TUCSON REGIONAL WATER COALITION

Arizona Builders Alliance

Alliance of Construction Trades

Marana Chamber of Commerce

Metropolitan Pima Alliance

Northern Pima County Chamber of Commerce

Safe and Sensible Water Committee

Southern Arizona Home Builders Association

Southern Arizona Leadership Council

Tucson Association of Realtors

Tucson Metropolitan Chamber of Commerce

Tucson Utilities Contractors Association

Tucson Hispanic Chamber of Commerce

August 17, 2009

City/County Study Oversight Committee:

Please accept the Tucson Regional Water Coalition's policy paper titled *Water as an Economic Resource.* As the title suggests, we believe that application of economic principles, methods, and instruments will lead to more informed water policy in the Tucson AMA. This paper is the product of the Coalition's yearlong research and interest in the internationally recognized concept of managing water as an economic good. The paper aims to introduce fundamental water economics concepts and highlight their applicability and usefulness in local policy discussions.

Several University of Arizona professors with expertise in the fields of water economics and water markets reviewed the paper and provided comments. Special thanks to George Frisvold, Carl Bauer, and Bruce Billings for their assistance in writing this paper. Similarly, outlines and drafts of the paper were distributed to the Coalition's membership for review and comment throughout the writing process. We have attempted to address all comments and incorporate recommended changes. The final paper is truly a collaborative effort and we hope it is a positive contribution to the Phase II report.

Many of the concepts explained in the paper were first introduced in the Coalition's *Principles of Sustainable Water Resource Management* submitted during Phase I of the City/County Study. We continue to rely on the sustainability principles to guide our efforts as well as our on-going evaluation of the City/County Study. We encourage the Oversight Committee to review those principles as you begin drafting policy language for the Phase II report. We appreciate the opportunity to contribute this policy paper and look forward to hearing its concepts discussed by the Committee.

Thank you,

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Water as an Economic Resource

Submitted by the Tucson Regional Water Coalition

ABSTRACT

Few will disagree that fresh water is a relatively scarce resource in many locations throughout the world, meaning supplies are (or will be) insufficient to meet all competing uses. Consequently, government agencies are increasingly looking to economically-minded water policies to achieve efficient use and allocation of available supplies. This is particularly relevant to rapidly growing arid and semi-arid regions with increasing demands across multiple water use sectors—municipal, industrial, agricultural, and environmental. Economically efficient allocation maximizes the general welfare or net benefits enjoyed in utilization of a community's water resources. This is achieved by allocating water to highly valued uses and away from uses that hold less value to the community. This paper will show how economics provides invaluable principles, methods, and instruments to understanding how communities can maximize the net benefits derived from available water supplies. We argue that economics' fundamental concern with allocating scarce resources makes it uniquely qualified to provide water policy debates with baseline facts about all associated costs and benefits of alternative uses, leading to more informed, rational allocation of arguably our most precious resource.

I. Introduction

In 1992, the International Conference on Water and Environment in Dublin, Ireland reached consensus regarding an emerging global water crisis and the need to reform water management in both developed and developing countries alike. Participants adopted a policy statement and principles known as *The Dublin Statement on Water and Sustainable Development* (ICWE, 1992). The globally applicable statement addressed water scarcity, misuse of water, and the rising number of water-related conflicts, and proposed a series of principles and actions to confront these challenges.

The Dublin Statement's most frequently cited recommendation is that water should be treated as an economic good: "Water has an economic value in all its competing uses and should be recognized as an economic good" (ICWE, 1992). Today, treating water as economic good or economic resource (Briscoe, 1996) is a generally accepted principle among the international water world. However, the meaning and intent of this principle has been rigorously debated in the literature and among water professionals over the past decade and a half (Bauer, 2004; Bauer, 2004b; Briscoe, 1996; Briscoe, 1997; Hanemann, 2006; Rogers et al, 1996; Rogers et al 2002; Savenije et al, 2002).

Those that accept the principle of *water as an economic good* generally fall along an ideological spectrum that ranges from a strict or narrow interpretation of the concept to an increasingly broader view (Bauer, 2004). The narrowest interpretation (often held by traditional neoclassical economists) believes efficiency would be best achieved if water rights were traded in well-functioning markets as a purely private commodity, subject only to forces of supply and demand. However, as one moves along the spectrum, a greater number of economic principles, methods, and instruments are seen as acceptable to understanding how to achieve a more economically efficient use and allocation of water resources. These broader conceptions of water as an economic resource do not necessarily discredit water markets (albeit under optimal conditions), but view the tool box to improve economic efficiency as somewhat larger. A broader conception might be critical of the ability to create truly well-functioning water markets, and yet acknowledge the efficiency gains likely achieved from voluntary "market" transfers where water rights are traded from a low value use such as agriculture to a higher value urban use.

