water rights to maintain or restore streamflows. For example, restoration of habitat along the channel of the Colorado River in Mexico has been supported by purchases of water rights. The Colorado River Delta Water Trust was formed in 2008 as a partnership of NGOs, including the Sonoran Institute, Pronatura Noroeste, and the Environmental Defense Fund, to provide a mechanism for securing water that can be dedicated to the Delta in perpetuity. The Trust buys water rights on the open market and moves them from irrigated agriculture to support plantings of native trees and encourage native vegetation growth. The water trust has invested about $1 million to secure about 3,200 acre-feet of water as of 2013. Long-term annual base flow needs for the Lower Colorado River in Mexico are estimated to be 50,000 acre-feet. The cost of rights for this base flow on the Mexican market is likely to reach $12-15 million.

In 2012, the United States and Mexico signed Minute 319, a landmark five-year binational agreement defining how the two countries will share the Colorado River amidst growing pressures on water resources. As part of the agreement, the parties agreed to an environmental component that returns water to the river in Mexico for the purpose of Delta restoration. The agreement requires the Delta Water Trust to secure one-third of the total base flow that will be allocated to the Colorado River in Mexico, while Mexico and the United States will contribute the remaining two-thirds of the flows. To this effect, the Trust launched the “Raise the River” campaign in collaboration with the Nature Conservancy, National Fish and Wildlife Foundation, and the Redford Center. The objective of the campaign is to raise $10 million by 2017 to secure a base flow for the river, temporarily reconnect the Colorado River with the Gulf of California, and scale up restoration efforts across 2,300 acres of delta habitat.

In the United States, organizations such as The Nature Conservancy have used organizational funds and gifts to acquire land with water rights in order to protect streamflow and water dependent ecosystems. In the upper San Pedro River, the Nature Conservancy, the Department of Defense and Cochise County established a partnership to enable more successful water recharge efforts. They have acquired lands, established conservation easements, and constructed water recharge facilities within a mile of the San Pedro to mitigate impacts of groundwater withdrawals on the river ecosystem. On the Verde River, the Nature Conservancy is investing in automated head gates to allow irrigation districts to better manage their diversion flows. The new technology monitors the ditches’ flow rate. With it, farmers take only the amount of water they need, leaving more in the ditch for downstream water rights holders.

Effluent and Reclaimed Water

The unique legal status of treated wastewater and reclaimed or recycled water make it a relatively commonly traded commodity. Under Arizona law, water produced by a wastewater treatment plant is, in general, owned by the owner of the plant. This gives control of its wastewater, for example, to the Multi-City SROG, which owns and operates the 91st Avenue Treatment Facility, producing an average of

