IMPERIAL VALLEY WATER AND THE CONCEPT OF BENEFICIAL USE

Water rights and delivery contracts are explicitly limited by beneficial use. The Bureau of Reclamation in its March 18, 2003 brief for IID v. U.S. et. al. (on page 12) cites United States v. Alpine Land & Reservoir (1983) to define the term "beneficial use"

> There are two qualifications to what might be termed the general rule that water is beneficially used (in an accepted type of use such as irrigation) when it is usefully employed by the appropriator. First, the use cannot include any element of 'waste' which, among other things, precludes unreasonable transmission loss and use of cost-ineffective methods. Second, and often overlapping, the use cannot be 'unreasonable' considering alternative uses of the water.

This report examines beneficial use in the Imperial Valley in the context of this definition and related engineering and economic concepts of efficiency and waste. This report demonstrates that given available information both Imperial Valley farmers and the Imperial Irrigation District (IID) do not employ cost-ineffective methods in current water use and that administratively restricting current use and reallocating to junior rights holders based on the relative value of alternative uses of the water is counter to current Department of Interior policy, effectively eliminates water market solutions, and would thus be economically inefficient.

Efficiency Concepts

The concept of beneficial use is connected to a number of concepts of efficiency: one engineering efficiency concept—hydrological irrigation efficiency—and four economic efficiency concepts—technical efficiency, productive efficiency, allocative efficiency, and economic efficiency. After a general discussion of each concept, application of the concepts to the use of water by farmers within the Imperial Valley, to the management of water resources by IID, and to the management of Western U.S. water resources by the Bureau of Reclamation are considered in the context of beneficial use as expressed within U.S. v. Alpine.

Hydrological Irrigation Efficiency

Hydrological irrigation efficiency is defined as the ratio of hydrological beneficial use to total applied water. This concept is applicable at both the farm level and the irrigation district or basin level. In both cases, hydrological beneficial use is equated with the hydrological concept of consumptive use, which is defined as the quantity of water that is actually needed for the physical growth of the agricultural plant. This typically includes two components evapotranspiration and leaching requirements, but may also include other components dependent on the climate such as frost protection in freezing climates and crop cooling in desert climates such as IID. Plant growth inherently involves transpiration from the plant and evaporation from the soil (as well as water content in harvested plant); in combination referred to as evapotranspiration. If salinity build up in the soil is a problem for plant growth then water must be applied to leach the

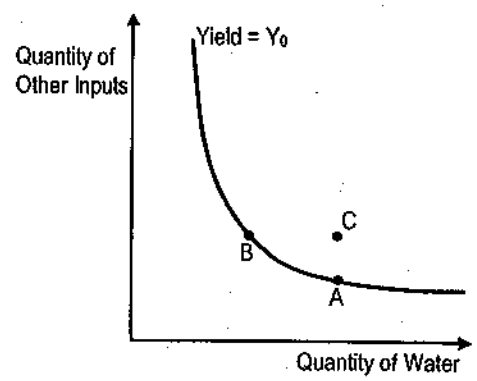
salts beyond the root zone of the plant. This type of engineering efficiency concept only considers a single key input to production.

Technological Efficiency (or Technical Efficiency)

As evidenced by the different farming methods employed around the world, the same crops can be produced with many different combinations of inputs. The economic concept of technological efficiency considers the relationship of all inputs to production. Economists represent all the technologically efficient methods of producing a specified crop yield based on current knowledge with a curve[1] as shown in Figure 1. In this case the axes are labeled to depict the relevant tradeoff under discussion between water and other inputs in the production of a certain crop yield. Other inputs include capital (including irrigation technologies), labor, fertilizer, pesticides, crop varieties, etc. Crop production is *technologically efficient* if the farmer cannot produce the current quantity of output with fewer inputs. Points A and B are both technologically efficient. While moving from A to B consumes *less* water, it also requires *more* of other inputs. To be technologically inefficient, a farmer must be able to produce the same yield using *less* water and the *same* amount of all other inputs.

The slope of the curve at any point represents the rate at which one input can be substituted for another. For example, farmers could substitute irrigation technology (capital) or increased irrigation management (labor) for water (reduced tailwater). Similar opportunities for substitution of labor and capital for water are also available within urban areas. For example, homeowners in the Metropolitan Water District (MWD) with swimming pools could substitute a pool cover (capital) and the time and effort (labor) to remove the pool cover prior to swimming and replace it after swimming for water (reduced evaporation).

Figure 1 – Crop Production Function



An input is *wasted*, if production of the same quantity of output is possible with *less* of that input and the *same* amount of other inputs. Thus point C is technologically inefficient to produce the quantity of output depicted by the curve, because the same amount of output could be produced either with less water and the same amount of other inputs (point B) or with the same amount of water and less of other inputs (point A). Therefore, even though point B uses less water than point A to produce the same amount of output, using production method A does not waste water by this measure.

Productive Efficiency

To be *productively efficient*, a farmer must choose from among the many technologically efficient options the one combination of inputs that produces the

[1] Economists call this curve an *isoquant*. In general, it may not be smooth but have kinks, if for example, there is a discrete number of available irrigation technologies.

specified crop yield at the lowest possible cost. Thus, if the price of water is low relative to the price of other inputs the farmer would choose point A, but if the price of water were to increase the farmer would substitute other inputs for water and minimize production costs at point B. This basic concept explains much of the observed farming practices around the world, for example, the labor intensive agriculture in the developing world where labor is relatively inexpensive and the capital intensive agriculture in the developed world where labor is more expensive relative to capital.