A slightly broader view of acceptable economic instruments might extend to allocation via retail pricing of water. Setting prices according to water's economic value—like well functioning markets or even spot market transfers—will result in reallocation of resources from lower value uses to higher value uses, and thus efficiency or welfare gains (Agthe et al, 2003; Rogers et al, 1996; Rogers et al, 2002). Pricing water according to its economic value shares ideological space and is generally compatible with other quantitative economic analysis methods such as Cost-Benefit Analysis and Cost-Effectiveness Analysis, which serve to inform decision makers of the relative economic efficiency of policy alternatives in administrative allocation processes and other water management decisions. The broadest views are of those in the field of institutional economics that expand acceptable methods to include more interdisciplinary, qualitative analysis, attempting to place economic efficiency in the context of cultural, historical, political, and legal realities (Bauer, 2004).[1] These so-called "broad" views are most compatible with an administrative or legislative allocation system.

We support a broad interpretation of water as an economic resource. However, this paper has a somewhat narrower scope, focusing on the core issues considered and tools used in the analysis of economic efficiency as the primary objective in water resource management and allocation. While we propose use of economic efficiency as the central criterion in water policy debates, pure technocratic economic analysis is not a substitute for integrated, interdisciplinary, deliberative processes where a whole range of hard to quantify and/or monetize social, cultural, political, legal and environmental factors are considered by key stakeholders.

II. Economic Principles, Methods, and Instruments to Improve Efficiency

As water becomes scarcer in any region or basin, efficient allocation among competing users is increasingly important. Economically efficient allocation maximizes the general welfare or net benefits enjoyed in utilization of a community's water resources. In practice, this is achievable by allocating water to highly valued uses and away from uses that hold less value to the community. There are three distinct and widely recognized allocation methods: 1) governmental administrative or legislative processes; 2) retail pricing that includes economic costs such as opportunity cost and externalities; and 3) markets in tradable water rights (Rosegrant and Binswanger, 1994). All three allocation processes can improve economic

[1] For more complete discussion and summary of the different perspectives on what it means to treat water as an economic good see Bauer, 2004, pages 6-30; Hanemann, 2006; Savenije and van der Zaag, 2002.

efficiency or the net benefits derived from available water resources—each may be more or less suitable depending on the context.

The use of markets in tradable water rights to achieve efficient allocation has relatively limited applicability to the City/County Water Study. For the purposes of this study, the description of water markets is primarily included to introduce key concepts such as opportunity cost and transfers of water based on a willingness to pay to accrue future benefits derived from resource utilization. Understanding water markets or market-based transfers also provides good conceptual information for discussions regarding acquisition of additional supplies to meet future demands in the Tucson AMA.

Water Markets as an Allocation Method

Economists have traditionally supported allocation of scarce resources via markets (Rosengrant and Binswanger, 1994). Support is typically predicated on the notion that the property rights over said resources are exclusive, transferable, enforceable (like other commodities) and transaction costs (such as those associated with obtaining necessary legal approvals) are low or preferably zero. In reality, water rights transact relatively infrequently in most places; when they do, it is most often in environments where these conditions are not perfectly in place. Still many economists continue to support policies encouraging markets in tradable water rights, particularly in areas where water is scarce relative to demand, where economic growth is occurring, and lower value uses such as agriculture hold much of the available supply.[2] Even where conditions are not perfect, market-based transactions typically lead to efficiency or welfare gains through voluntary transfers from lower value users to higher value users who demonstrate a "willingness to pay" to accrue future benefits derived from use of the resource. These transfers can occur within and across water use sectors such as municipal, industrial, agricultural, and environmental. The agricultural sector seems to be involved with the greatest number of transfers—between two farmers, between farmers and environmental groups like land and water trusts, from farmers to municipal providers, etc.

Literature on markets in tradable water rights is extensive, outlining a broad range of pros and cons in theory and in practice (Young, 1986; Saliba and Bush, 1987; Smith, 1988; Colby, 1990; Rosegrant and Binswanger, 1994; Bauer, 1997; Agthe et al, 2003; Bauer, 2004; Bauer, 2004b; Brewer et al, 2007; Glennon and Pierce, 2007). Many praise markets in tradable water rights for their ability to force rights holders to face opportunity costs and the fluidity in which markets convey information about supply and demand through price signals (Briscoe, 1996). The most common critique of water markets is the high-degree of market failures, which reduce or negate efficiency/welfare gains. An often-cited market failure is the inability to internalize or capture externalities in a market price.

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[2] For examples of locations where water rights transact regularly see Chile's Los Andes Province (Bauer, 1997) and Colorado's Big Thompson Project. A considerable challenge to facilitating transfers is the availability of infrastructure to physically move water from one place of use to another. The above referenced locations have the necessary canals and/or reservoirs to convey supplies, likely contributing to the number of water rights transactions.