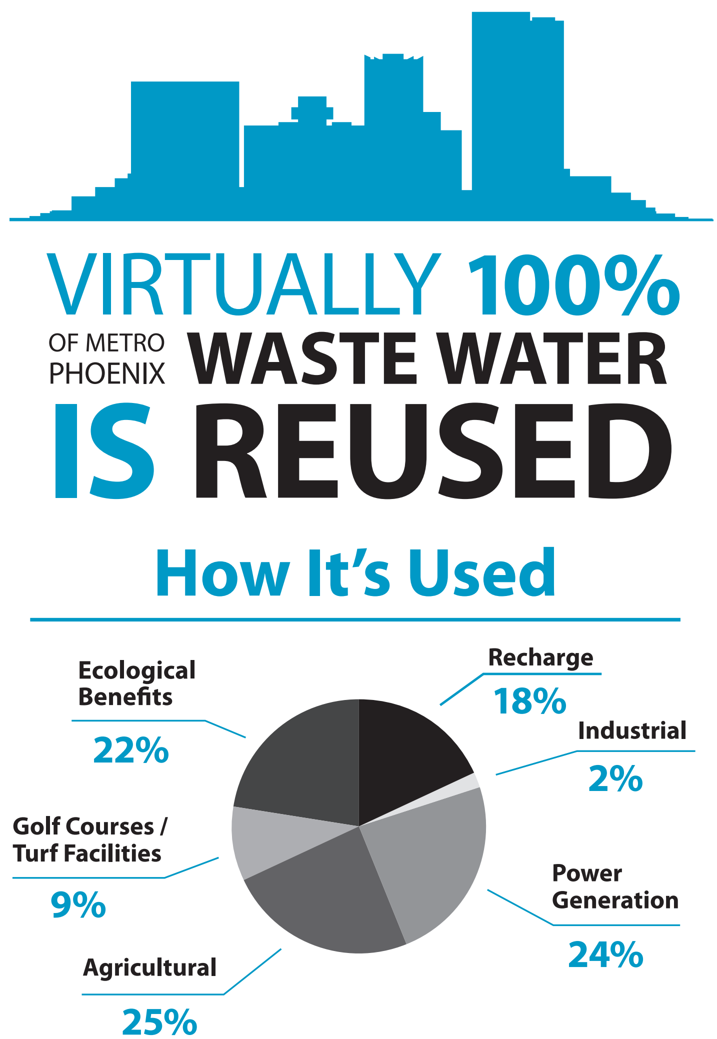

Figure 10. *Info-graphic on Metro Phoenix water reuse. Source: Central Arizona Project*

140 million gallons per day (about 430 acre-feet) of treated effluent.

Water for reuse occupies a middle ground between a waste product and a tradable good. It is generally more expensive to treat and distribute than potable water and its use is more restricted, two factors that depress potential markets. Public perceptions have also discouraged reuse. As the demand on existing potable supplies increases, however, the reuse of treated wastewater will represent a larger portion of Arizona's water supply portfolio. Current prices are supported by supplier subsidies, by legal requirements within AMAs, and conditions set by the ACC for certification of private water companies. The City of Tucson distributed about half of the reclaimed water it produced in 2013 at a rate of $797 per acre-foot plus a flat fee ranging from $7.74 to $948.84 depending on meter size (5/8 to 12 inches). Flagstaff charges between $372 and $1,128 per acre-foot inside the city limits.

Metropolitan Phoenix uses nearly all of its treated effluent, but not all of it is sold (Figure 10). Twenty-two percent is used to produce ecological benefits, 18 percent is recharged, and 24 percent is used for power generation. Agricultural use accounts for 25 percent of the total and the agricultural portion is used principally by irrigation districts to the southwest that receive flows through the natural river channel. Buckeye Water Conservation and Drainage District has a contract to receive 30,000 acre-feet of treated wastewater from the 91st Avenue plant, and the Roosevelt Irrigation District entered into an exchange agreement with the City of Phoenix whereby the District uses up to 30,000 acre-feet of treated wastewater in exchange for reuse credits that help the City comply with GMA regulations.

The 22 percent of metropolitan Phoenix's treated wastewater used for ecological benefits flows through the Tres Rios constructed wetland that, in addition to its treatment services, provides important habitat and passive recreational opportunities to the region. The City of Tucson, along with Pima County, Metropolitan Domestic Water Improvement District, the Town of Oro Valley and the U.S. Bureau of

Figure 11. *Riparian corridor along the Santa Cruz River. Source: Arizona Important Bird Areas Program*

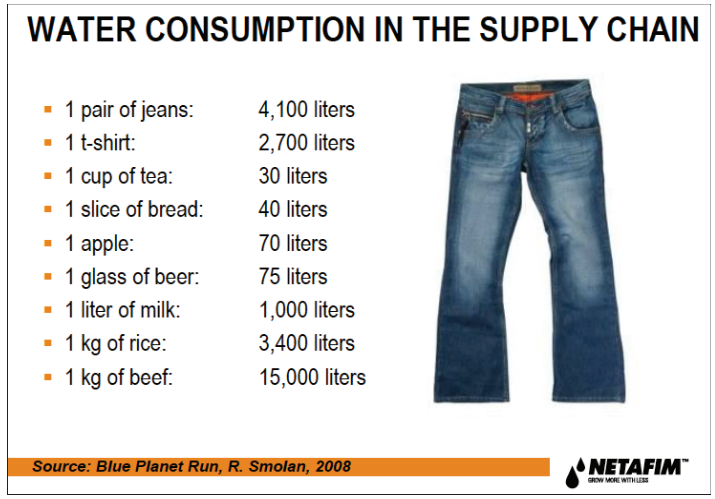

Figure 12. *Virtual water in the supply chain for various consumer goods. Source: Blue Planet Run, R. Smotan, 2008*

Reclamation, operate a managed recharge project in the bed of the Lower Santa Cruz River, which stores effluent from Pima County's two major wastewater treatment facilities underground for recovery at a later time. The flow into the project and beyond supports a strip of riparian vegetation that is considered by some to be a valuable community asset. Reallocation to other uses of the effluent that supports environmental amenities is becoming an issue of concern to advocates of the environment.

