ECONOMIC NONMARKET VALUATION OF INSTREAM FLOWS

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This paper presents the results of a literature review on the economic valuation of instream flow from the perspective of recreation and nonuse values. In addition to an economic theory discussion focusing on water allocation and recreation, a methodology section describes the results of studies using the travel cost, contingent valuation, and contingent behavior approaches.

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by

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UNITED STATES DEPARTMENT OF INTERIOR BUREAU OF RECLAMATION

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1.0 INTRODUCTION

Most U.S. Bureau of Reclamation (Reclamation) water resource studies require some form of economic analysis to justify proposed actions. Planning studies, environmental impact documents, safety of dams evaluations, etc., all generally involve economic review.

To conduct the required analyses, economic values need to be estimated for all the benefits and costs associated with each proposed project. Impacted water uses requiring valuation typically include not only the traditional off-stream uses, such as agriculture and municipal and industrial (M&I) needs, but also the broad range of instream uses. Traditional instream uses, such as hydropower and navigation, have been a standard component of most water based economic analyses. In recent years, valuation of some of the more nontraditional uses of water, such as recreation, water quality, and nonuse values, have been included in the analyses.

The objective of this document is to describe how economic analysis can be applied in the allocation of water among competing off-stream and instream uses. (Chapter 2 presents information on the economic theory of water allocation.) Specifically, the primary issue addressed is that of valuing instream flows. Data and methods for valuing traditional off-stream and instream uses are readily available and generally lacking in controversy, given that these goods and services are exchanged within a market setting. As a result, the emphasis of this document is placed on the more difficult and controversial estimation of nonmarketed instream flow benefits related to recreation and nonuse valuation. While the valuation of recreation is a well accepted concept, nonuse valuation is still controversial. Nonuse values refer to society's willingness to pay (WTP) to preserve a resource even when the resource may never be used.

The recreation component of economic studies has become increasingly important over time. Early Reclamation projects didn't even include recreation as a project purpose; today, recreation impacts constitute a core element of virtually any analysis. The need to value changes in recreation activity has increased with the level of recreation use of Reclamation facilities. Fortunately, over the past 30 years, the economic community has conducted a great deal of research in the areas of recreation visitation and valuation (chapter 2 presents information on the economic theory of recreation valuation.)

The U.S. Water Resource Council's "Economic and Environmental Principles and Guidelines (P&Gs) for Water and Related Land Resources Implementation Studies" (WRC, 1983) provides a reasonably detailed, although dated, discussion of several approaches available for estimating recreation use values. Given that nonuse value concepts were fairly new at the time the P&Gs were written, they were not mentioned in the guidelines. While nonuse values are well accepted in theory by the economics community, they are being accepted only slowly by non-economists. Further controversy exists because of the lively debate within the economics community as to the validity of the approach and accuracy of the estimates used to measure nonuse values. Validation of the concept and measurement of nonuse values by a panel of economic experts for use in environmental damage assessments has increased the attention placed on nonuse valuation.

Since neither recreation nor nonuse values can be estimated from market data, nonmarket valuation approaches have been developed. The P&Gs describe three nonmarket approaches for valuing recreation: (1) travel cost method (TCM), (2) contingent valuation method (CVM), and (3) unit day value method (UDV). Since the UDV approach is fairly arbitrary and seldom used, it will not be discussed in this paper. Chapter 3 presents information on valuation methodologies, and Chapter 4 presents a table showing the results of the studies reviewed for this paper.

2.0 ECONOMIC THEORY OF INSTREAM FLOW VALUATION

The following sections describe the economic theory behind instream flow valuation. The first section discusses how economics could be used in making water allocation decisions. The second section describes the economic theory behind valuing recreation, one the primary instream flow uses.

2.1 Water Allocation Theory:

Instream flow uses are many and varied, as are offstream uses of water. Instream uses of water include recreation, aesthetics, water quality, hydropower, navigation, and fish and wildlife habitat. In addition, the general public may experience nonuse values, also referred to as passive use or intrinsic values, associated with simply knowing the river exists in a relatively pristine state (preservation or existence values) or that the river will be preserved for future generations to experience (bequest values).

Conflicts or competition over use of water exist since off-stream uses often preclude instream uses and vice versa. However, mutually exclusive or competitive use of water may be a characteristic only during certain times of the year. For example, a reduction in excessive snowmelt based instream flows could provide complementary benefits both to recreation and irrigation during the spring months because upstream agricultural diversions may reduce excessive spring runoff to acceptable levels for recreation. Conversely, upstream agricultural diversions could become competitive with recreational instream flow needs later in the season when early summer flows become too low for recreation. Finally, still later in the year, increased instream flows may benefit recreation without adversely affecting agriculture once irrigation has ceased for the year. Obviously, the upstream/downstream location of instream needs and off-stream diversions is critical to determining the nature of the competitive/complementary relationship. This static, within-year perspective fails to account for long-term intertemporal needs of the various uses as created by the ability to store water within reservoirs.

Focusing purely on instream uses, again both complementary and competitive situations can arise if requirements for timing and magnitude of flows vary between the different instream uses. Even within the context of recreation, uses of the water may vary depending on the activity or location. For example, high river flows for rafting and kayaking may conflict with more moderate flows for fishing, or instream flows for river recreation may reduce reservoir water levels for lake recreation. Finally, instream flow needs even for the same in-river recreation activity may vary along different stretches of the same river as a result of changing physical characteristics - preferred flows for rafting within a narrow canyon would differ from those within a wide floodplain. When water uses become competitive, decisions must be made regarding water allocation. The allocation of water within a competitive situation is a critical policy question driving the need to value instream flow uses.

Competition for water within a river basin implies water scarcity, where demand exceeds the supply, and often results in an over-appropriation situation where the sum of the water rights exceed the amount of water in the system in a given year. If demand did not exceed supply, water allocation would be unnecessary because additional users could tap the unused water without adversely affecting other users. From an economics perspective, such a situation reflects a Pareto Optimal solution. Since excess water supply is typically not the case, especially in the arid West, economists apply a compensation principle to Pareto Optimality by assuming an economically efficient solution would arise if those benefiting from an action could hypothetically compensate the losers and still be better off.

Economic theory provides a framework for achieving optimal allocations of water between competing user groups. One of the primary advantages of an economic analysis is that impacts across all affected parties are measured commensurately in dollar terms. As a result, once values are estimated, comparisons across competing uses can be easily made. To obtain the maximum economic benefit to society, water should be allocated among competing uses until the marginal values, or values associated with the next unit consumed, equate for each use. Alternatively stated, the optimal allocation is achieved at the point where the marginal benefits associated with the additional instream flow equal the marginal opportunity costs of obtaining the flow.

As represented in figure 1, the curve TB reflects the total instream flow benefits to society, as aggregated across individuals and businesses, for the various levels of instream flow. Curve MB reflects the aggregated marginal instream flow benefits to society for each of the various levels of instream flow. The TC and MC curves reflect the total and marginal cost to society of providing the various levels of instream flow. The primary component of the cost curves is the opportunity costs forgone in providing the instream flows, although certain fixed costs associated with dam reoperation may arise. The opportunity costs are measured by the sum of the benefits lost to agriculture, M&I, etc. The optimal allocation of water between instream flow and off-stream use occurs at point F^*, where the marginal benefits of instream flow equate with the marginal costs. This point is analogous to the point where the marginal benefits of all potential uses of the water equate. Obviously, the point of optimal allocation (F^*) implies instream flows below those associated with the maximum possible instream flow benefit (F_1).

Although there may be certain legal and practical difficulties involved in achieving economically optimal solutions, the basic economic concept of allocating water toward those uses with the highest marginal benefit can also be applied in moving toward more optimal solutions. The concept of moving toward a more optimal allocation is perhaps even more useful than actually knowing when one is at an optimum. This is the case because it is unlikely an optimum would ever be achieved, and even if achieved, maintaining the optimal allocation would be difficult because values are constantly changing with fluctuating demand. This characteristic of an unstable optimum creates the need for periodic reviews of water allocation decisions.