The concept of opportunity cost is critical to an understanding of water as an economic resource and the role of markets in efficient allocation. The relationship between agricultural and urban uses in a basin where scarcity exists illustrates the concept. The value of water to urban users (measured by their collective maximum willingness to pay for the use of the resource) is often an order of magnitude or ten times greater than the value of water in agricultural uses (Briscoe, 1996). If the economic benefits for a farmer to use water in crop production and sale are 'X', and the economic benefits for the same water used to support a multitude of economic activities in a city are '10X', then the farmer will be induced to sell his water rights to a municipal provider or other urban uses such as industrial. The fact that urban users put the water toward uses that produce a significantly greater economic return or benefit is what drives their willingness to pay much more. Briscoe states: "if the user values the water less than it is valued by the market, then the user is induced to sell the water. This is the genius of the water market approach—it ensures that the user will in fact face the appropriate economic incentives" (Briscoe, 1996).

The "economic incentives" Briscoe refers to is the opportunity cost. The farmer (and society) experiences economic loss or opportunity cost, if, under the above conditions the water produces crops instead of going to urban users. The presence of markets or policies that encourage market transfers help water rights holders understand the value of water in alternative uses, realizing the different economic gains from either use or sale to willing buyers. Market-based allocation systems reduce the chance of undervaluation and misallocation between users, leading to welfare gains for the community in aggregate (Rogers et al, 1998).

While markets are praised for their ability to transmit signals regarding opportunity cost, they seldom capture or internalize so-called externalities unless policies are in place to force internalization. Externalities refer to either costs (negative externalities) or benefits (positive externalities) experienced by an entity that is not directly using or benefiting from the water in question. For example, a market transfer between a willing buyer and seller may have so-called "third party" environmental or economic impacts or externalities not accounted for in a market transaction. Failure to internalize these externalities in a water rights transaction reduces the resulting efficiency or welfare gains created by the transfer. Additionally, water is allocated in a manner far removed from the perfectly competitive environment required to achieve well-functioning markets. It is highly regulated and there are considerable institutional barriers to water transfers as well as potential for monopoly by large buyers and sellers. Removal of any one of these so-called distortions and movement toward a market-based allocation, will not necessarily improve welfare (Frisvold, 2009).

Full Cost of Water

Theoretically, a well-functioning water market with policies in place to take care of externalities will match demands with supplies to improve the economic efficiency of allocation over time. However, where use of markets is not applicable, not easily implemented, and/or not desired, pricing water according to its economic or scarcity value should also lead to reallocation to higher value uses and therefore efficiency gains. The paper titled *Water as a Social and Economic Good: How to Put the Principle into Practice,* explains full cost or economic retail pricing of water. It describes how economic or scarcity pricing leads to allocation to most valuable uses, forcing end users to face opportunity cost and externalities in addition to the traditional "full supply" cost basis for water rates (Rogers et al, 1998). This full cost framework is generally compatible with other economic principles such as "Polluter Pays" and/or "User Pays", where pricing ensures end users pay an amount equal to the benefit they receive and/or the impact their usage has on others (Rogers et al, 2002). This section will focus on components of full cost pricing, but the final section of the paper will show how principles like "polluter pays" can be put into practice.

Full Supply Cost: O&M and Capital Charges

Most water utilities set rates based on the full supply cost, which includes Operation & Maintenance (O&M) and Capital Charges. O&M expenditures include costs associated with the day-to-day operation of a water utility such as labor and energy, etc. O&M costs are the most straightforward and can easily be accounted for in a utility's annual accounting receipts (Agthe et al, 2003). Capital Charges are those costs associated with delivery, storage, and treatment infrastructure, where costs are measured as the combination of all depreciation and the interest paid to service debt. There is some dispute whether Capital Charges should be "backward" or "forward" looking: "Traditional methods use a backward accounting approach and include only the costs associated with repaying the historical investments. Newer approaches use forward-looking accounting and consider the cost of replacement of the physical assets and the potentially increasing costs of new additions to the capacity of supply sources" (Agthe, 2003, p. 48).