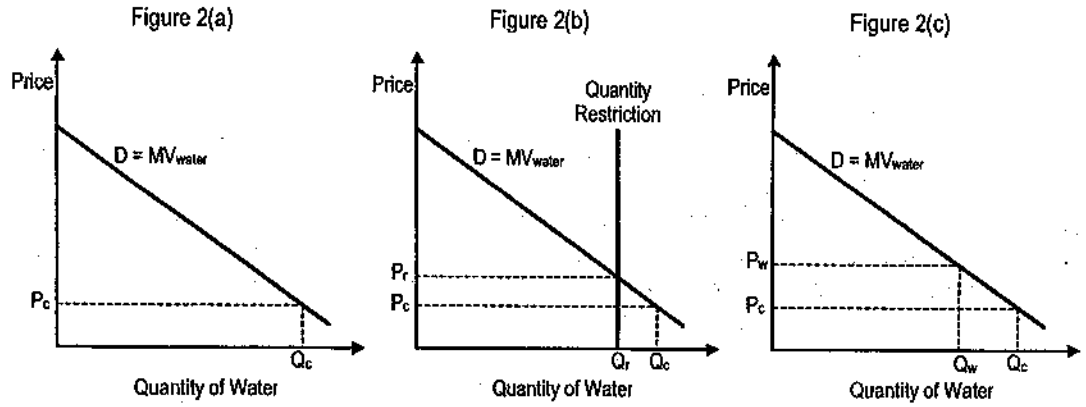
This concept is directly applicable to the evaluation of whether Imperial Valley farming practices employ "cost-ineffective methods."

Allocative Efficiency

To be *allocatively efficient* in production, a farmer must allocate productive resources, such as land, labor, capital and water, to their highest value use. This concept incorporates both the choice of crop type and the quantity to grow. In the context of water, the farmer must allocate each unit of water to that use which generates the highest marginal value[2]. This marginal value derives from two factors: the increase in output from using an additional unit of water and the value for which this increase in output can be sold.

Graphically, this concept is expressed as the farmer's demand curve for water, which is equivalent to the marginal value of water curve. The fact that the demand curve is downward sloping just indicates that the farmer allocates water to the highest value uses first and then to subsequently lower value uses. In Figure 2a, where the farmer faces a price for water of P_c, the farmer consumes Q_c units of water. Consuming more than Q_c units is not efficient because the marginal value of water in use is less than its price, and consuming less than Q_c units of water is not efficient because the marginal value of water in use is greater than its price.

Figure 2 – Agricultural Water Demand



If the quantity of water is restricted by contract to Q_r as in Figure 2b but the farmer still pays the same price for water P_c, the farmer still must choose among

[2] The economic term for this concept is the *marginal revenue product of water* or as in this case where the firm's output market is competitive the alternative term *value marginal product of water* is sometimes used.

alternative uses. A profit-maximizing farmer will allocate the limited quantity of water to the highest value uses. The full opportunity cost of using the marginal unit of water now equals P_r which is the sum of the price P_c paid for delivery and a scarcity value $P_r - P_c$, which arises from the quantity limit that forces the farmer to choose from the available opportunities for use.

If the farmer has the right to sell or lease water in a water market, then an additional option is available to the farmer. A farmer can never be worse off by having one more option to choose from because the prior choice is still available. If the farmer has a water right for quantity Q_c and the market price of water is P_w as in Figure 2c, then this price becomes the opportunity cost of using the marginal unit of water. In other words, the farmer must give up the opportunity to sell water at this price to use the water in farming. This opportunity cost becomes the effective price of water in decision making even though the farmer still pays the same lower conveyance fee P_c to the district for water delivered to the farm. In this case, the farmer will allocate Q_w units of water to agricultural production, because up to this point the marginal value of use is greater than the market price, and will allocate $Q_c - Q_w$ units to be traded on the water market since the farmer's marginal value of agricultural use is below the market price. In this manner, decentralized decision making in water markets would allocate water to its highest value use.

It is also possible that agricultural acreage in production would not decrease even though water use decreases since the opportunity to sell water creates economic incentives to use water differently. First, the relative increase in the effective price of water creates an economic incentive to substitute other inputs for water on all crops illustrated by a movement from A to B in Figure 1. Before markets, only water conservation methods with a cost per AF of water conserved below the price of water P_c would be cost effective and lead to higher profits. Now with markets, water conservation methods with a cost per AF of water conserved above the district delivery price P_c and below the higher market price of water P_w become cost effective because a farmer could sell one unit of water at P_w and pay the cost of the conservation method for a net gain while still growing the same crop. Second, the opportunity to sell water creates an opportunity to replace high water using crops with less profitable low water using crops and more than make up the difference by selling water for a net gain. A simple numerical example illustrates this concept. Suppose on an acre of land with a water right of 2 AF, a farmer has the choice of growing crop A which uses 2 AF and earns a profit of $200 or growing crop B which uses 1 AF and earns a profit of $150. Without a water market the farmer will grow crop A and earn the maximum $200. Now suppose a water market develops and the farmer can sell water for $100 per AF. The farmer can still grow crop A and earn $200; or the farmer could use 1 AF to grow crop B earning $150 and sell 1 AF for $100 for a total profit of $250; or the farmer could fallow the land and sell 2 AF of water for $200. With the water market, the farmer grows crop B for the maximum profit of $250, earns more than without the water market, and no land in fallowed.

Economic efficiency

Economic efficiency in production requires all three preceding economic concepts of efficiency: technical efficiency, productive efficiency, and allocative efficiency. In fact, each subsequent economic concept of efficiency subsumes the previous concepts

(i.e. productive efficiency requires technical efficiency, allocative efficiency requires both technical efficiency and productive efficiency).

In practice, the planning decisions by farmers are more complex than indicated in the above discussion due to the inherent uncertainty in future crop and input prices, nature (weather, pests, etc.), and the future regulatory environment.

Application of Efficiency Concepts to Imperial Valley Farmers

All available evidence indicates that Imperial Valley farmers are not using cost ineffective methods of water use given the price of water that they face.