The problem with attempting to apply the marginal rule of allocating the next unit of water to its highest valued use is that water allocation decisions are not made on a marginal unit by unit basis. Typically, one is dealing with reallocation of fairly large quantities of water among uses. In this case, the decision is not based on equating marginal values, but on achieving positive benefit-cost comparisons. To move toward a more optimal allocation, the incremental benefits associated with the increased water uses should exceed the incremental operational and opportunity costs associated with the decreased water uses. Therefore, additional recreation and hydropower benefits associated with an increase in stream flow would need to exceed the incremental construction/operational costs to pass the flow (e.g., possible dam modifications) and the opportunity costs of lost offstream uses (e.g., lost agricultural and M&I benefits).

In attempting to measure values for all the potentially impacted uses, both producer and consumer benefits and losses should be analyzed. In the case of measuring recreation values, producer profits generated by guide boat operations would be combined with consumer values

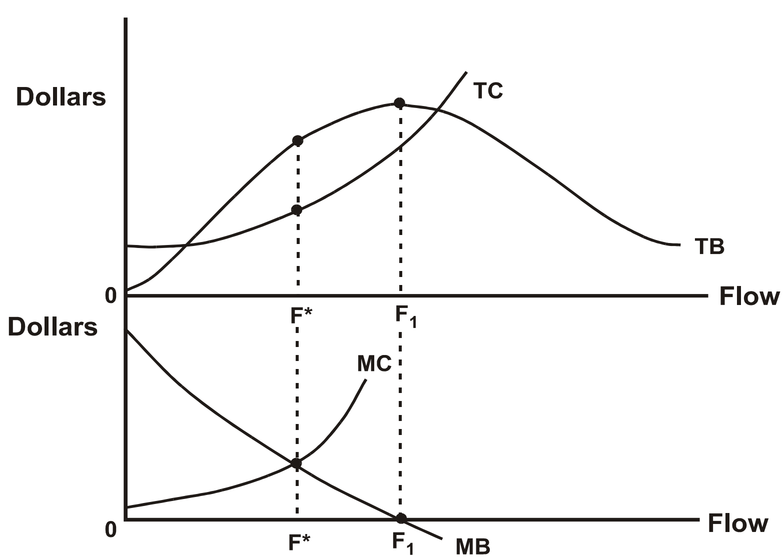

Figure 1.—Total and Marginal Benefit and Cost Curves

experienced by recreators[1]. Similarly, industry profits in agriculture, hydropower, etc., would also be combined with consumer values. While this is theoretically the case, for many marketed goods, consumer surpluses are often deemed to be relatively minor under the assumption that market pricing typically extracts most consumer values.

In measuring possible gains or losses between the various uses of the water, one should also attempt to address substitution. Substitution refers to the transfer of activity between locations, between activities, across production methods, etc. For example, if water were allocated away from agriculture and toward instream flows, what would be the impact on agriculture? Would a certain amount of land and associated crops simply go out of production? Would industry convert to different, more efficient irrigation methods? Would industry convert to less water intensive crops, including the possibility of dryland agriculture? Would production lost along this river be compensated for by increases in production elsewhere? Conversely, if more water were allocated to agriculture and away from instream uses, would recreation activity be completely lost? Would recreators switch to different activities? Would recreators move to another reach of the river or to another river altogether?

The location substitution issue begs the question as to how geographically far reaching the substitution analysis should be? While one could theoretically argue that a broad national geographic perspective may be necessary, most water allocation decisions within a given river basin typically focus on impacts to benefits and costs experienced in-basin. According to Hansen (1986), allocating water within a river system must be done from a systemwide perspective because rivers cross state lines, and upstream use has implications for downstream use. Estimating the recreation benefits of a quantity of water should take into consideration recreation use of that water throughout the river system. Given that different reaches of a river can act as recreation substitutes (or complements), a systemwide perspective is necessary.

Most water allocation questions focus on the use of available water within a given water year (water years typically run from approximately October to September). However, given the capability to store water within reservoirs, a longer term approach may be warranted. A dynamic, inter-year analysis would move toward optimal allocations by accepting economically efficient reallocations until the discounted present value of incremental benefits equal the discounted present value of the incremental costs. One could evaluate each proposed water allocation scenario by estimating the total discounted net economic benefits through a process of summing the present value of the long term expected gains and losses across the impacted parties. A positive (negative) net economic benefit would imply that the discounted sum of gains (losses) would outweigh the discounted sum of the losses (gains). However, this inter-temporal analysis becomes much more difficult as the time horizon is extended and requires the analyst to select an appropriate discount rate for converting future benefits and costs into present values.

Marginal values for many market based uses of water such as irrigation, hydropower, and M&I are often discernible through application of readily available information on competitive market

[1] Consumer values, also referred to as consumer surplus, represent the average recreator's WTP in excess of trip costs rather than do without the experience. The same concept applies to all measures of consumer value.

prices. To estimate the marginal value for water uses not exchanged within a standard market setting, nonmarket benefit estimation approaches are applied. A primary purpose of this paper is to discuss nonmarket valuation procedures, particularly from the perspective of recreation and nonuse valuation (see chapter 3).

Difficulties arise when some of the impacted goods or services are marketed, implying a price or economic value is readily available, but other impacted goods are not marketed. In these situations, the value for nonmarketed goods, such as recreation, needs to be estimated. Difficulties in estimating nonmarket benefits often result in such benefits being ignored. As a result, water allocation decisions are often made without full economic information. The decisions are based solely on standard market based analyses. Obviously, such limited analyses can lead to misallocations of water.

Exclusive reliance on market based valuation can create problems not only by omitting nonmarket benefits, but also because of the potential for market failure. Two relevant market failure issues involve externalities and public goods.

> **Externalities**: Off-stream uses of water often are characterized by externalities that may have only been partially offset or internalized. For example, water polluted by agricultural or mining enterprises typically affects downstream users without compensation. As a result, the benefits accruing to agriculture or mining may be overstated to the extent that pollution costs have not been included.
>
> **Public Goods**: Instream flows are a public good and therefore are affected by certain public good problems - most notably by excludability/free ridership and collective ownership. The excludability/free rider problem implies that more flow for one recreator results in more flows for all recreators. Individuals cannot be prevented from using the public good (excludability) and may benefit from use of the public good without compensation (free ride). From an individual recreator's perspective, use of public goods can be obtained at zero marginal cost. The excludability/free rider problems arise because public goods are characterized by collective ownership such that the good is owned by society as opposed to individuals. As a result, public goods are not priced or exchanged within a typical market setting. Ultimately, nonmarket goods tend to be under-represented in a market based economy. The zero marginal cost concept doesn't imply that public goods can be provided and maintained without cost. The lack of provision of public goods via the markets results in such goods being provided primarily by Federal, State, and local governments.

Another issue that may confound valuation of a market good is the presence of subsidies. Subsidies are typically provided by government to encourage some sort of development. For example, the cost of providing water in the arid West has been heavily subsidized, particularly for agriculture. While this is technically not a market failure because the provision of subsidies removes one from the realm of competitive market pricing, subsidized prices are often used in valuation. Accurate valuation would need to account for the influence of subsidies.

Legal considerations to some degree impede economically efficient allocations of a river system's water supply. Whenever demand exceeds the supply of water within a river system in the West, water rights come into play to help allocate water based on beneficial use and seniority. Historically, beneficial use has implied that the water must be used for irrigation, M&I water supply, power, or other traditional purposes. While instream flow uses for recreation, fish and wildlife habitat, water quality dilutions, etc., have gained wide acceptance, there are still those who feel leaving water in the river is a waste as opposed to a beneficial use. Seniority is based on the doctrine of prior appropriation or first in time, first in right. Water users with the oldest legal claims are virtually guaranteed to get their water. Water supplies for junior water right holders may be reduced or eliminated in a given water year, depending on the total amount of water available.