Full Economic Cost: Full Supply Cost + Opportunity Cost + Externalities

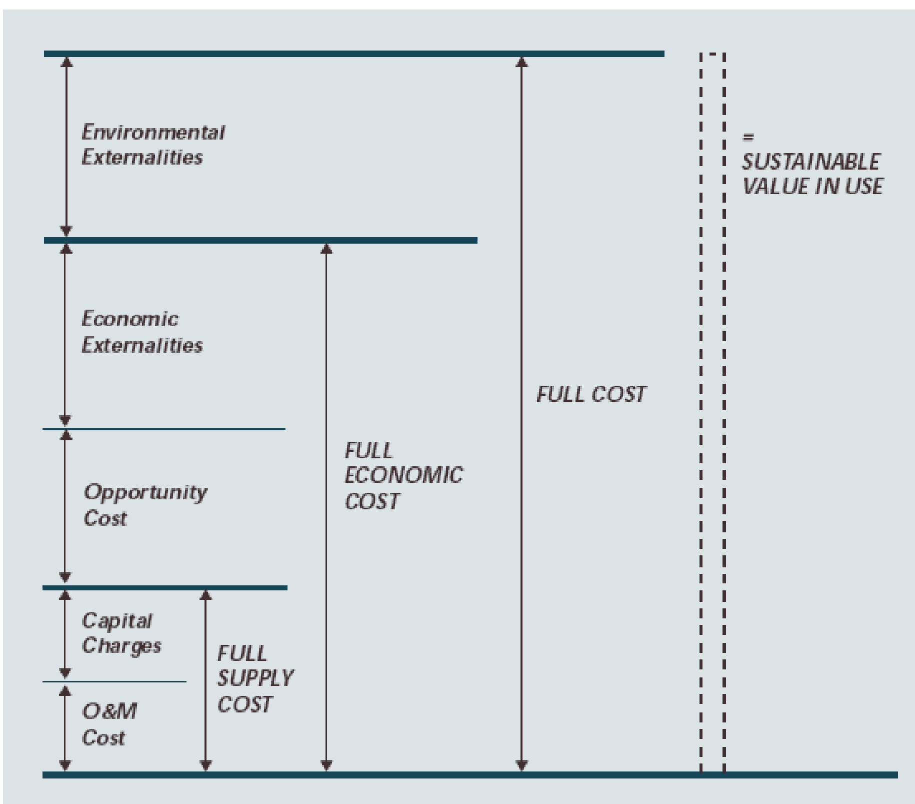
Full supply cost described above is the foundational component of the full economic cost. However, stopping at full supply cost fails to account for the value of water as an economic resource to many competing uses. It fails to price water according to its relative scarcity, leading to over consumption by so-called lower value uses and economically inefficient allocation or "misallocation". To achieve an economic pricing of water, one must also include opportunity cost and any externalities—to the extent that they exist (Figure 1) (Briscoe, 1996; Briscoe, 1997; Rogers et al 1998; Rogers et al, 2002; Agthe et al, 2003).

As noted, opportunity cost is an economic concept that describes the fact that if water is in fact scarce—meaning available supplies are insufficient to meet all competing demands—then social welfare losses occur when water is allocated to lower value uses instead of those capable of yielding greater economic returns. Opportunity cost represents the value of water in the best alternative use foregone. Said another way, opportunity cost can be understood within the context of an investment decision. If water is allocated to uses with a lower economic return or net benefit than what could have been achieved in an alternative use, then the community suffers the loss of higher returns that could have been achieved (i.e. benefits foregone). Again, this assumes available supply is insufficient to meet existing demand and the competing uses present are associated with varying economic returns. The fact that opportunity costs are not considered in a municipal provider's rate setting processes may indicate available water supply is believed sufficient to meet all demands.

Briscoe notes markets' ability to transmit information on opportunity costs with a degree of ease and flexibility that is not possible in a pricing or administrative allocation system. While it is difficult (due to high degree of information required), it is not impossible to incorporate opportunity costs into retail water rates. Moreover, it is necessary to include opportunity costs if a community desires to use pricing to improve the economic efficiency of water allocation. However, two important factors should be reiterated. First, opportunity cost only exists where scarcity exists. That is, if the demands of all uses are met, then there are no potential benefits of an alternative use foregone and therefore no opportunity cost. Second, among urban users in the municipal and industrial sectors, the opportunity costs may be quite low and not worthy of much consideration in retail pricing for an urban water provider's rate structure (Briscoe, 1996).

One way to address externalities in a municipal provider's water rates is by including the cost of wastewater treatment. That is, before discharging wastewater into a stream or recharging into the aquifer, it must be treated to a high enough quality such that it does not degrade other users' water supply. If not treated appropriately, discharges impose costs on downstream users or other groundwater users who must pay more to remediate their degraded water supply. By treating the water before discharging it, users are in fact "internalizing" the externalities associated with their usage. Including wastewater charges in a municipal water providers' volumetric rates (instead of two separate bills for water and wastewater service) takes the concept one step further, sending the appropriate price signal to end users of the true cost of service.

Figure 1 – Full Cost Pricing



Source: Rogers et al, 1998

Cost Analysis Methods

Cost-Benefit and Cost-Effectiveness Analyses are primary economic appraisal tools used to inform decision-makers of the relative efficiency of two or more alternatives. These methods are helpful in administrative allocation processes as well as other water management decisions such as conservation programs, supply augmentation strategies, environmental restoration projects, and countless others. Application of these methods is not a substitute for interdisciplinary, participatory decision-making processes. However, these tools provide invaluable baseline quantitative data to inform and rationalize water policy debates. They can help structure community dialogue around a common language, allowing for expression and comparison of diverse values in the same analytic framework.