Confusion often arises when both engineers and economists are involved in the same decision-making process. Hydrological irrigation efficiency only considers a single input, whereas productive efficiency considers all inputs in the determination of the least cost method of production. Therefore, improving hydrological irrigation efficiency can be cost ineffective if the substitution of other inputs for water raises production costs for the same quantity of output. Productive efficiency is the appropriate method to examine whether farmers are using cost ineffective methods with respect to water applications.

For example, installing drip irrigation systems throughout the Imperial Valley would improve irrigation efficiency but would not be the least cost method to produce the current mix of crops and therefore would be highly productively inefficient.

The only evidence presented by Bureau of Reclamation representatives concerning possible cost effective methods of reducing on-farm water use is found in the declaration of Robert W. Johnson, the Regional Director of the Lower Colorado Region of the Bureau of Reclamation for the March 18, 2003 hearing in IID v. USA et. al. Johnson makes repeated claims (in paragraphs 25, 28, and 35) that on-farm tailwater runoff could be reduced to as little as 2 percent of applied water. Paragraph 35 discusses the issue:

> ...More intensive use of full-time irrigators to manage the flow of water on farms in IID could result in reduced tailwater runoff which is lost to further beneficial use. The full-time irrigator can employ an early cutoff strategy when irrigating alfalfa. Such a strategy has been demonstrated by University of California researchers at the Holtville station as being very beneficial in reducing tailwater. AR V:186:3049. Water losses from the field can be reduced to less than 2% with little impact upon yield. The Reclamation Regional Economist on my staff has demonstrated to me that on alfalfa alone, employment of such a strategy could reduce on-farm water needs district wide by over 250,000 acre feet a year with the net cost to the farmer estimated to be about $25 per acre. Alternatively, reduced late summer irrigation of alfalfa could result in lowering on-farm water needs by over 200,000 AF. The Regional Economist on my staff has demonstrated to me that, based on his analysis of the University of California 1999 study, the net cost to the farmer is estimated to be about $36 per acre for added labor and reduced yields, and would save about one acre foot of water per acre.

Ignoring for the moment that the University of California researchers state in the referenced report that "Additional work is needed to verify the applicability of this method to commercial fields and under conditions where irrigation water deliveries are set for either 12 or 24-hour orders as is common in the Imperial Valley"[3] and ignoring the impacts of water conservation on power generation and potential environmental mitigation costs, we examine whether the proposed reduction in tailwater is cost effective. Based on the last statement that a reduction of on-farm water needs by 200,000 AF would save about one AF of water per acre, we conclude that this analysis considered that approximately 200,000 acres was planted as alfalfa, which was the case in 2001 when seed alfalfa is included.

Then the first method, which reduces tailwater to 2 percent by increasing labor costs by $25 per acre for full-time irrigators, reduces water usage by 250,000 AF or 1.25 AF per acre. Now a productively efficient farmer producing at least cost must compare the cost decrease by using less water with the cost increase by using more labor. The current price of water for farmers is $16 per AF. Therefore, reducing water purchases by 1.25 AF per acre reduces the farmer's water cost by $20 per acre while simultaneously increasing labor cost by $25 per acre, resulting in net increase in cost of $5 per acre or an increase in farmer cost of $1 million for the 200,000 acres. Therefore, employing this proposed method of water conservation is cost ineffective and productively inefficient.

The second method, which reduces late summer irrigation by 200,000 AF or 1 AF per acre thus reduces water cost by $16 per acre but simultaneously increases costs by $36 per acre through increased labor and reduced yields, resulting in a net increase in costs of $20 per acre or an increase in farmer cost of $4 million for the 200,000 acres. Therefore, this proposed method of water conservation is also cost ineffective and productively inefficient.

Both of these methods become more cost ineffective than the above analysis indicates if the potential impacts on farmer costs resulting from reduced power generation and increased potential environmental mitigation costs are factored in.

All the available evidence indicates that the practices of Imperial Valley farmers are cost effective, as one would expect, since any cost ineffective practices would result in reduced net revenues (profits). One would also expect that farmers possess the most accurate knowledge about their alternative production methods. Moreover, since farmers operate as profit-making enterprises, they would willingly employ any information, method, or practice that proved to reduce cost and increase profits.

Application of Efficiency Concepts to IID Management of District Water Resources

All available evidence indicates that IID does not use cost ineffective methods or have unreasonable transmission losses given lack of quantity limits faced by their customers; in other words, all water use is satisfied down to a marginal value of $16 per AF and the cost to develop additional supplies through conservation is greater than $16/AF.

The declaration of Rodney T. Smith for the March 18, 2003 hearing in IID v. U.S.A. et. al. (on pages 54-5 of Exhibit B, see also p. 35-6) identifies the cost of reducing

[3] Khaled M. Bali, Mark E. Grismer, and Richard L. Snyder, *Irrigation and Drainage Management and Surface Runoff Reduction in the Imperial Valley Draft Final Report*, Grant Agreement No. B-80560, University of California, December 1999, p. 3.

conveyance losses of between $25 and $150 per AF for various sized projects absent power generation losses and environmental mitigation costs. Since these costs exceed $16 per AF, they are not cost effective. IID through the 1988 Water Conservation agreement with MWD has shown a willingness to invest in similar transmission loss reduction projects if the cost are subsidized by another party which renders the projects cost effective. Therefore, given the cost to deliver current water and the remaining low beneficial uses of water (i.e. below $16 per acre foot), IID does not have unreasonable transmission losses or use cost ineffective methods.

The declaration of Rodney T. Smith for the March 18, 2003 hearing in IID v. U.S.A. et. al. (on page 66 of Exhibit B) also identifies the cost of structural projects to capture tailwater without changes in farmer irrigation practices of between $124 and $245 per AF absent power generation losses and environmental mitigation costs. Since these costs also exceed $16 per AF, they are not cost effective. IID has also shown a willingness to invest in these projects in negotiations with MWD, San Diego County Water Authority (SDCWA), and Coachella Valley Water District (CVWD) if the projects are subsidized with transfer payments and potential environmental mitigation costs are considered which renders the projects cost effective. However, the cost of these projects in comparison to the potentially lower cost of tailwater reduction through changes in farmer irrigation practices discussed above point out the need for improved integration of decision-making and policy between farmers and the water district to find the most cost effective method of reducing tailwater if transfer payments make it cost effective.