Depending on the legal requirements involved in obtaining water rights in each state, recreators or other instream flow advocates could conceivably purchase instream flow water rights as a group. The need by recreators to cooperatively purchase instream flow water rights tends to impede water rights transactions compared to transactions exclusively between individuals. Non-governmental organizations, such as environmental groups and recreator associations, may be able to mobilize their memberships to agree to purchase instream flow water rights from irrigators. These groups act on behalf of their membership to create a more manageable single-buyer, single-seller atmosphere.

2.2 Recreation Economic Theory:

Recreation is generally not exchanged within a market setting as are other uses of water. However, simply because recreational use of instream flows is not priced within a market setting, one shouldn't infer that instream flows have no recreation value. Many believe the recreation value of instream flow is sufficient to warrant maintenance of certain levels of flow for recreation use (Daubert and Young, 1979). However, some still believe that instream flows have no value and therefore represent a waste of water.

While in some cases, a recreator can purchase a recreation trip directly through the market from a commercial guide or outfitter, in most cases, recreators, in essence, "produce" their recreation activity. Based on what has been referred to as the household production concept, recreators combine their leisure time, recreation expenditures for visiting sites and purchasing equipment, and characteristics of publicly provided recreation sites to actually produce a recreation trip. Since most recreation trips are not marketed, most recreation benefits are typically reflected by recreator (consumer) benefits as opposed to outfitter (producer) benefits.

Recreator benefits per trip are measured in terms of net WTP, or consumer surplus, which represents the maximum a recreator would be willing to pay in excess of actual trip costs rather than forgo the experience. Total recreator benefits for a given recreation site are calculated by applying estimates of the average per trip benefits by recreation activity to the total number of trips taken by activity. Total recreation benefits would further combine recreator benefits with any commercial outfitter/guide operation profitability that may result. To measure a recreation site's value to society, one would also need to deduct the costs of operating and maintaining the recreation site from the total economic benefits.

Within the context of measuring recreation benefits, instream flow is typically treated similarly to any other site quality characteristic. Based on the literature, there appears to be a bell-shaped relationship between recreation visitation/value and instream flow. At zero or very low flows, visitation and value are nonexistent, implying a required lower bound flow before recreation begins. At low flows, visitation and value increases with increasing flows. At some point, optimal flows are achieved, and visitation and value reach their peak. Subsequently, as flows exceed the optimum, visitation and value decrease. Finally, at some high flow level, visitation and value cease as flows become too dangerous for participation. Therefore, there typically exists an acceptable flow range bounded by high and low end flow level thresholds beyond which point visitation and value go to zero. The actual average low end, optimal, and high end flow thresholds can vary by river, reach of the river, and recreational activity.

Water based recreational activities, such as fishing, boating, and swimming, that involve direct water contact are more likely to be affected by changes in instream flows than water influenced activities such as picnicking, camping, and hiking, which require no direct water contact. According to Daubert and Young (1981), since instream flows enhance non-contact recreation experiences primarily from a visual perspective, such recreators may be indifferent to alternative flow levels except under extreme changes.

Walsh, et al. (1980) found a bell-shaped relationship between value and instream flow for fishing, kayaking, and rafting. However, the optimal flow point was significantly lower for fishing than for kayaking and rafting. An aspect of the analysis related to the timing and magnitude of flows between fishing and kayaking/rafting was that despite the fact that kayaking/rafting values are highest during the spring runoff, annual total instream recreation benefits could be maximized by retaining a healthy share of these spring flows for instream boating and fishing activities later in the recreation season. As a result, the analyst would need to first evaluate the optimal intra-year recreational allocation of water between all the in-river activities before considering the overall allocation with other competing uses.

River recreation obviously depends on flows; the question is how much flow is desirable. The valuation problem typically involves estimating the recreation value for changes in stream flows. Based on the law of diminishing returns, which states that as one consumes more and more of a particular good, the marginal value of the next unit consumed continues to drop and may even become negative (see marginal benefit curve, figure 1), the value of an increment of flow depends on the point of reference. At low flows, additional water would be highly valued by recreationists, whereas at high flows, the value of additional water would be considerably lower. This diminishing returns concept applies to all goods and services, not just recreation. Aggregating marginal values of flow level changes across the total population of river recreators and commercial operations would provide an estimate of the full marginal value of instream flows to recreation for that particular flow level.

As illustrated in figure 2, the area under the individual recreator's marginal benefit or demand curve reflects total WTP for each level of recreation trips. Based on the original demand curve (D_0), subtracting the sum of the recreator's costs of obtaining the (area $0CBT_0$)[2] from the total WTP associated with taking those trips (area $0ABT_0$) provides a measure of recreator consumer surplus (area CAB). Aggregating recreator benefits across site users, the process of vertically summing individual demand curves provides an estimate of total recreator benefits. As noted above, when looking at total benefits to society, one would also want to subtract out the total costs of providing the recreation site (e.g., agency operating costs). From the perspective of an incremental change in instream flow, agency operating costs may be fixed because they probably wouldn't fluctuate with instream flows. Therefore, when considering the incremental value associated with different instream flows, agency operating costs would probably be irrelevant.

To estimate the recreation value for different instream flows, the analyst would need to measure the differences in consumer surpluses associated with the different levels of flow. The demand curve shifts in or out as site quality characteristics, including instream flow, change. Within the acceptable range of instream flows (positive section of the marginal benefit curve [see figure 1]), increases (decreases) in instream flows are associated with outward (inward) shifts in the demand curve. Referring again to figure 2, the hypothetical increase in instream flow shifts the demand

[2] Trip costs reflect the costs to access the site including transportation, food, and lodging. Given that these access costs are relatively stable for trips to the same site, the marginal cost or price curve is horizontal.

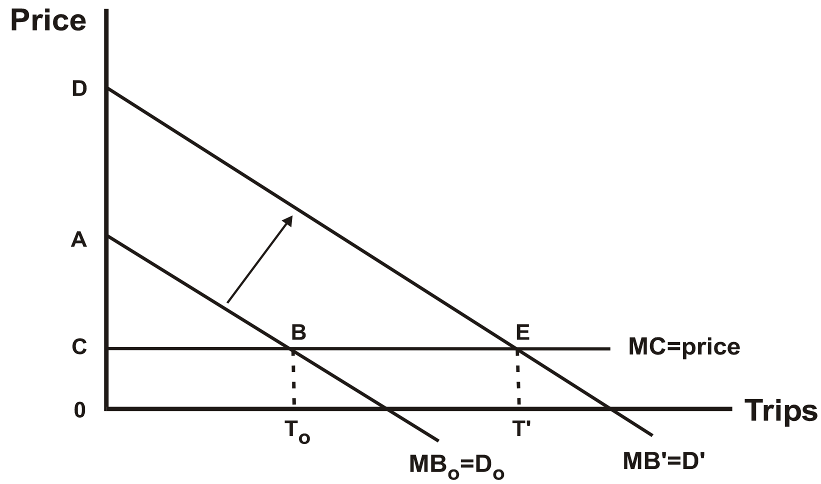

Figure 2.—Shifting Demand Curves Caused by Instream Flow Changes.

curve out from D_0 to DN. Depending on the flow level associated with D_0 and the magnitude of the flow increase, the shiFt. to DN could be large or small. Trips increase from T_0 to TN. Recreator consumer surplus increases from area CAB to area CDE, a gain measured by area ADEB.