Cost-Benefit Analysis

Cost-benefit or C/B Analysis compares the economic efficiency that would result from alternative allocation scenarios or water management policies. All benefits and costs of various alternatives are expressed in the common language of money, including "non-marketed" ecological and/or social costs and benefits that are not typically expressed in monetary terms. Additionally, since costs and benefits occur over different times in the future, a discount rate is applied to evaluate the net present value of costs or benefits in a common time or "day one" of the analysis. Once the discount rate is applied to monetized costs and benefits, the difference between the two represents the alternative's net benefit or net present value. Net present values of one or more alternative policies or scenarios are compared against that of the "no action" or "business as usual" alternative. The alternative with the highest net benefit is deemed the most economically efficient option of those evaluated. Said another way, economic efficiency is based on maximizing the present value of the net benefit stream (AWWA, 2007; AWWA, 2006).

A common critique of C/B Analysis is the challenge of monetizing non-marketed costs and benefits, particularly those associated with the environment. However, great strides have been made in the field of environmental economics to estimate such costs and benefits, including hedonic studies that conclude homes near natural open space have higher sales prices. Another challenge of C/B is to accurately include all the significant groups affected by a project or policy, while also avoiding double-counting of impacts (Frisvold, 2009).

Cost-Effectiveness Analysis

Cost-effectiveness analysis establishes the "least cost" method of accomplishing a clearly defined goal. For example, if a jurisdiction is faced with the need to increase the available water supply, policymakers might identify a number of methods including both conservation measures and possibly water rights acquisitions, hoping to find the so-called least cost option of augmenting their supply portfolio. Under this example, all the options would have a pre-determined acre-feet of water supply needed, but would vary by how much each supply costs. Cost-effectiveness analysis simply indicates which option has the lowest present value of costs to meet the stated goal. The method and idea of cost-effectiveness may help find the best way to employ limited financial resources to achieve a stated objective. For example, given that a community in aggregate has limited finances to commit to a water conservation program, which measures yield the greatest water savings or net resource gain for the available funds?

III. Examples in Local Water Policy

There are a number of past, current, and future local policy decisions that require comprehensive economic analysis, considering regional (defined as the Tucson AMA) net benefits defined by the inputs of all key stakeholders. Continuing to ignore the aforementioned economic principles, methods, and instruments in local water policy and allocation discussions will have welfare consequences for the Tucson region. We support holistic appraisal of costs and benefits on a regional scale for the purposes of this study and other local water policy decisions. Water policy that includes the values and needs of all Tucson AMA stakeholders in a common analytic framework is required to achieve regional sustainability goals.

This section attempts to put the abstract economic principles, methods, and instruments into the local context. However, the following examples remain conceptual in nature—designed to promote further analysis and debate, underscore the applicability of economic analysis in water policy decisions, as well as reinforce understanding of the methods introduced in the first half of the paper. The analyses in this section are not finalized policy recommendations, but are illustrative and intended to spark community dialogue regarding management of water as an economic resource.

Conservation Effluent Pool

Effluent is increasingly seen throughout the southwestern U.S. as the most reliable component of municipal providers' renewable water supply portfolio. On February 7th, 2000, the City of Tucson and Pima County entered a Supplemental IGA that provided the framework to reallocate up to 10,000 acre-feet of the region's effluent from urban uses to riparian projects (i.e. the Conservation Effluent Pool). The IGA contemplates making effluent available for riparian projects from the Conservation Effluent Pool (CEP) at no cost, but that all costs associated with transportation and reclaimed treatment are paid by what the agreement refers to as the "operator" or "beneficiaries" of the projects. In short, the proposal forces operators or beneficiaries of restoration efforts to pay the "full supply cost" (Figure 1).

The Economic Value of Local Effluent Supplies

The City and County IGA fails to consider the future opportunity costs associated with reallocation of effluent from urban to environmental uses. Opportunity cost addresses the fact that by consuming water, one user is depriving another user of the water. If that other use yields a higher net benefit, then there are some opportunity costs experienced by the region due to this so-called misallocation. When evaluating the full economic cost of water used for environmental restoration, it is necessary to consider all other competing alternative uses and estimate value in the best alternative foregone. The City/County Phase I Report states that the local economic value of water in urban uses is approximately $160,000 per acre-foot ($1.6 billion to the local economy in this case). This estimate is derived by dividing regional Gross Domestic Product by acre-feet of water used. This measure at best may be thought of as an average value of water, which is not appropriate for allocation decisions and should not be used to accurately represent opportunity cost (Frisvold, 2009).[3] However, a statement that urban uses are the best alternative foregone is defensible.[4] Briscoe notes that the value of water in environmental uses such as maintenance of wetlands, wildlife refuges, and river flows is typically greater than the value of water in agricultural uses, but lower than values in municipal and industrial sectors (Briscoe, 1996).