Application of Efficiency Concepts to Western Water Law and U.S. Bureau of Reclamation Management of Western Water Resources

Any person just briefly acquainted with the economics of water in the Western U.S. knows that the marginal value of water use differs between urban and agricultural areas, and even varies among different urban areas and among different agricultural areas. In other words, the institutions and law that govern the allocation of water in the Western U.S. are allocatively inefficient because water is not allocated to its highest value use.

The increasing scarcity of water relative to demand over at least the last 30 years has led to extensive investigation of the best method to reform water institutions and laws to more efficiently allocate water. The one solution that has generated almost universal support is the development of water markets. Competitive markets are allocatively efficient because they allocate water based on market price. Any party that has a use for water with a marginal value above the market price will be better off by purchasing water, and any party that possesses water which they can only put to use at a marginal value below the market price will be better off selling water. Price will automatically adjust until market equilibrium is established, and the marginal value of water in all uses will be equalized (up to differences in transportation costs).

The development of water markets as the method to allocate water among private uses is the policy of the U.S. Department of the Interior: "The Secretary's [of the Interior] blueprint encourages voluntary water transfers through water banks or other water marketing tools. These include agreements that allow agricultural producers the option to rent or lease their water to cities and towns or other users in times of drought, and still

have the ability to farm in most years."[4] The Water 2025 document expressing this policy states:

> Water banks and markets are essential to avoiding crises in critical areas of the West. The use of water banks and markets is sometimes a source of concern to agricultural areas and the communities that support them. However, the Department of the Interior strongly supports the use of these mechanisms to allow water to be shifted between competing water uses because they are based on a recognition of the validity of existing rights. Water banks also avoid or reduce the conflict, crisis, and heartache that results when water uses are changed through regulatory or other means. More importantly, water banks can provide a mechanism for preserving irrigated agriculture and meeting other water supply needs.[5]

U.S. Federal Reserve Board economists support the development of markets to allocate water:

> Over the longer term, deregulated water markets could offer an automatic mechanism to solve the allocation problem in the least-cost way.[6] Given the limited amount of additional water that would be consumed by nonagricultural sources if trading were allowed, price effects on the farms cannot be large, at least on average. Small cutbacks by individual farmers would be sufficient to generate enough water to clear the market with minimal agricultural price increases. Moreover, by engaging in those transactions, the farmer would have the financial resources to invest in water-saving technologies.[7]

Congress through the Central Valley Improvement Act supports the development of water markets to reallocate water, in particular the law gives individual farmers, and not just water districts, the right to transfer water.

The development of markets to allocatate water is the primary mechanism recommended by the Congressional Budget Office for the reform of Bureau of Reclamation water supply policies. "Water markets are most effective for addressing the first objective—improving the efficiency of water allocation among private economic uses."[8]

A National Research Council Committee formed under the auspices of the National Academy of Sciences states:

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[4] U.S. Department of the Interior, Office of the Secretary, Press Release, *Denver Conference to Kick Off Consultations on Water 2025: Preventing Crises and Conflict in the West*, May 16, 2003.

[5] U.S. Department of the Interior, *Water 2025: Preventing Crises and Conflict in the West*, May 5, 2003, p. 16.

[6] Ronald H. Schmidt, Senior Economist, Federal Reserve Bank of San Francisco, :Droughts and Water Markets," *FRBSF Weekly Letter*, March 15, 1991.

[7] Ronald H. Schmidt, Senior Economist, Federal Reserve Bank of San Francisco, "Diamonds and Water: A Paradox Revisited," *FRBSF Weekly Letter*, December 4, 1992.

[8] Congressional Budget Office, *Water Use Conflicts in the West: Implications of Reforming Bureau of Reclamation's Water Supply Policies*, August 1997, p. 16.

> Water marketing has great potential to enhance the efficiency of water use. Markets respond to price signals to move resources from lower- to higher-valued uses. Markets respect existing property entitlements, and thus water rights holders set the pace of transition and receive compensation when water is transferred. Reliance on water marketing, as opposed to government subsidy and regulation, reflects a general societal belief that markets are a more effective way to allocate scarce resources to meet the twin goals of efficiency and equity. For sound reasons, water transfers will remain a central component of water policy in the next century.... This committee believes that voluntary water transfers are the single most significant tool available for responding the these new and changing water needs.[9]

The California Business Roundtable with the California Chamber of Commerce, the California Farm Bureau Federation, and the California Manufacturers Association released a report supporting water markets and voluntary water transfers based on the economic efficiency of these allocation mechanisms.[10]

Environmental groups such as the Environmental Defense Fund support the development of markets to allocate water.

More than 30 years of economic research and literature supports water markets as the most efficient means of allocating water.

Two Minimum Requirements for Functioning Water Markets

Economic efficiency dictates that the Bureau of Reclamation should pursue policies that promote the development of water markets and voluntary water transfers. Two properties of many that must exist in any functioning market in which trades take place are: 1) well-defined property rights and 2) different marginal values among market participants. First, if property rights for the good in question are not well defined, then the seller does not have the right to sell or lease the good and the buyer is uncertain of the right to maintain ownership and utilize the good after payment. Government institutions, which enforce property rights and contracts, are essential for well-functioning markets. Second, trades will only occur in markets if participants have different marginal values; those with higher marginal values purchase, those with lower marginal values sell, and both parties are better off.