A study in the journal *Water* by Norman et al. evaluated the impacts of effluent discharge on the Santa Cruz River basin in terms of real estate values and other ecosystem services. The effluent maintains an area of riparian habitat along the Santa Cruz River that includes the Tumacácori National Historical Park (TUMA). The park itself is classified as an Important Bird Area (IBA), in which a wide array of rare bird species congregate because of the unique habitat (Figure 11). Aside from the recreational activity generated by the park and birds, effluent also naturally recharges aquifers and increases the value of private property within close proximity to the riparian zone.

The study used five scenarios, each depicting a different percentage of effluent discharge. Ecosystem impacts from reductions in effluent discharge were projected for each scenario. In the most extreme scenario, the river received only 33 percent of current discharge. In that scenario, the IBA, which now sees water year round, would be dry 60 percent of the year (217 days). If such water decreases were to occur, the loss of riparian habitat would negatively affect real estate and local community economies.

Virtual Water

Water is required in the production of essentially all goods and services. The water volume that goes into production can be quantified and then serve as a sort of water price tag. The volume of water embodied in a product is referred to as a product's virtual water content (Figure 12). In order to produce one kilogram (2.2 lbs) of grain, for example, 1000-

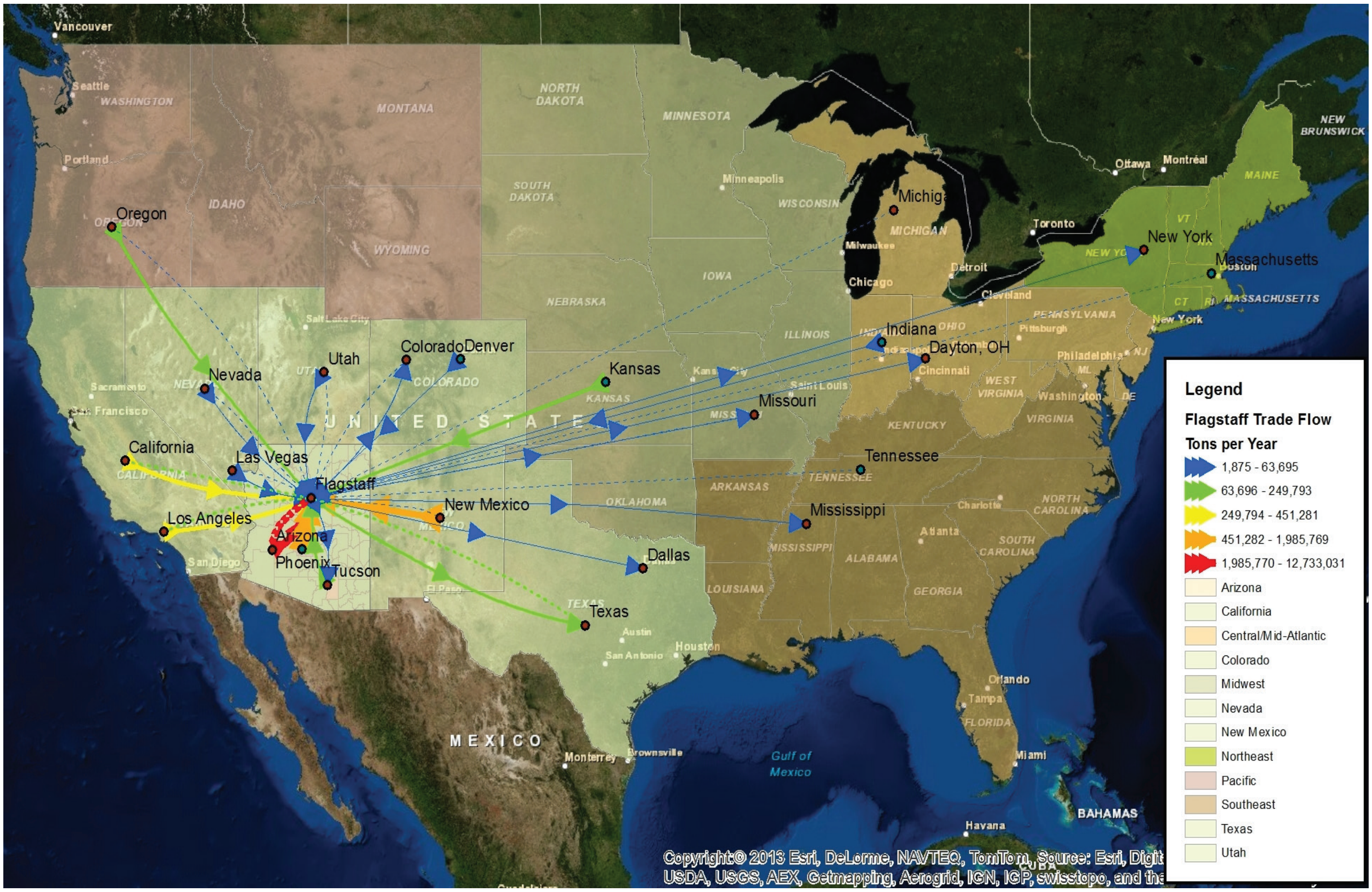