As previously stated, there is no opportunity cost if scarcity does not exist. One way to overcome scarcity is to augment basin supplies by importing more water to sufficiently meet all demands. Paying the replacement cost may in fact be a less costly alternative than foregoing the future benefits experienced had the water been allocated to municipal or industrial users. The Central Arizona Water Conservation District (CAWCD) is currently coordinating a supply acquisition program known as ADD Water (Acquisition, Development, and Delivery). Water rights belonging to agriculture and Indian communities along the Colorado River are the most likely supplies available for acquisition. The current acquisition price of these water rights is estimated to be $5,000 per acre-foot, translating to a CEP replacement cost of approximately $50,000,000—more when considering annual transportation costs.[5] However, this scenario assumes that sufficient water rights are available for purchase and that CAP will grant access to the Canal to transport supplies to the region. The uncertainties related to these assumptions must be considered before reallocating any volume of locally available effluent. Failure to replace reallocated effluent results in the region suffering considerable opportunity costs in the future due to reduced economic development potential.[6]

Cost-Sharing Among Beneficiaries

Assuming water rights are available to purchase and CAWCD allows use of the Canal, the question quickly moves from what are the associated costs to how do we equitably distribute costs. The current framework prescribed by the IGA would likely lead to new residents paying the replacement cost associated with the CEP. That is, reallocating 10,000 acre-feet from municipal providers' supply portfolio means that providers will need to purchase additional supplies to accommodate growth and maintain their Designations of Assured

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[3] See W. Hanemann's *The Economic Conception of Water* (Hanemann, 2006) for thorough discussion of relationship between water and regional economic development.
[4] See Briscoe (1996) *Water as an Economic Good: The Idea and What it Means in Practice* for conceptual discussion regarding value of water in various water sectors.
[5] Note: a discount rate could be applied to future costs associated with annual transportation of new supplies through the CAP Canal (i.e. wheeling charge) in order to understand to present value of all costs associated with that policy alternative. Assuming the wheeling charge is equal to the Excess CAP rate of $133/AF and increases 3% per year, the net present value of annual transportation costs of 10,000 acre-feet over 20 years is approximately $17 million.
[6] Note: Reduced economic development potential is a cost the region would experience at some point in the future when it exhausted the available supply portfolio. This future cost must be discounted back to present day for an apples-to-apples comparison.

Water Supply. Acquisitions will likely be financed by bonds and paid back (partially or completely) by future increased water resource impact fees.

Apportioning costs in this manner is contrary to equity principles such as "polluter pays" and "beneficiary pays." No reasonable argument can be made that future residents caused the historic damage to riparian areas that now require reparation. Also, restoration projects are a regional benefit. Costs sharing for these projects should include all beneficiaries—current and future residents/ratepayers. Yet another way of looking at the issue is to characterize ecological damage caused by historic and current groundwater pumping as an environmental externality. Economic value of ecological damage is typically based on an estimate of remediation costs. In this case, remediation costs are largely paid through reallocation of 10,000 acre-feet of effluent, valued according to water right replacement costs at $50,000,000 (plus annual wheeling costs).

Possible Solution

Reallocation of effluent for environmental restoration projects contributes to a sustainable water management plan. Sustainable water management involves balancing environmental, economic, and equity factors for the greatest net benefit of the region. This could be achieved by: 1) remediation of ecological damage by reallocating some volume of regional effluent to restoration projects; 2) replace all or a portion of water reallocated to environmental uses by acquiring new water rights for urban uses/economic development; and 3) distribute costs associated with water right acquisitions among all regional beneficiaries/polluters.

This could be accomplished by a volumetrically assessed (per Ccf) Environmental Fee on potable water sales, where funds collected are committed to servicing debt related to water rights acquisitions necessitated by reallocating effluent to environmental remediation.[7] Tucson Water uses a similar volumetrically assessed fee concept to support its Conservation Program. The Conservation Program annual budget is approximately $1.5 million. The per Ccf fee is then calculated based on what funds are needed to support the program's annual budget compared to the projected annual potable water sales. In 2008, Tucson Water projected 50,000,000 Ccfs of potable sales and consequently the fee was set at $0.03 per Ccf.