Changing instream flows can potentially affect both the number of trips and value per trip. Therefore, when evaluating a change in flows, the analyst may need four pieces of information for each impacted recreation activity: (1) original number of trips, (2) original value per trip, (3) revised number of trips under the new flow level, and (4) the revised value per trip. Multiplying (1) by (2) provides the original recreation value for activity 1, and multiplying (3) by (4) provides the revised recreation value for activity 1. The difference between the original value and the revised value reflects the change in value for activity 1. Summing the change in value across all activities estimates the total recreator value for the flow change at the site.

Taking the above discussion one step further, changing instream flows might also affect the number of participating recreators. Assuming one is dealing with a change in flows within an activity's acceptable range where an increase in flow is associated with an increase in visitation and vice versa, gathering data from a sample of current recreators would likely be sufficient for flow reductions, but may be insufficient for increases in flows. It is possible, particularly for large increases in flows, that the additional flows might entice new recreators to visit the site. In such situations, data from a sample of the general population may also be needed to evaluate the potential impact on the number of recreators. A standard approach to estimating the number of recreators applies what is referred to as a probability of participation model. Such models can evaluate the relationship between the number of recreators and flows. With potential changes in the number of recreators, three pieces of information could be necessary for each flow level and activity: (1) the number of recreators, (2) the average number of trips per year per recreator, and (3) the average value per trip.

Walsh, et al. (1980) suggest that when valuing changes in instream flow, one should also take into account the impact upon congestion. The authors surveyed recreators about their preferences regarding a range of instream flows and congestion levels. The optimal number of recreators is determined by the point where the marginal benefits of the additional recreator equals the sum of the marginal congestion costs experienced by all existing recreators. If instream flows increase, leading to an increase in visitation, congestion costs would also likely increase. Since congestion negatively affects recreation benefits, failure to consider congestion impacts may result in overstated benefits. Therefore, the authors believe that increases in recreation value associated with increased instream flow need to be tempered by potential crowding effects.

As adapted from Loomis and Creel (1992), recreation decisions are based on the economic theory of constrained utility maximization. Focusing on fishing decisions, the theory assumes an individual angler's preferences for recreation sites $X_1, X_2, ..., X_n$ can be represented by a utility function which reflects the satisfaction the angler obtains from visiting the different recreation sites. To determine the optimal level of visitation to each site, the theory assumes the angler would maximize utility subject to the angler's income constraint. The income constraint suggests that the average site specific expenditure per fishing trip multiplied by the number of fishing trips taken to each site, when aggregated across sites, should equal one's fishing budget. This discussion is based on the assumption that utility functions and budgets are separable such that an individual's fishing decisions and budget can be distinguished from that individual's consumption of all other goods and services, including other recreation activities.

Maximize: $U= f(X_1(Q_1), X_2(Q_2), ..., X_n(Q_n))$

subject to:

$I = P_1 X_1 + P_2 X_2 + ... + P_n X_n$

where: U = utility
$X_1, ... , X_n$ = quantity of visits to sites 1, ... , n
$Q_1, ... , Q_n$ = quality of sites 1, ... , n
I = fishing budget
$P_1, ... , P_n$ = price or expenditures per fishing trip at each site 1, ... , n

Solving this constrained maximization problem results in a set of demand functions, one for each recreation site. The demand functions depicted below determine the optimal (*) number of visits to take to each site, given the price and quality associated with each site and one's budget.

$X_1^* (P_1, Q_1, P_2, Q_2, ... , P_n, Q_n, I)$
$X_2^* (P_1, Q_1, P_2, Q_2, ... , P_n, Q_n, I)$
.
.
.
$X_n^* (P_1, Q_1, P_2, Q_2, ... , P_n, Q_n, I)$

Plugging the demand functions back into the original utility function provides the indirect utility function, which measures the highest level of utility achievable at each level of price, quality, and budget.

$$V(P_1, Q_1, P_2, Q_2, \ldots, P_n, Q_n, I) = U(X_1^*, X_2^*, \ldots, X_n^*)$$

From this indirect utility function, one can measure the compensating variation associated with quality changes (e.g., a change in instream flows) at each site. Compensating variation reflects the amount of money one would be willing to pay (WTP) or willing to accept (WTA) to maintain the same utility level before and after the quality change. For an increase in quality at site 1 (Q_1 improves to Q_1'), compensating variation (WTP) would be defined as ...

$$V(P_1, Q_1', P_2, Q_2, \ldots, P_n, Q_n, I - WTP) = V(P_1, Q_1, P_2, Q_2, \ldots, P_n, Q_n, I)$$

The increased WTP needed to obtain the improvement in quality at site 1 maintains overall utility at the same level as without the quality improvement. Stated differently, the additional quality experienced in visiting site 1 is directly offset by the increased WTP to obtain the site 1 quality improvement. Therefore, the individual would be indifferent between the two situations. The WTP represents a measure of the effect on the individual's welfare or economic value associated with the quality change. Aggregating the change in welfare or value across recreators provides an estimate of the change in societal welfare.

For a situation where quality at site 1 is expected to decrease, the recreator would need to be compensated or paid to maintain the same overall utility level before and after the quality change. WTA is the theoretically correct measure of compensating variation with a quality decrease, particularly for a public good where society holds the property rights. However, in practice, recreators are typically asked about their WTP to prevent a quality decrease to avoid problems associated with infinite WTA bids.

Despite the theoretical emphasis on utility functions, the reader should realize that an individual's utility function is not directly observable. However, if we assume the individual acts in a rational utility maximizing fashion, observing an individual's consumption decisions would allow for inferences to be made about that individual's underlying utility function.

It should be noted that instream flows can enter a recreator's utility function either directly or indirectly. For boaters and shoreline users, flow directly influences utility or satisfaction as would any other purchased input (X).

$$U = f(X_1, X_2, \ldots X_n, Flow)$$

Alternatively, as depicted above for anglers, flow can also enter the utility function indirectly. Flow can influence fish production or populations as well as catchability. As a result, flows enter the angler's utility function indirectly through the catch rate variable.

$$U = f(X_1(Flow), X_2, \ldots X_n)$$

3.0 VALUATION METHODOLOGIES

Nonmarket studies of instream flow valuation typically focus on either recreation value or total value. Recreation oriented studies value the impact of changing instream flows on both water based activities (e.g., fishing, boating, swimming) and water influenced activities (e.g., camping, picnicking, hiking). Recall that when dealing with recreation use values, the analysis needs to account for both the change in value per trip and the change in trips associated with the change in instream flows. Recreation studies typically apply some variant of either the contingent valuation method or travel cost method. Total value studies estimate nonuse values in addition to use values for recreation. In many cases, the nonuse component far outweighs the recreation use component. Total value studies apply the contingent valuation approach because that is the only existing method for estimating nonuse values. Most instream flow valuation studies to date have used the contingent valuation approach. Variants of both the contingent valuation approach and the travel costs approach are discussed below.

Loomis (1998 and 1986) presents literature reviews of several studies that attempted to estimate the effect on recreation use and value of fluctuating instream flows. The basic conclusion was that instream flows generate substantial recreation and preservation values that can significantly exceed traditional consumptive use values. This finding provide contrary to historical thinking that water left in the river was assumed to be wasted and not put to beneficial use.

Instream flow values are normally very site specific and depend on the range of recreation activities and nonuse value issues, current flow levels, and expected changes in flows. As a result, most instream flow studies involve original research that requires gathering information and developing models to specifically answer the question being asked. Benefits transfer applications that involve using values or models estimated at a different site are, therefore, difficult within the context of instream flow valuation.