Figure 13. *Map of virtual water flows generated by economic activities in Flagstaff, Arizona. Source: Rushforth and Ruddell, 2013*

2000 kg (264-528 gallons) of water may be required. This is a full life-cycle amount, reflecting not just irrigation water, but also the water required for the production of inputs employed in the production of the grain. The volume of water required for a product such as grain varies significantly depending on where and when it was produced. Thus, the virtual water content of one kilogram of grain will vary with its "water use efficiency".

In order to portray virtual water, it must first be evaluated in two ways. One approach quantifies the water volume actually used to produce a product at its site of production. The second approach determines the amount of water it would have taken to produce that product in the place where it is being consumed. When calculated, these two quantities can be compared to determine how much water a country or region is importing by importing a product rather than producing it.

Studies by virtual water experts such as Hoekstra have indicated that, "virtual water can be seen as an alternative source of water." Rather than transporting real water from one region to another, which is often costly and impractical, water trade can occur through the transfer of products that require real water to produce. However, unless the relative value of the water is known, it is not possible to determine if a region is gaining or losing economically through the trade.

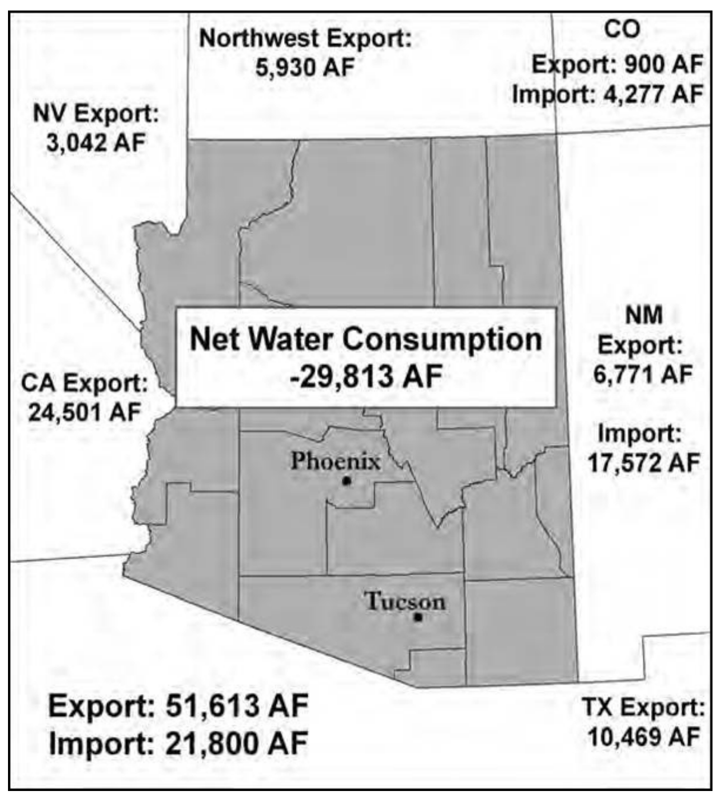

Figure 14. *Net water consumption by Arizona for thermoelectrical generation (imports minus exports), 2002-2006. Source: Scott and Pasqualetti, 2010*