The proposed Environmental Fee could be established in a similar manner—matched to the region's appetite (i.e. willingness to pay) for environmental reparation. If the replacement costs of 10,000 acre feet of effluent are $50,000,000 (does not include annual wheeling costs), the fee would be set based on the annual debt service of $50,000,000. For example, if the associated annual debt service was $5,000,000 and Tucson Water projected 50,000,000 Ccfs in potable sales, then the Environmental Fee would be set at $0.10 per Ccf. The average residential ratepayer uses between 10 and 12 Ccfs per month, translating to a monthly contribution of $1 to $1.20. Moreover, this concept is scalable—structured to allow reallocation of effluent for environmental restoration to whatever volume the region demonstrates a willingness to pay, up to the entire volume of effluent available (if replacement supplies are available).

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[7] This example is based on an average cost and pricing scheme. Future analyses should be based on the marginal cost of the new supplies to set rates appropriately signaling scarcity (Frisvold, 2009).

The volumetric fee concept internalizes environmental externalities, distributing those costs directly to the end user/beneficiary/polluter and reinforcing cultural messages urging conservation. The fee enables individual ratepayers to legitimize the value ascribed to the community's ecological assets by demonstrating a willingness to pay for reparation, permanently dedicating the water resources needed without sacrificing future economic development potential.

Conservation or Acquisition

As a water utility's demand approaches full utilization of its supply portfolio, it faces the question of whether it is more cost-effective to invest in conservation or acquisition. It is increasingly popular to argue in favor of conservation investments as a more cost-effective alternative to supply acquisition to augment local supply portfolios. The Pacific Institute's report titled *Waste Not, Want Not: The Potential for Urban Water Conservation in California* states:

> "Since each water-conservation measure is an alternative to new or expanded physical water supply, measures are considered cost-effective when their unit cost—what we call the 'cost of conserved water'—is less than the unit cost of the cheapest alternative for new or expanded water supply. We conclude that in California, it is cheaper to conserve water and encourage efficiency than to build new water supplies or even, in some cases, expand existing ones" (Gleick et al, 2003).

The Pacific Institute's report concludes that conservation is more cost-effective than developing new supplies, but it is not clear whether it is more or less cost-effective than acquiring and transferring already developed supplies.[8] The report's analysis tends to focus on the environmental impacts (costs) associated with additional water supplies developed by building new dams, desalinization plants or taking more water "out of the stream." These environmental externalities weigh heavy in cost analyses, making convincing arguments for conservation investments. However, if a supply is already developed or diverted, then there are no additional environmental costs associated with the transfer (though there may be economic externalities that need to be addressed).

The question we pose is whether conservation is more cost-effective than acquiring and transferring already developed supplies. This analysis is conceptual in nature, intended only to generate discussion. The topic requires rigorous analysis of additional conservation measures and all associated costs, particularly a utility's avoided costs linked to postponed or eliminated capital projects due to conservation measures reducing peak demand. However, the analysis should be helpful to conceptualize a least-cost framework on the subject of conservation versus acquisition in policy discussions.

Toilet Replacement Program

Water utilities often look to toilet replacement or retrofit programs as an effective and cost-effective conservation measure. These programs look to replace older, less efficient toilets

[8] We use the phrase "already developed supplies" to refer to water volumes annually diverted and beneficially used.

(generally 3.3 gallons per flush or greater) with newer models known as ultra-low flow (1.6 gallons per flush) or so-called high-efficiency toilets (1.28 gallons per flush). There is a wide range of costs per toilet depending on the model, quantity purchased, whether additional installation costs are considered, or if the utility rebates a portion of the toilet cost versus outright purchase. For the purposes of this simple analysis, assume that the utility is offering to cover 100% of cost to replace 3.3 gallons per flush toilets with 1.28 gallons per flush toilets at a total cost of $150 per toilet. Assume the water provider's goal is to augment supply by conserving water.

Additional model assumptions include: 1) average house has 2 bathrooms, meaning 2 toilets; 2) average household size of 2.7 people; 3) and each person averages 5 flushes per day.[9] These assumptions mean that a home with two 3.3 gallons per flush toilets, uses approximately 44.5 gallons per day (toilet use only), which translates to 16,260 gallons per year or 0.05 acre-feet per year. If the utility replaced the 3.3 gallons per flush toilets with 1.28 gallons per flush models, the same household uses 17.28 gallons per day—6,307 gallons per year or 0.019 acre-feet per year.

Under these assumptions, the toilet replacement program augments the water supply 0.031 acre-feet per year per household retrofitted with two 1.28 gallons per flush toilets. If each toilet costs $150, then the utility spends $300 to save 0.031 acre-feet per year. This means that to save an acre-foot of water per year, the utility must retrofit approximately 32 houses with 1.28 gallons per flush toilets at a cost of $300 per house or approximately $9,660. This is comparable to purchasing a perpetual water right at a price of $9,660 per acre-foot. Given a goal to augment the supply by 1,000 acre-feet per year, the cost to achieve using a toilet retrofit program is approximately $9,660,000.