Despite the difficulties, benefits transfer may still be an option, particularly for analysts under tight time and budget constraints. The difficulty with instream flow transfers lies in the need to match conditions between sites. Ideally, one would want the study site to match the policy site in terms of the range of flows, physical characteristics, and market characteristics. If the sites match up well, the model or estimated values could be used to estimate values at the policy site. If the sites match up reasonably well except for actual flow levels, there may be some potential for normalizing the flows using a ratio approach. The flows of interest at the study and policy sites could be converted to a percentage of the optimal flow for each recreation activity. Values could be assigned to the range of flow percentages studied in the original research. The values at the study site could be transferred to the same percentages of optimal flows at the policy site. To address specific flows proposed at the policy site, some interpolation between values may be required. Carlson and Palmer (1997) present a scaling oriented benefits transfer application where results from a contingent valuation study at Glen Canyon Dam on the Colorado River are applied to the Green River below Flaming Gorge Dam. Obviously, great care would need to go into this type of benefit transfer application.

While most instream flow recreation studies have been site specific, some studies have estimated multiple site models. Site specific predictions from these multi-site models tend to be less accurate than the predictions from individual site specific models. Pooling and averaging the flow relationship across sites, calls site specific prediction accuracy into question. Of course, compared to site specific models, multi-site models generally do a better job in predicting visitation and value across all sites within the region by better accounting for recreation site substitution effects.

3.1 Contingent Valuation (CV) Method:

CV involves the use of in-person, mail, or telephone surveys to obtain information from the general or recreator public as to the value it places on a given nonmarket good or resource. From the perspective of instream flow valuation, after setting up a realistic, but hypothetical scenario, CV survey questions are typically posed which have the respondent estimate his or her WTP for maintaining or changing instream flows.

The CV questions elicit WTP responses in a variety of formats including opened-ended (OE), iterative bidding (IB), and closed-ended/dichotomous choice (CE/DC). The OE CV approach simply asks the respondent to estimate his or her maximum WTP for the hypothetical scenario. The IB approach starts off by asking the respondent if he or she would be willing to pay a given amount for the scenario. Assuming the respondent says "yes" to the initial asking price (also referred to as bid amount), the interviewer increases the asking price until the respondent says "no." Reaching a response of "no," the interviewer then reduces the asking price until the maximum WTP is obtained. The CE/DC approach typically asks each respondent one CV question for each hypothetical scenario. Each respondent is asked whether he or she would be willing to pay the stated asking price to obtain the hypothetical scenario. The asking price is varied across respondents in the sample. Choosing the bid amounts has generated a lot of research with no apparent consensus. Typically, selection of the range of bid amounts is based on the results of survey pretests. The information on the range of yes/no responses to each of the bid amounts allows for model estimation. Variants of this approach include double bounded (two CV questions for each scenario) and multiple bounded (multiple CV questions for each scenario) approaches. The multiple bounded approach, in essence, becomes somewhat akin to the IB approach. The open-ended and iterative bid approaches have the advantage of estimating value directly from the survey responses, whereas the dichotomous choice approach requires statistical modeling to estimate value. Despite extensive use of the three elicitation approaches, most of the more recent studies have applied the CE/DC approach because it was endorsed by a panel of economic experts chaired by two Nobel Laurets (Arrow et al., 1993). Despite the CE/DC endorsement, the other elicitation approaches are still widely used.

Another important CV question element is the selection of the most appropriate method of payment or payment vehicle. Standard payment approaches include additional trip costs, taxes, entrance fees, and sole purpose funds.

Numerous biases are claimed to be characteristic of CV approaches, but most of them have been shown to be either unfounded or correctable. For example, a key assumption of CV is that reasonable estimates of value can be obtained from the hypothetical questions. Opponents of the method claim this assumption to be false, implying that asking hypothetical questions results in hypothetical answers (hypothetical bias). While comparisons of recreation use values between CV and travel cost studies have validated CV results by showing no statistical difference (Carson et al., 1996), comparisons of nonuse values between stated values and actual cash experiments have resulted in stated values exceeding actual payments. Recent innovations with certainty of response questions[3] have improved the reliability of the nonuse CV results (Champ et al., 1997).

The following subsections present discussion of several CV studies designed to value instream flow. Separate sections are included for CV studies focusing on recreation value versus nonuse value.

3.1.1 Contingent Valuation of Instream Recreation Use:

A given cubic foot per second (cfs) flow can convert to different river flow velocities and water depths depending on the physical characteristics of the river at a particular point. To help recreationists visualize what an increase (decrease) in instream flows may imply at different points along a river, drawings or pictures depicting the different flow levels are often used when asking instream flow oriented CV questions. Alternatively, Walsh (1980) and Walsh et al. (1980) referenced historically high water marks visible along the reservoirs and rivers and asked recreators how they would react if water levels were 75%, 50%, 25% of the historic peak.

Two approaches have evolved when referencing instream flow conditions for CV questions, one which limits the questions to flows within the range experienced by each recreator and another which inquires about flows outside the recreator's range of experience. The experienced flow range approach requires questions of each respondent about the range of flows each recreator has experienced in the past. The logic in focusing only on previously experienced flows is that they should be easier to value, given their familiarity. The analyst encounters problems with this approach when evaluating alternatives beyond the historical range of flows. The never-experienced flow range approach has no such constraints and must be accompanied by photos/artists renditions of the river at various flows, statistical information, and narrative.

Boyle et al. (1993) tested the experience issue using a sample of CV responses from both inexperienced rafters (patrons of commercial trips) and experienced private rafters. The authors varied survey question order across both groups to see if experienced rafters better understood the scenarios compared to inexperienced rafters. The authors found that question order was somewhat significant in explaining WTP for inexperienced rafters, but not at all for experienced rafters. While this doesn't mean that inexperienced rafters cannot value flows beyond their range of experience, this does suggest that it is easier when they have experienced the flows. It should be noted that this study did not include recreators who had no experience with the Grand Canyon (i.e., the issue of nonusers becoming users).

As is apparent from the literature, setting up the hypothetical market and fully explaining the proposed scenarios is critical to obtaining useful CV results. Clear, well presented descriptions

[3] Certainty of response questions involve asking respondents how certain they are of their WTP responses. Responses associated with low levels of certainty are discounted.

of exactly what is being valued, how much it will cost and for how long, what happens if the action is not pursued, and what options exist for substitution are all required information.

As noted in Brown et al., 1992, there are basically two approaches for gathering and modeling information from recreators as to the relationship between flow and economic value or quantity of recreation trips: (1) ask each respondent about his or her current or most recent trip and use the variation across the sample to evaluate the relationship, and (2) ask each respondent not only about current or most recent trip, but also how he or she would react to changing flow conditions. The later approach has an advantage in that one would not require as many surveys, but the former approach may provide more acceptable results should the relationship prove to be statistically significant. However, the first approach may assume a relationship exists when the recreators are not even aware of the actual flow levels at the time of the trip.

The following paragraphs discuss the results of a series of CV studies of recreation, presented in order by date.

Daubert and Young (1979, 1981) provide an early application of the CV approach to valuing the whitewater boating, fishing, and shoreline recreational use of instream flows on the Cache La Poudre river of northern Colorado. Using an iterative bid approach and a combination of a sales tax/entrance fee as a payment vehicle, WTP estimates were collected for various increments in instream flow as depicted in a set of photographs and described in terms of water depth, velocity, and expected trout catch rates. The authors estimated separate quadratic (fishing and shoreline) and linear (boating) ordinary least squares models for the three primary activities using a stepwise estimation procedure. The dependent variable of each model was total WTP per recreation day. Independent variables varied across the models and included the following: instream flow, instream flow squared, number of days by activity on river, number of days on the river squared, years of experience by activity, income, age, gender, river location, occupation, size of residence. The authors calculated marginal WTP estimates for 50 cfs interval increases in stream flow based on both the entrance fee and sales tax payment vehicles for each activity. As expected, individual incremental WTP per day for each subsequent increase in streamflow declined and became negative at 500-550 cfs for fishing and 700 cfs for shoreline activities. (For whitewater boating, no decline was seen within the studied range of flows.)