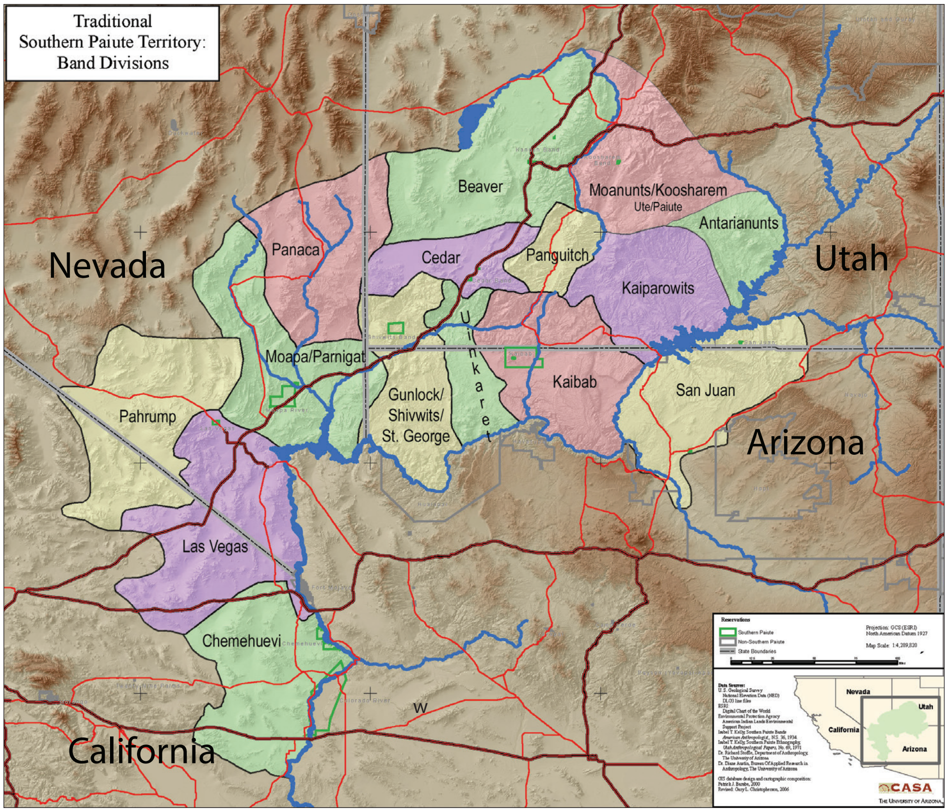

Figure 15. *Traditional Southern Paiute Territory. Source: Center for Applied Spatial Analysis (CASA), University of Arizona*

Rushforth and Ruddell of Arizona State University have conducted studies analyzing virtual water flows in the City of Flagstaff and the Phoenix Metropolitan Area in Arizona. They looked at virtual water flows generated by urban economic activity and associated these flows with the creation of value in the economy. They concluded that the value of virtual water increases as it flows through the economic network (Figure 13), and cities capture some of these gains by importing more water-intensive goods and services than they export. Most of a city's water use is virtual. In essence, virtual water flows because of economic activities that add economic value.

Scott and Pasqueletti determined that Arizona is a net exporter of virtual water embodied in energy (Figure 14). By determining the total electricity generated in Arizona, the consumptive use of water per megawatt-hour of electricity, the amount of electricity exported, and the amount of electricity imported, they were able to calculate the amount of virtual water that crosses state borders in each direction.