Application of the Second Aspect of Beneficial Use as Defined in U.S. v. Alpine Destroys the Foundation of Water Markets

The Bureau of Reclamation in its March 18, 2003 brief for IID v. U.S. et. al. (on pages 18-19) agues that IID's water use is no longer reasonable given alternative uses:

> Interior has long taken the view that the strict application of beneficial use is fundamentally triggered by the existence of unmet demand. AR V:197:3245; see also AR X:284:6548ccc n. 25. This administrative

[9] Committee on Western Water Management, National Research Council, *Water Transfers in the West: Efficiency, Equity, and the Environment*, National Academy Press, Washington, DC, 1992, p. 3 and p. 249.
[10] California Business Roundtable, *A Model Water Transfer Act for California*, May 1996.

> practice is not only pragmatic, but exemplifies the accepted legal principle that: "What is a beneficial use at one time [e.g. IID's use under the QSA with all California demand met] may, because of changed conditions [e.g. no QSA and significant unmet demand], become a waste of water at a later time." Tulare Dist. v. Lindsay-Strathmore Irrig. Dist., 45 P.2d 972, 1007 (Cal. 1935). ...Interior must therefore consider the interests of both senior and junior priority holders within the State of California.

This argument, to quantitatively limit the water rights of Imperial Valley landowners which are held in trust by IID, appeals to the second aspect of the definition of beneficial use in U.S. v. Alpine, that "use cannot be 'unreasonable' considering alternative uses of the water". This approach claims that water rights are quantitatively undefined without reference to alternative beneficial uses.

As discussed above, the marginal value of water use differs between holders of water rights in the Western U.S. This situation is economically inefficient for the region as a whole. From an economic perspective this situation is unreasonable. By the above argument, water rights become quantitatively undefined unless all marginal values of water use are equal. Thus, the property right to water only becomes quantitatively well defined when all marginal values are equal, which is exactly the case in which no trades would occur, otherwise known as market equilibrium.

While the application of the second aspect of the definition of beneficial use in U.S. v. Alpine to a single water dispute would appear to lead to an improvement in economic efficiency, it also destroys the property rights foundation of water markets. The nearly universal support of the market mechanism of water allocation derives from its allocative and economic efficiency. Therefore, consistent application of the second aspect of the definition of beneficial use in U.S. v. Alpine is unreasonable based on the following economic inefficiency consequences.

Consistent application of this definition of beneficial use would establish the Bureau of Reclamation as the de facto market clearing mechanism. The Bureau of Reclamation would have to establish a threshold beyond which differences in the marginal value of uses was unreasonable. Then the Bureau of Reclamation would have to examine marginal values of water use throughout its system for all levels of possible use to determine the source and destination of reallocated water, since as it reallocates, at all source locations, marginal values of water use increase and, at all destinations, marginal values of water use decrease. In a dynamic economy, the marginal values of water use in different sectors continually change; therefore, the Bureau of Reclamation will have to continuously reallocate water. For example, if water is allocated away from IID and a new high value agricultural market develops in the Imperial Valley, then the Bureau of Reclamation will have to reallocate water back to IID right holders. Essentially, this argument would create a system where water is continuously administratively allocated through continuous study of the reasonableness in disparity of marginal use values. In other words, water would become a planned, centralized decision-making sector of the economy rather than a market, decentralized decision-making sector of the economy. This approach has historically been highly economically inefficient. In the long run, structuring the water allocation system in this manner is unreasonable because it would be much less efficient than a market allocation system.

Furthermore, markets continually encourage efficient innovation based on price signals of scarcity while administrative allocation continually encourage economically inefficient litigation, review by courts, and attendant high transaction costs. Uncertainty about security of long-term water rights would inhibit economically efficient long-term investment decisions. Finally, administrative allocation is also more susceptible to economically inefficient political manipulation and corruption.

The Need for Administrative Allocation for Public Uses such as the Environment

The one area where water markets will not function efficiently is with respect to public uses such as the environment. In this case, there is either no market participant expressing the value of water for public environmental uses or limited participation by environmental organizations, which will tend to lead to an under provision of water to environmental uses because of the public good nature of environmental benefits.

Therefore, there is a limited role for administrative allocation of water with respect to environmental uses. However, in this case the Bureau of Reclamation is pursuing a policy to administratively reallocate water among private economic uses, which simultaneously reallocates water away from a public environmental use prior to its determination of the future course of protection for the environmental use: "This status report makes no recommendation regarding future action relating to restoration of the Salton Sea. In fact, given that all of the alternatives identified to date are extremely expensive, it is difficult, if not impossible, to make any recommendation without a decision by Congress regarding the relative importance of the Sea in light of other pressing national priorities."[11]

Policy Recommendation Based on Economic Efficiency

The recommended policy path is clear. The Bureau of Reclamation should support the development of water markets for water trades between and within water districts by both individual right holders and water districts. To achieve this goal, the Bureau of Reclamation should support policies that remove institutional barriers to market allocation rather than create additional institutional barriers. Markets will be most efficient if the water rights of all right holders are quantitatively well defined.

In the transition to water markets, there is an administrative role for protection of third party impacts. Since not all markets will open simultaneously, there is also a role for phased transitions which help the planning of water districts, such as the clause in the Central Valley Project Improvement Act that limits water trades by individual right holders without district approval to 20% of the district water contracts. Economic estimates indicate that only a small percentage of water would be transferred from agricultural to urban uses statewide in California under water markets.[12] The percentage would likely be higher in low water price agricultural districts and lower in high water

[11] U.S. Department of the Interior Bureau of Reclamation Lower Colorado Region, *Salton Sea Study Status Report*, Boulder City, Nevada, January 2003.