Water Rights Acquisition

As noted in the previous section, we estimate a market price of Colorado River water rights at $5,000 per acre-foot. However, this is solely an acquisition cost. There are likely annual costs associated with wheeling the water through the CAP Canal to the Tucson AMA. For the purpose of this analysis, we assume the wheeling rate is the same as the 2010 price of Excess CAP or $133 per acre-foot and that it escalates at 3% each year. The net present value of the wheeling charges on 1,000 acre-feet over a 20-year period is approximately $1.7 million. This adds to the initial acquisition charge for an apples-to-apples comparison. Therefore, the acquisition cost for 1,000 acre-feet is $5,000,000 (at $5,000/acre-foot), and the net present value of annual wheeling charges is $1,700,000. Total cost to acquire 1,000 acre-feet of Colorado River water rights using these assumptions is estimated at $6,700,000 or $6,700 per acre-foot.

It is important to note this simple analysis does not include any environmental externalities from transfer of supplies, because we assume this is an existing/developed supply. That is, the 1,000 acre-feet will be used annually in agriculture or transferred to another user and therefore no new environmental impacts arise with the proposed transfer. We also assume that only the consumptive use component of the water right is transferable. Therefore, any return flows historically contributed back to the river system remain "in the river." For

[9] Source: ADWR Tucson AMA Third Management Plan.

example, the farmer may have rights to 1,500 acre-feet per year, but only 1,000 acre-feet per year are consumed in crop production and the other 500 acre-feet per year are returned to the river. To net 1,000 acre-feet per year, the buyer must actually purchase a 1,500 acre-foot per year right. The acquisition scenario described above accounts for this policy limitation on the proposed transfer. This is an example of internalizing environmental externalities in a water rights transfer policy. There may also be economic externalities experienced by the region from which the water right's use transferred (i.e. basin of origin). The hypothetical market transaction described above does not account for these economic externalities or losses potentially experienced by the agricultural region in question.

Other Considerations

The above analysis indicates that it may be more cost-effective to acquire water rights than to invest in a toilet rebate program. While there a number of other costs and benefits, as well as different analytic methods available, this example demonstrates the usefulness of economic analysis to inform water policy decisions. There are a number of other "non-economic" factors to consider in this debate.

Conservation measures are distinguished by whether or not they target a consumptive or non-consumptive use. For example, water used indoors is sent to a water reclamation facility where it is treated and available for reuse. Indoor water use is a "non-consumptive use." Consequently, water "saved" in a toilet rebate program does not result in a net resource gain or true supply augmentation, because all water used indoors is reusable. This fact may prompt the utility to evaluate conservation measures that target outdoor uses that are in fact consumptive. For example, measures that reduce the amount of outdoor irrigation such as turf-removal programs may be preferred because they reduce consumptive use and achieve net resource gains.

Second, the cost of conservation or efficiency measures goes down over time, while the cost of water rights continues to climb with rising demand across multiple sectors. For example, the cost of high-efficiency toilets and efficient irrigation controls has reduced dramatically in recent years and will likely continue to drop. Assuming water rights will be more expensive over time with rising demand over finite fresh water supplies and conservation measures will become more affordable over the same time horizon, then a utility may want to consider acquiring new supplies now and investing in conservation later.

Third, conservation measures like toilets, cisterns, irrigation controls, etc have a useful life. The useful life of a conservation measure compares to the fact that water rights acquisitions (not lease) are a perpetual entitlement for use of the resource. Similarly, the utility would likely weigh the reliability of the water entitlement, understanding the probability and degree of curtailment in times of shortage due to the right's priority relative to other rights holders.

Finally, the utility may evaluate the difficulty to demonstrate "conserved water" as an acceptable water supply augmentation strategy with applicable regulatory agencies such as ADWR. That is, when water rights are purchased, they are easily added to the provider's supply portfolio in a Modification of Designation of Assured Water Supply. Demonstrating conserved water as a reliable supply may prove more difficult, possibly requiring a multi-year trend with reduced water usage directly resulting from the conservation measure.

IV. Recommendations

1. Recognize water as an economic resource with value in all its competing uses.

2. Establish policy declaring economic efficiency as the central criterion in water management decisions.

3. Establish policy requiring economic analysis methods, principles, and instruments to establish baseline facts that inform decision-makers of the welfare implications or net benefits of various policy alternatives.

4. Structure community dialogue around the common language or numeraire of money to allow expression and comparison of diverse values in the same analytic framework, and rationalize debate.

5. Evaluate past, current, and future policy decisions such as the Conservation Effluent Pool, Conservation Programs, and Water-Related Ordinances using economic analysis methods and principles.

6. Support holistic appraisal of costs and benefits on a regional scale (defined as the Tucson AMA) for the purposes of this study—including the values and needs of all Tucson AMA stakeholders in a common analytic framework is required to achieve regional welfare gains.

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