Thinking about virtual water can change the way people think about export and import of commodities. In a 2013 news item, the export of hay from Utah to China brought attention to the export of its virtual water content from water scarce states. For example, hay exports have exploded in the past 15 years; the largest increases are in export to China and the United Arab Emirates. In 2012, more than 485,000 metric tons of hay—or roughly 50 billion gallons of water—were exported, and that figure is expected to grow substantially. Exporting water embodied in hay provides economic benefits in Utah, Arizona and Southern California, where the hay is grown using Colorado River water, but precludes other uses that would keep the water in the region. With hay, large quantities of Colorado River water are being sent virtually to China.

The majority of water an individual uses is embedded in the products consumed by that person. The United States, which imports a majority of its consumer goods, is a net importer of virtual water, roughly 62 trillion gallons, much of it in the form of consumer goods.

Non-Monetary Values of Water

So far, this *Arroyo* has primarily addressed the economic value of water. Even the discussion of the environment measured values in monetary terms. Economists have techniques for estimating the economic value on a vast range of non-market goods. They can monetize the value people place on the features of a scenic view or the existence of something they will never experience—so-called "existence value." These generally require surveying a representative sample of people with questions that elicit their willingness-to-pay for the existence of something, or that allows the economist to infer people's willingness-to-pay based on their preferences among scenarios. Willingness-to-pay becomes the measure of value.

However, many people argue that water has values that cannot be expressed in economic terms. These include the community value and the spiritual value of water. Water has extremely strong social interconnections. Across the world, many societies manage their water resources based on social relations and cosmology, and not exclusively on technical calculations of supply, demand and operation costs. As

Charging for Water Withdrawals

Those who argue for pricing water for its full value note that in most contexts, the price of the water itself is zero. Incorporating unaccounted-for values in the price would entail mechanisms that convert those values into user costs. All wells that pump more than 35 gallons per minute within an AMA are required to have a groundwater withdrawal permit, to meter pumpage, and to pay an annual groundwater withdrawal fee. The fee helps fund the ADWR's regulatory activities and can be used for conservation and augmentation projects, water storage initiatives and retirement of irrigated land. In 2013, the withdrawal fee was $3.00 per acre-foot. The fee is too small to have an impact on water use, but sets a precedent for placing a price on pumped groundwater in support of conservation and resource values.

social scientists have shown, the social and spiritual values of water often prevail over its economic value.

In an effort to assess the spiritual value of water, research identified how religions and spiritual practices value water. Linking those religions or spiritual practices with the number of their adherents yields the unsurprising result that the majority of the world's people value water in non-monetary ways based on their spiritual beliefs.

For Indigenous people, water resources are crucial for cultural vitality and resilience. For example, in the dry Hopi mesas of Northern Arizona, water is not only a means of survival and economic development, but also the core of Hopi culture. As Nakai explains in the *Arizona State Law Journal*, the Hopi creation story explains that when Hopi ancestors climbed into this world from an underground one, a deity gave them maize seeds, a planting stick, and a gourd filled with water to be able to survive here. Native to a homeland where precipitation reaches 12 inches in a good year, the Hopi developed a dry farming tradition that relies on precipitation, and combines hard work, prayer and humility toward the will of nature.

Each Hopi village is located near sacred springs, which are living entities that hold Hopi ancestors. Throughout the year, ceremonies—including the widely known Kachina and Snake Dance—are performed around these springs for and in honor of water. Through ceremonies, the Hopi communicate with their ancestors, who have become one with the clouds, and call forth the water needed for survival. The use of water for religious and cultural purposes is not only of symbolic importance, for without water the Hopi cannot perform the rituals that keep water regenerating in the mesas. Thus, from an early age Hopi children are taught the importance of preserving water resources and the sacred springs for their physical and cultural survival. Sacred springs and related life forms continually appear in Hopi stories and art, illuminating the cultural importance of water for the Hopi way of life.

There are many other examples among Native American communities in the region. The Tohono O'odham of Southern Arizona are working to foster an understanding of water's value that integrates sacred and economic dimensions. The San Xavier Coop Farm teaches the younger generations that while CAP water has economic value, for the Tohono O'odham culture water is sacred, as the culture is built around the calling for, and celebration of, the coming of rain.