[12] Henry Vaux Jr. and Richard E. Howitt, "Managing Water Scarcity: An Evaluation of Interregional Transfers," *Water Resources Research*, 1984, volume 20, p. 785-792.

price agricultural districts. One estimate places equilibrium water price at $57 in 1992 dollars.[13]

To generate all the economic efficiencies of water markets, the one factor that cannot be sacrificed is the exposure of farmers to the opportunity cost of water in alternative uses both within the district and outside the district. District policies that shield individual right holders from these opportunity costs will not achieve the efficiency gains created by the economic incentives to conserve water both by substitution of other inputs for water and by innovation of new farming methods. Therefore, the Bureau of Reclamation should support policies that convey economic incentives through water district organizational structure and policies to the individual right holders to achieve the highest economic efficiencies. The most straightforward method of achieving this goal is to quantitatively define individual landowner water rights and to permit temporary and permanent trades of the water covered by these property rights.

Organizational Structure of IID May Be Economically Inefficient

The IID organizational structure appears to need restructuring to achieve economic efficiency.

One source of apparent inefficiency is what economists call the principal-agent problem. The foundation of the IID organization is the Imperial Valley water rights. Since IID holds the water rights in trust for the landowners, IID acts as an agent for the principal owner of the water rights, the landowners. The principal-agent problem of economic inefficiency arises when the agents act in their own interest and not in the best interest of the principal. In other words, the agent does not manage the property (water right) in the best interest of the owners of the property. Solutions to this problem try to structure organizational incentives for the agents that align with the interests of the principal.

The very structure of the IID trust raises serious concerns in this regard. First, IID directors and management do not serve at the behest of the property right holders but at the behest of the Imperial County electorate. This structure creates significant divergences in principal and agent interests. The electorate includes many groups with potentially divergent interests: owners of the water rights, IID directors, IID employees, IID water customers, and IID electricity customers. This structure needs to be examined more closely to assess the extent of this economic inefficiency. In this vein, IID as the agent for the landowners should provide all necessary data to landowners to undertake an examination of the efficiency of the business and operational practices of IID.

Current Policy Being Developed by IID for Conservation is Economically Inefficient

The current policy being developed by IID to meet the conservation requirements of the QSA for water transfers to SDCWA, MWD, and CVWD are economically inefficient. These comments are preliminary and may require revision as the conservation implementation program becomes more fully defined.

First, by independently guaranteeing the quantity of conservation for transfer, IID shields the farmers from the opportunity cost of water including any economic incentive

[13] Ronald H. Schmidt and Frederick Cannon, *Using Water Better: A Market-Based Approach for California's Water Crisis*, Bay Area Economic Forum, October 1991.

to conserve based on this opportunity cost. Moreover, this establishes IID as the sole buyer (monopsonist) of conservation reductions from landowners, and thus IID has the market power to garner the lion's share of the gains from trade derived from the landowners' property rights. Given the divergent interests of IID director constituency groups, the ultimate destination of the gains from trade is unknown, and is likely to be economically inefficient based on the principal-agent problem discussed above.

Second, economic efficiency dictates that the farmers in combination with IID should conserve the target quantity of water in the least-cost manner. If water is not conserved in the least cost manner, then the gains from trade, which is the difference between the price received (derived from urban district demand) and the cost to produce conserved water, are not maximized which diminishes the value of the water property right from which the trade derived.

Any method of conservation for transfer of a specific quantity will reduce hydropower generation by the same amount. However, different methods of conservation will have different effects on Salton Sea inflows and the attendant risk of environmental mitigation costs. As a baseline assessment, assume the risk of environmental costs can be mitigated through risk bearing by other agencies. While this may not occur any time soon, the fallowing policy is a transparent attempt to maintain some level of in-stream flows. It would be more economically efficient to make a determination of in-stream flow requirements if a long-term managed ecosystem is desirable, and then allow farmers and the district the flexibility to achieve conservation and in-stream flows in the least cost manner.

This least-cost manner may not include fallowing and the attendant reduction in the productivity of the agricultural sector in the Imperial Valley. However, fallowing serves as a useful reference point for comparison of the economic efficiency of different methods of water conservation for transfer. Current agricultural land rental values in the Imperial Valley are in the neighborhood of $125 to $225 per acre and include the right to take delivery of water from IID at $16 per AF. As a rough estimate, renting the land and fallowing it would result in a water conservation cost of $25 to $35 per AF conserved. If IID's total operation costs do not vary with the level of water delivery reductions contemplated, then the lost revenues of $16 per AF should also be included in the water conservation cost yielding $41 to $51 per AF conserved. Notice that these values are not much less than the estimated market-clearing price for water of $57 for fully developed water markets within California. This additional $25 to $35 per AF is a reflection of the marginal value of water use in agriculture within IID to the economy as a whole, because if the right to use water were not bundled with the right to use land, land rents would drop precipitously as the opportunity cost of land use without water is very low. However, for this opportunity cost to affect farmers' marginal use of water decisions requires both quantification of water allocation to the land and the right to sell or lease water beyond the boundaries of IID because demand is already satisfied down to a marginal value of $16 per AF within IID.

In any case, assume a central value of $46 per AF as the cost of water conservation through fallowing. Using this as a benchmark, any conservation program that costs less than this amount per AF should take place before fallowing is considered, and any conservation program that costs more than this amount per AF is economically inefficient under transfer payments and wastefully diminishes the property value of the

water right. Therefore, the only system improvement that is a potentially economically efficient form of water conservation with transfer payments is the East Highline seepage recovery project with an annual yield of 20,000 AF at a cost of $25 per AF[14]. All other system improvement projects cost more than $80 per AF, much more than fallowing and therefore diminish the value of the water property rights of landowners.

Since water conservation from IID identified structural tailwater recovery projects costs between $124 and $245 per AF[15], these projects are economically inefficient in comparison to $46 AF for fallowing and therefore diminish the value of the water property rights of landowners. As an analogy to the type of argument put forward by proponents of these projects with costs up to $150 AF necessary to achieve the current specified 103,000 AF system conservation target, consider the case of a landlord that offers a local businessperson an office rental for $460 per month. The businessperson replies that he would rather pay $1500 for the office because that will generate more jobs in the real estate sector. That's bad business. The market should allocate society's scarce resources for private investment creating jobs in the sectors that are most productive at the margin. If agriculture is only generating output at the margin that the market values at $46 per AF of water allocated, it is economically inefficient to invest $150 per AF to achieve the same ends; the difference between $150 and $46 would be better invested in another sector of the local economy creating jobs in that sector.