Bishop et al. (1987) used mail surveys and dichotomous choice CV questions to estimate recreation values for anglers, private white water rafters, and commercial day-use rafters of the Grand Canyon under both current and hypothetical flow conditions. All three recreation activities indicated a bell shaped flow preference. Anglers preferred constant flows in the 10,000 cfs range whereas private and commercial rafters preferred much higher constant flows in the 29,000 to 33,000 cfs range.

Johnson and Adams (1988) developed a bioeconomic model for the recreational steelhead fishery on the John Day River in Oregon. The biological modeling estimated adult steelhead population as a function of parental stock size, environmental conditions (including flows), and fishing pressure. The economic modeling used contingent valuation survey results to develop an aggregate bid function for anglers as a function of hours of fishing per fish caught. These two models were combined to estimate WTP as a function of flow.

Butkay (1989) estimated recreation values for the Big Hole and Bitterroot rivers in western Montana as a function of instream flows using a dichotomous choice CV approach. Two dichotomous choice contingent valuation questions were posed, one for current trips and flow conditions and another for preferred flows. Current flow levels were regressed on the current WTP responses, and preferred flows were regressed on preferred WTP. Results proved to be mixed. A significant positive relationship between current flows and value was estimated for the Bitterroot but not for the Big Hole. Using the preferred flow and WTP responses, the Big Hole model resulted in a positive significant relationship, but the Bitterroot model proved unsuccessful. The expected quadratic relationship between flows and value did not materialize using either the current or preferred flow data. In addition, the study successfully developed daily use estimating models based on instream flows with quadratic and cubic forms. By separating the data into shoreline and in-river activities, the models show that the incremental values for achieving preferred flows were greater for the water based activities than for the shoreline activities.

Duffield et al. (1992) estimated both valuation and visitation equations as a function of instream flows. The authors gathered WTP information from a dichotomous choice contingent valuation survey. Per trip WTP estimates were obtained only for the current trip, so that all flow information could be considered familiar (experience issue). Variation in flows and values across trips allowed for model estimation. Values were developed for both residents and nonrresidents, and as expected, nonresidents were willing to pay more per trip. In addition, a visitation model was developed with sampled trips per day as the dependent variable and flows, flows squared, and flows cubed as the primary independent variables.

Harpman et al. (1993) developed a workable bioeconomic model for measuring the effects of flow changes on the value of trout angling on the Taylor River in Colorado. The relatively sophisticated biological component of the model estimated a relationship between brown trout populations and flow. A catchability index was used to convert estimated trout populations to catch. The additional catch was distributed over the current number of fishing days to estimate changes in catch per day. A dichotomous choice logit model was estimated using contingent valuation survey results to calculate marginal values per fish.

A possible shortcoming of the Harpman et al. (1993) approach is that no change in visitation or fishing effort is assumed. The interaction between fish populations, catch per day, and number of fishing days is difficult to address because of the simultaneous nature of the relationship. Analyses often assume one of two extreme positions: (1) assume trips do not change, but the catch rate per day increases to the maximum level, or (2) assume catch rate per day remains fixed, but the number of trips increase to the maximum level. The most likely scenario is obviously somewhere between these extremes, the question becomes where.

Willis and Garrod (1999) used a comprehensive set of CV surveys to estimate the WTP of anglers and general recreators for improved flow conditions in southwestern England. The survey used three elicitation approaches (open-ended, dichotomous choice, and iterative bid). Open-ended questions were asked of anglers who currently pay to fish. Closed-ended/ dichotomous choice and iterative bid approaches were used on samples of general recreators (non-anglers) who weren't accustomed to paying for recreation. The authors found consistent results across the elicitation approaches. They also found significant WTP from both anglers and general recreators, implying studies that focus only on anglers can substantially understate total value. In addition, the household surveys simultaneously asked about total values and then had the respondents allocate WTP by recreation versus other elements and between resource areas (rivers, beaches, etc.).

3.1.2 Contingent Valuation and Nonuse Valuation:

In addition to measuring the value a recreationist obtains from instream flow, CV can also be used to measure nonuse values. Nonuse values reflect an individual's WTP to preserve a resource, even if the individual doesn't ever intend to use the resource. Despite the emphasis on nonusers, it should be noted that site users may hold nonuse values in addition to their use values. Nonuse values are expected to be greatest when a resource is unique and irreplaceable (i.e., a resource with few substitutes), of national significance, and impacts are expected to be irreversible. Nonuse values may exist for many reasons, including the desire to pass the resource on to future generations (bequest values), or simply the pleasure in knowing that the resource continues to exist (preservation or existence value)[4]. From an instream flow perspective, existence values can stem from knowledge of a free-flowing river, maintenance of unique flow dependent scenery, or preservation of critical fish and wildlife habitat, especially for endangered species.

CV studies of nonuse values follow the general requirements of any CV study, with certain exceptions. The following issues specific to nonuse value studies were noted in Bishop and Welsh (1992):

- Are Nonuse Values Limited to Environmental Resources? While nonuse values evolved from the valuation of natural environments, one cannot rule out the possibility of nonuse values for other resources. Claims have been made that hydropower generation may provide benefits beyond those of the power itself, given its non-polluting nature, and agriculture may provide aesthetic benefits due to its pastoral setting, etc.

- Regional Definition: An important issue relates to defining the region. In CV studies of recreation use, onsite surveys are normally conducted to question a sample of recreators. In nonuse value studies, households are surveyed. A question arises about how large the region should be where the households are contacted. Often, nonuse values are assigned to resources of unique national significance, implying a national perspective. However, this is not to say that nonuse values cannot exist for resources of more local significance.

- Designing the CV Question: Nonuse value oriented CV questions can be very complex, typically more complex than recreation use oriented CV questions. Given

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[4] Early nonuse value literature also included the concept of option value, referring to the WTP by individuals to maintain the option to use the resource in the future. Recent literature suggests this should not be considered a component of nonuse value, but more of a use value under conditions of uncertainty (Harpman et al., 1993).

the need to explain the setting and market to the potential respondent, great care must go into developing the nonuse value CV question.

- Background Information: To learn more about public opinions and preferences, the authors suggest using focus groups or attitude surveys. Such information, obtained prior to conducting the nonuse value survey, would prove useful in addressing all three of the above issues.

While more research has gone into the area of instream flow valuation from the perspective of recreation use than from the perspective of nonuse in the last decade, several studies have expanded into the realm of nonuse valuation. These nonuse studies have been primarily academic exercises, but recent events suggest that nonuse valuation may become an important component of natural resource decision making processes (Harpman et al., 1993). The following nonuse value studies are presented in order by date.

Sanders et al. (1990) surveyed both users and nonusers of 11 Colorado Rivers to estimate benefits for preservation. In addition to the open-ended CV questions, several follow-up questions were asked to allocate the total value among current recreation use, future recreation use (option value), knowing the resource exists (existence value), and preservation of the resource for future generations (bequest value). While unique environmental goods are not expected to show regional differences in value, the responses in this study did show a regional effect where value of the rivers declined with distance from the site. The authors state that for studies which only address recreation use, total benefits would likely be significantly understated. They urge use of the total value concept within the context of federal and state benefit-cost analyses.

Brown and Duffield (1995) tested their CV results for possible part-whole/embedding problems. This issue questions whether respondents would logically pay more for greater quantities of public good preservation. The authors used a series of CV questions (both dichotomous choice and open-ended) designed to value either one or five Montana rivers. On average, respondents indicated that they would pay more if more rivers were protected, but the rate of increase decreased with each additional river (consistent with the economic law of diminishing returns). It was interesting to note however, that recreators would pay more for more rivers, but nonusers would not. In addition, the authors confirmed the importance of providing information on substitute sites in the scenario description.