As another example, the Southern Paiute of the Arizona-Utah border understand the value of water from a holistic and relational perspective. Although their small reservation is far from the river, the traditional homeland of the Southern Paiute is bounded by more than 600 miles of the Colorado River (Figure 15). Despite the distance and restricted action, the Southern Paiute still consider it their right and responsibility to protect and manage the land and water of the Colorado River Canyons. Although boat tourism along these canyons damages their cultural resources, the Paiute did not advocate denying non-Paiutes access to springs and water sources, but chose instead to join with other stakeholders trying to manage the river canyons in the Glen Canyon Dam Adaptive Management Program. As Austin and Drye explain in *Policy and Society*, Paiute cultural practices proscribe excluding anyone from access to a water source.

The social and cultural value of water is also made evident in the acequia communities of New Mexico and Southern Colorado. Acequias—like their counterparts in Spain and the Middle East—are communal, gravity-fed earthen canals that divert stream flow for distribution in fields. These autonomous collective organizations of water users developed as a mechanism to ensure a formal civil process to resolve water-rights issues, especially in times of water scarcity. In the upper Rio Grande, acequia systems have supported hispanic farming communities for nearly three centuries. As Rivera illustrates in *Acequia Culture*, these irrigation systems lie at the heart of complex self-maintaining interactions between culture and nature that maintain community identity, cohesion and economic sustainability via drought adaptation. Maintaining and repairing the common canal is considered a sacred duty. Working communally to keep up the community's primary irrigation supply bonded villagers together over the years. As a social institution, the acequia has worked to preserve the historic settlements and local culture in a region that has undergone major political transitions from Spanish, to Mexican, to territorial, to modern U.S. sovereignty. Water is hence seen as a conduit for preserving the homeland and identity of hispanic communities in this region.

2013 Summer Intern Passionate About the Environment

Max Efrein, the Montgomery & Associates Summer Writing Intern at the WRRC, was a Senior with a double major in History and Journalism. Basic human needs such as food and water have always fascinated Efrein. He believes that we are constantly making choices that have noticeable repercussions on our personal health and the health of current and future populations by directly affecting the availability of those resources. This was made clear to him on a trip to Ghana with Global Water Brigades, where he worked along with 27 other volunteers to construct rain-harvesting systems for villages that have limited access to clean water. He intends on continuing his pursuit of knowledge on water by focusing much of his journalistic reporting on related issues.

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Conclusion

Water is essential. Without water, life in a form familiar to us could not exist, thus water's value is immeasurably high. It falls from the sky and has been available for the taking from lakes, streams and wells since time immemorial, thus it is free. When flooding, it may have a negative value. Between these extremes are the many values placed on water by its users. Other values may be placed on the same water by people who would prefer to see it used another way. These values reflect the complex interrelation of multiple factors, perspectives and contexts. Any effort to present the value of water will fall short of a comprehensive description.

Yet, if society is to respond appropriately to water challenges, it is important to understand the implications of limited current supplies and growing demands. Action today is needed to forestall shocks, either in price spikes resulting from the need for supplies that are expensive to acquire, or the loss of reliability resulting from failure to secure additional supplies. Better to appreciate the value of water now then regret our lack of understanding in the future.

Many varied sources were consulted to put together this summary. Those interested in following up on information presented here are invited to contact the editor.

This publication benefited from comments and suggestions by the following reviewers: Kathleen Ferris, Arizona Municipal Water Users Association; Patrick Graham, The Nature Conservancy; Kelly Mott Lacroix, University of Arizona; Tom McCann, Central Arizona Project; Amy McCoy, Ecosystem Economics; Leslie Meyers, Bureau of Reclamation - Lower Colorado Region; Cliff Neal, City of Phoenix; Bill Plummer, Agri-Business and Water Council of Arizona; Dave Roberts, Salt River Project; Ben Ruddell, Arizona State University; Ken Seasholes, Central Arizona Project and Margaret Wilder, University of Arizona. We are grateful for their comments. Any errors of fact or interpretation are the authors'.

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Cover photos (clockwise): 1) San Pedro Riparian National Conservation Area. *Source: Bureau of Land Management, Tucson Field Office.* 2) Palo Verde Nuclear Generating Station. *Source: Maricopa County, Department of Emergency Management.* 3) Agricultural field in the Phoenix Active Management Area (AMA). *Source: Arizona Department of Water Resources.* 4) Automatic water reader. *Source: City of Tucson.*