This is not a recommendation to fallow land. Rather, it is a recommendation to let the farmer face the opportunity cost of using water through water markets, and then choose the least-cost means of achieving the conservation target. This will preserve the highest value for the water property right. The opportunity to sell or lease water creates economic incentives to use water differently. With the opportunity to sell some water, changes in irrigation technology and water management practices that were unprofitable become profitable. The University of California study referenced above indicates that on-farm conservation may be able to generate water conservation in the neighborhood of $20 to $36 per AF. When conserving an AF only saves the $16 water delivery charge these methods are unprofitable, but when the opportunity cost of using water is higher because it can be traded, these methods are profitable. And they are more profitable than fallowing marginal land at $46 AF. These methods would also substitute labor for water and thus would increase agricultural employment. Therefore, this would be a preferred alternative to fallowing at $46 per AF because it would be least cost, preserve the value of water property rights, and increase employment. Farmers have the best knowledge on the feasibility of these methods and facing the opportunity cost of water through water markets creates the economic incentive to pursue these and other options that may substitute capital equipment for water and increase sales in the farm equipment sector. If the opportunities differ for on-farm conservation within IID due to different soil qualities or other factors, it will be important to establish an intra-district water market to reallocate water within the District to its highest value use in order to receive the highest net returns available for all farmers.

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[14] Declaration of Rodney T. Smith for the March 18, 2003 hearing in IID v. U.S.A. et. al., p. 54-5 and p. 35-6 of Exhibit B.

[15] Declaration of Rodney T. Smith for the March 18, 2003 hearing in IID v. U.S.A. et. al., p. 66 of Exhibit B.

Finally, the opportunity to sell or lease water creates an opportunity to replace high water using crops with less profitable low water using crops and more than make up the difference by selling the extra water for a net gain (see illustrative example above on page 4). The potential crop-switching opportunities for water conservation are unexplored by IID because farmers choose the crops to grow not IID. Many opportunities may be available that are profitable resulting in little or no fallowed land.

Perhaps, some land may initially be fallowed after the transfer, but then come back into production as farmers experiment to find changes in irrigation technology and water management practices that are profitable when the conserved water can be sold or experiment with lower water using crops that jointly with sale of conserved water are more profitable than fallowing land. This approach would require close cooperation between IID and farmers to jointly choose the portfolio of least cost conservation options from among the system options available to IID and the farming practice options available to farmers.

Conclusion

The crux of the appearance of water waste within IID to outsiders derives mostly from three facts: 1) the desert climate requires high evapotranspiration for plant growth, 2) the high salinity of Colorado River water requires high quantities of leaching water, and 3) the economic price of water that IID farmers face is a low $16 AF.

Careful consideration of these factors prior to the initiation of transfer payments reveal that given the climate, water salinity, and the historical water rights and water institutions and law which result in a current cost of water of $16 per AF, both the IID and individual farmers respond to these physical and economic signals and make cost effective water use, development, and conservation decisions accordingly. In a market system, price reflects the scarcity of a good relative to demand for the good. The allocative inefficiencies of Western U.S. water law and institutions create different water prices throughout the West sending unequal signals as to the scarcity of water. The economically efficient solution to this problem is to reform water law and institutions to support market allocation of private economic uses of water while developing efficient mechanisms to administratively allocate water to public uses and to mitigate third party impacts.

However, under pending transfer payments from SDCWA, MWD, and CVWD, IID's proposed methods of water conservation are cost effective (payment greater than cost) but not economically efficient (not the least-cost method). The proposed policies would diminish the value of landowner's water property rights.

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EDUCATION

Ph.D. Agricultural & Resource Economics, University of California, Berkeley, 1999
M.A. Economics, University of Colorado, Boulder, 1990
B.A. Physics and Applied Mathematics, University of California, Berkeley, 1984

RESEARCH EXPERIENCE

Visiting Assistant Professor, Department of Economics, State University of New York, Fredonia. Economic and policy research projects: 1) dynamic optimization model for groundwater extraction from a confined aquifer with seawater intrusion, 2) climate change policy under uncertainty, and 3) investment under market and regulation uncertainty in the U.S. electric sector with particular focus on carbon sequestration, multi-gas regulation, and induced technological change, 2001-present.

Post-doctoral researcher, Center for the Integrated Study of the Human Dimensions of Global Change, Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, Pennsylvania. Economic and policy research projects: 1) development of a Monte Carlo dynamic optimization technique applicable to trend uncertainty (as opposed to noise) to examine climate change policy under uncertainty, 2) an analysis of the change in optimal sizing of dam spillways over the last century including an examination of the relative importance of changing precipitation distributions, upstream changes in watershed land use, and downstream development within the flood plain, and 3) a project to model investment in the U.S. electric sector under both market and regulation uncertainty with particular focus on carbon sequestration, multi-gas regulation, and induced technological change, 1999-2001.

Economic research consultant for Maloney Law Offices, Alameda, CA. Responsible for all economic analysis of seawater intrusion and reservoir operations issues in conjunction with a finite element integrated ground and surface water model for the Salinas Valley: 1) review and analysis of proposed project plan, environmental impact reports, historical reservoir benefits analysis; 2) developed distribution of historical tax burdens and alternative assessment proposals, 3) work with hydrological engineer to model geographical effects of ground water pumping and historical causes of seawater intrusion, 4) attend water agency public meetings including stakeholders meetings to develop regional cost allocation for proposed project, and 5) trial support on validation of assessments, 1997-2002.