Welsh et al. (1995) successfully used a dichotomous choice CV survey to value changing Glen Canyon Dam operations and instream conditions within the Grand Canyon. Separate surveys were sent to both a national sample and a regional sample. The payment vehicle for the national sample was increased taxes, whereas the regional sample used increased electric bills (the regional sample was drawn from the population influenced by changes in power generation). Another aspect of the CV question was the use of a certainty scale to verify value responses (ranged from definitely no to definitely yes). Responses were treated in two ways: (1) a very conservative approach where all responses were considered a “no” unless the respondent indicated definitely yes to the CV question, and (2) a somewhat less conservative approach where all responses were considered a “no” unless the respondent indicated “definitely yes” or “probably yes” to the CV question. As expected, the later approach resulted in substantially higher WTP values. The authors suggested reliance on the conservative approach. Another interesting aspect of this study was that individuals were asked if they would vote for the proposal if it cost nothing. For those that said "no" or "chose not to vote," a WTP of zero was assigned. For survey nonrespondents, information from follow-up telephone surveys were used to adjust WTP responses.

Berrens et al. (1996) used a telephone based dichotomous choice CV survey to evaluate the total value (recreation, water quality, fish and wildlife habitat, and other nonuse values) for protecting insteam flows in several New Mexico rivers. While the authors made no attempt to separate the total value into use and nonuse components, they speculate that most of the value relates to nonuse aspects because the goal was to value minimum flows as opposed to recreationally preferred flows.

To help respondents understand the hypothetical market and WTP scenarios, the household survey developed by Berrens (1996) began by asking general awareness questions about water issues. The introductory text described benefits and costs associated with protecting instream flows, including a discussion of related endangered species. Respondents were informed of the linkage between minimum instream flows and endangered fish habitat and the intent to estimate household values for instream flows. The respondents were also reminded of their budget constraint and of available substitutes. A 5-year voluntary contribution into a special trust fund defined the nature of the program.

Berrens et al. (1996) also tested CV responses for the influence of embedding and public support. The authors evaluated embedding by varying the scope of the public good to be protected from a single endangered fish in one river to 11 endangered fish across four major rivers. The authors tested the influence of the degree of public support on WTP by including a reminder of the number of New Mexico households supporting the public good (i.e., 500,000). The reaction to the embedding issue proved significant and of the expected sign (i.e., saving more fish in more rivers lead to greater WTP), whereas the reminder of public support proved insignificant.

Douglas and Taylor (1999) conducted CV surveys of both recreators and nonusers of the Trinity River in northern California. The authors applied a complex series of mail and telephone surveys using a range of elicitation formats. The intent was to value increased Trinity River flows and resultant fish population increases. Both recreation use and nonuse values were compared to expected losses in terms of hydropower, agriculture, and municipal and industrial uses. The results indicated that the total benefits, dominated by the nonuse benefits, substantially outweigh the losses.

3.2 Contingent Behavior and Use Estimation Modeling

Contingent behavior information is gathered using a survey in a fashion similar to contingent valuation information. Instead of asking how the respondent's value would change, the contingent behavior format asks how a recreator's visitation would change. The advantage of this approach is that it may be easier for respondents to predict changes in visitation as opposed to value. This information can be applied in developing a use estimation model where visitation is predicted as a function of instream flows. In some studies, contingent behavior information has been combined with observed behavior to estimate travel cost models. Obviously, this approach deals only with visitation and, therefore, does not account for valuation. Typically, contingent behavior questions are combined with CV questions so as to address both changes in visitation and value for a given change in instream flows.

Walsh et al. (1980) developed recreation benefit and use estimation models based on the results of contingent valuation and contingent behavior questions designed to gather information about various levels of instream flow and congestion. The equations estimated WTP and visitation as a function of instream flows, crowding, participant characteristics, and management costs. Beyond the point of the optimal number of users per mile of river, congestion costs for current users outweigh the values associated with additional users. Both CV and CB questions resulted in a bell shaped relationship between instream flows and value/use.

Narayanan (1986) combined a travel cost model for estimating current value with a contingent behavior based use estimating model. For the visitation component, recreators were asked at what flow level they would stop participating in each activity. The contingent behavior questions used a series of eight percentage decreases in flow from current levels (0 to 100 percent decrease). A logit model was estimated where the dependent variable was based on the yes/no responses for each of the eight percentages. The author noted that by excluding any visual or descriptive aids, it may have been difficult for the respondents to link flow percentage reductions with the actual corresponding flows.

Duffield et al. (1990) used contingent valuation to estimate both current values and values under various flow scenarios. The instream flow options were based on a percentage of current flows as defined by the respondent's most recent trip. Like Narayanan (1986), contingent behavior questions asked at what flow level the respondent would stop recreating. The authors also asked CV questions regarding WTP into a trust fund to maintain instream flows. This question was asked of both recreators and nonrecreators, thus bringing in a nonuse value element.

Loomis and Feldman (1995) conducted contingent valuation/behavior surveys using the results to estimate WTP and use estimating models as a function of instream flow. By including the contingent behavior questions, the authors were able to estimate visitation changes in addition to valuation changes. Most earlier recreation studies tended to focus purely on the value per trip changes. Combining the estimates of number of trips and value per trip at various flow levels, the authors were able to map out how total recreation use benefits changed with flow. This information was compared to the opportunity cost of hydropower forgone to estimate optimal flow levels.

Hansen and Hallam (1990) developed total value estimates by region of the country using the results of the 1980 National Hunting, Fishing, and Wildlife Associated Recreation Survey. Given that value estimates per day were assumed fixed within a region, the variation in total value was driven purely by visitation changes. The use estimation model (UEM) developed in the study predicted recreation visitation based on general explanatory variables related to the site and the user population. Hansen and Hallam (1990) developed both one and two stage visitation estimation approaches. The two stage method developed separate probability of participation models and frequency of visitation models based on the household and recreator components of the survey. The single stage approach merged the two models into one in which the dependent variable was the number of fishing trips taken annually by each individual. In all models, surface areas of both river and lakes were used in the estimation.

3.3 Travel Cost Method (TCM):

The general premise behind the TCM is that recreation use varies inversely with distance and travel costs, that is, the farther one lives from a site, the fewer visits are likely to be made. Travel costs, including transportation, food, lodging, and opportunity costs of time, are assumed to reflect a proxy for the price of accessing a recreation site. This negative relationship between travel costs and visitation allows for development of a downward sloping demand curve (see figure 2). As noted previously, the area under the demand curve and above price reflects net WTP, an appropriate measure of economic benefits for a recreator.

Travel cost models are estimated using actual observed visitation in conjunction with information on visitor origin, visitor socioeconomic/demographic characteristics, site quality factors (including instream flow), and characteristics of substitute sites. The reliance on changes in actual observed visitation, as opposed to responses to hypothetical questions, is seen by many economists as a major advantage of the TCM over the CV approach. While use of actual observed behavior is typically seen as an advantage, limited or inaccurate data can restrict application of the TCM. In addition, exclusive reliance on actual historic data can forgo use of TCM when the scenario to be studied involves flows beyond the range of available data. As a result, in recent years, use of contingent behavior responses in combination with actual observed visitation has become popular.

Loomis (1986) suggests a series of theoretical and data oriented assumptions which must hold for application of the travel cost model to an instream flow valuation scenario:

Theoretical Assumptions:

(1) A recreator's demand for instream flows influences his or her willingness to travel. In other words, improved site quality/instream flow attracts recreators from greater distances.

(2) Weak complementarity is necessary for the area between the demand curves with and without the change in flows to represent the total benefits of the flow change. Weak complementarity implies that if one doesn't visit a site, one would not value a change

in stream flows. If this doesn't hold, one gets into the area of nonuse values requiring contingent valuation approaches.

Data Assumptions:

(1) Recreators must live at significantly varying distances from the river.