Graduate Student Researcher with Professor Michael Hanemann, Department of Agricultural and Resource Economics, University of California at Berkeley. Analysis of Positive Mathematical Programming method and its application to federal water policy in the California Central Valley, 1995-96.

Graduate Student Researcher with Professor Anthony Fisher, Department of Agricultural and Resource Economics, University of California at Berkeley. Economic analysis of structural and non-structural policy response options of a large metropolitan water district to the prospect of drought 1991-95.

Program director, natural resource/environmental economist, and policy specialist for national park development projects in Russia, Tajikistan, and Uzbekistan in conjunction with host universities or academy of sciences. Responsible for the development of projects, including initial project conception, negotiation of cooperation agreement, planning, coordination in the field, and preparation of final scientific report including economic assessment of park. These projects team scientists, park specialists, government officials, and students from both the host country and the U. S. providing an international forum to exchange ideas, methods, and experiences, Service Adventures, Denver CO, 1992-94.

Aerospace engineer responsible for research, design, development, and testing of space science experiments for NASA. Projects: Nondestructive Cosmic Dust Collector for space station, Net Flux Radiometer for Galileo Mission to Jupiter, CCD Imaging Spectrometer for Advanced X-ray Astrophysics Facility, Shuttle Electro-dynamic Tethered Satellite Experiment for space shuttle, Microgravity Particle Research Facility for space station. Payloads, Sensors, and Instruments section of Martin Marietta Astronautics, Denver CO, 1984-88.

ANALYSIS SKILLS

Natural Resource Economics, Environmental Economics, Cost-Benefit Analysis, Microeconomic Theory, Managerial Economics, Welfare Economics, Engineering Economics, Mathematical Economics, Econometrics, Water Resource Economics. Industrial Engineering and Operations Research, Dynamic Programming, Decision Analysis.

INTERDISCIPLINARY SKILLS

Strong scientific and engineering background with ability to foster effective communication between economists, scientists, and engineers.

COMPUTER SKILLS

GAMS, Matlab, Mathematica, Fortran, C, Microsoft Office. Unix, PC, Apple.

AWARDS

University of California Regents Fellowship 1991-92 (received after nomination by department)
Hilgard Scholarship 1991-92

DISSERTATION

Title: "Betting with the Planet: Uncertainty and Global Warming Policy"
Committee: Anthony Fisher (chair), Michael Hanemann, John Harte

PUBLICATIONS

Fisher, A. C., D. Fullerton, N. Hatch, P. Reinelt, "Alternatives for Managing Drought: A Comparative Cost Analysis," Journal of Environmental Economics and Management, Vol. 29, No. 3, November 1995.

Reinelt, P., Miller, J. and Clark, B., NASA contract study "Comets/Asteroids Chemical Composition, Volume 2: Nondestructive Cosmic Dust Collector," December 1987, (188 pages, NASw-3656).

PAPERS UNDER REVIEW

Reinelt, Peter, "Dynamic Optimization with Uncertain Trend Parameters, a Numerical Solution," Journal of Economic Dynamics and Control.

Reinelt, Peter, "Seawater Intrusion and the Dynamic Optimization of Groundwater Resources in a Confined Aquifer," Journal of Environmental Economics and Management.

PROFESSIONAL PRESENTATIONS

"Seawater Intrusion and the Dynamic Optimization of Groundwater Resources in a Confined Aquifer," March 2003, Minnesota State University, Mankato, Minnesota.

"Water Policy and the Political Economy of Water without Economists: Seventy Years of Seawater Intrusion into the Aquifers of Monterey County," June 2002, Second World Congress of Environmental and Resource Economists, Monterey, California.

"Betting with the Planet: Uncertain Knowledge and Global Warming Policy"
May 2001, Department of Economics, Clarkson University.
May 2001, Department of Engineering and Public Policy, Carnegie Mellon University.
May 2001, Department of Economics, University of Massachusetts, Lowell.

"The Weaknesses of Standard Utility Formulations to Cope with the Time-Correlated Uncertainties of Global Warming," July 2000, Annual Meeting of the Center for the Integrated Study of the Human Dimension of Global Change, Pittsburgh, Pennsylvania.

"Betting with DICE: Optimal Policy and Parametric Uncertainty Representations in the DICE model," September 1999, Department of Engineering and Public Policy, Carnegie Mellon University.

RESEARCH IN PROGRESS, WORKING PAPERS, AND REPORTS

Reinelt, Peter, "Dam Safety over the Century: An Analysis of Optimal Spillway Sizing under Changing Climate and Land Use," 2001.

Reinelt, Peter, "Economic Analysis and Review of the Claims of Regional 'Rough Proportionality' of Benefits from the Reservoir Projects in Zones 2 and 2A of the Salinas Valley," 2001.

Reinelt, Peter, "The Political Economy of Salinas Valley Water," 2001

Reinelt, Peter, "Risk Aversion and Dynamic Trend Uncertainty," 2001.

Reinelt, Peter "The Precautionary Principle: A Bounded Rationality Expression of Global Sustainability" 2001.

Reinelt, Peter, "Betting with DICE: The Policy Implications of Parametric Uncertainty Representations" 2000.

Thompson, J., Reinelt P., "Scientific Project Report and Management Recommendations, Ugam-Chatkalsky National Park, Uzbekistan," 1994.

Fisher, A. C., D. Fullerton, N. Hatch, P. Reinelt, "Optimal Response to Periodic Shortage: Engineering/ Economic Analysis for a Large Urban Water District," Giannini Foundation working paper no. 629, November, 1992.

Reinelt, Peter, "A Study of the Economics of Shirkent Natural-Historical Park of Tajikistan," November, 1992.

Reinelt, Peter, "A Preliminary Study of the Optimal Inventory of Water in a Reservoir System with Stochastic Inflows," December, 1991.

LANGUAGES

French, Russian

PROFESSIONAL ACTIVITIES

Member, Association of Environmental and Resource Economists.