(2) The study river must be the only site, or at least the primary site, visited by all or most of the recreators.

(3) There must be sufficient variation in flows for model estimation. Single site studies require flow fluctuation over time, either across the current recreation season or across years. To increase the potential flow variation, some researchers have combined data across sites or used contingent behavior data.

(4) The flow fluctuations must have been known to the recreators before they took their trips. Ward (1987) concurs with this position, noting that TCM can only be applied to instream flow modeling when fluctuating flows are perceived by users and impact their visitation levels. In cases where flow changes do not affect visitation, CV approaches need to be used to estimate possible changes in value. Unfortunately, in many situations, recreators may not be fully aware of flow conditions prior to taking the trip.

A disadvantage of the TCM is that it addresses only recreation use values. As noted above, instream flow studies often focus on nonuse values in addition to recreation use values. The CV approach is the only currently available method available for estimating nonuse values.

The remainder of this section describes variations of the two primary travel cost approaches, the zonal and individual travel cost models.

3.3.1 Zonal Travel Cost Model (ZTCM):

The ZTCM uses aggregated data across recreators to estimate total site visitation as a function of travel costs, among other variables. Total visitation or visitation per capita by origin zone (e.g., zip code, county, county groups, and concentric distance zones) reflects the model's dependent variable. Travel cost by zone, typically based from the largest population center in the zone, reflects the price term.

A major advantage of the ZTCM is that it simultaneously accounts for both the decision to participate in a given activity at the site and the number of trips taken within a given time period. As a result, separately modeling the potential impact on the number of recreators is not necessary.

A major disadvantage of the ZTCM is the required use of zonal average data, which may lead to accuracy questions.

Given that travel cost modeling efforts often use cross-sectional data, which implies information is obtained only for the current time period, data is sometimes pooled across different rivers or river reaches to provide sufficient variation in recreation use and instream flow. Instream flows for a single river or river reach may not fluctuate enough to allow evaluation of a statistical relationship. A difficulty with the concept of pooling data across sites is the relationships between the independent variables and dependent variable are no longer site specific. As a result, the model reflects, in some sense, the average site. While the model can be targeted toward the site(s) of interest by plugging in site specific values for the demographic, travel cost, and site quality variables, the relationships/coefficients between visitation and the independent variables are still based on all the sites included in the model. Bottomline, this pooled relationship makes it difficult to use a pooled site model to predict changes in use caused by changes in instream flows for a specific site.

Neher (1989) pooled data across 19 rivers to estimate relationships between instream flow and recreation use separately for residents and nonresidents before developing more fully specified travel cost models. The resident model showed a significant positive relationship between instream flow and visitation, whereas the nonresident sample showed no such relationship. This is not unexpected becasue nonresidents may have less knowledge of instream flow levels, and they may have less flexibility over the scheduling of their trips to coincide with higher flows. It should be noted that the significantly positive relationship for residents varied with different functional forms. Another interesting flow to visitation relationship was based on the level of control associated with a river. River control was classified into three categories: free flowing, slight dam control, and heavy dam control. Neher found that a statistically significant relationship between visitation and flow was apparent only for the no control, free flowing river group. The reason for this lack of streamflow significance for the controlled rivers was speculated to be the reduced variation in annual fluctuation for the controlled rivers. Reservoir storage can be used to smooth the peaks and troughs associated with natural flows. By reducing the annual average flow variation and presumably the variation in visitation, a statistically significant relationship between flow and visitation becomes less likely compared to a free flowing river with large extremes in flows and recreation use.

Given that the pooled site flow and visitation information varies considerably across the rivers, Neher normalized this information. The trips, days, and flow data were expressed as a percentage of the mean values. In this way, observed variation in flows and visitation was no longer a function of the size or popularity of the river. The final specification of the 19 river pooled site ZTCM used normalized instream flow and distance information regressed on visitation per capita. Data limitations requiring the use of an annual flow variable imply the resulting marginal values may be suspect. Marginal/incremental values per acre foot should vary widely across sites becuase they depend on the magnitude of the streamflow change and the starting point of the change.

Time series data, gathered for the same site over a series of months or years, may provide the necessary variation in visitation and instream flow information to allow for development of a statistical model. Generally speaking, the longer the time series, the better. On the downside, the greater the number of years involved, the greater the potential for unrelated changes in the underlying data (e.g., changes in data collection methods and changes in tastes and preferences). Theoretically, changes in tastes and preferences could perhaps be accounted for in the modeling with trend and income variables, but accounting for changes in data collection methodology is likely to be difficult. Therefore, it may make sense to limit the modeling to the use of time series data collected in a consistent fashion. Conversely, limiting the range of data by using a shorter time series for the modeling runs the risk of predicting a relationship between visitation and instream flows based on a temporary trend.

Neher (1989) also estimated site specific time series ZTCMs for each of the 19 rivers included in the study. Only the four free flowing rivers produced statistically significant instream flow variables. Given the smoothing or averaging effect of the pooled site model, the site specific models proved to be more accurate in terms of predicting visitation at each of the four rivers. Therefore, when data permits, it appears that the preferred approach would be to construct single site models designed to adequately address site substitution.

Loomis and Cooper (1990) developed a relatively simple two equation bioeconomic model for the Feather River in California where trips per capita where regressed on fish catch and fish catch was regressed on instream flow. A statistically significant relationship was found between catch and flow and between visitation and catch. The two equations were estimated simultaneously using two stage least squares. This is one of the few instream flow studies that relied exclusively on actual observed behavior within a travel cost framework.

Crandall et al. (1992) developed a simple ZTCM model for the Hassayampa River Preserve in central Arizona. Explanatory variables included travel and time costs, age, and income. A substitute variable was not included because of the lack of comparable riparian sites in the region. Also, an instream flow variable was not included in the model. Given the intermittent nature of stream flows, the valuation was considered in terms of a flow, no flow scenario. The authors also asked CV questions about restoring an intermittent stream to a perennial stream. The results from the two models were considered comparable.

3.3.2 Individual Travel Cost Models (ITCM):

Instead of using aggregated data summed across all recreators within each zone, as is the case with the ZTCM, the ITCM uses information gathered from each recreator as a separate observation in estimating the model. The advantage is that the analyst no longer uses zonal averages in the statistical estimation. A drawback of this approach is that surveys are generally needed to gather the wide range of data required from each recreator.

Ward (1987) combined the results of a series of travel cost models, benefit estimation equations, and nonlinear optimization model runs to evaluate water allocation options between recreation and other uses of the Rio Chama in New Mexico. Ten ITCM models were used to estimate recreational demand for whitewater rafting and angling as a function of varying flows. The ITCM models were based on both observed and contingent behavior data. A cubic benefit estimation equation was developed as a function of flows to estimate total benefits for each flow level. This total benefit function, along with opportunity costs for other water uses, was used to define the objective function for a nonlinear programming effort to estimate optimal flow releases.

Since the ITCM basically estimates average visitation and value per recreator, the results need to be aggregated across the number of recreators at the site. Therefore, modeling the potential impacts on the number of recreators may be necessary with this approach. An extension of this concept involves a three-step decision process requiring the individual first to decide whether to recreate (participation decision). Assuming the decision is made to recreate, the recreator then decides which sites to visit (site selection decision) and finally the number of trips to take to each site (trip frequency decision). The second and third decision steps have been reversed in some modeling applications.

Loomis and Creel (1992) used actual observed visitation information within a pooled site travel cost framework to develop separate site selection and trip frequency models addressing 14 rivers and wildlife areas in California's San Joaquin Valley. The count data trip frequency model was linked to the multinomial logit site selection model by using inclusive values for each individual from the site selection model as an independent variable in the trip frequency model.

A couple of interesting interpretations were used by Loomis and Creel (1992) in developing the price and quality variables used in the site selection model. Two distinct price terms were included in the equation. For individuals who worked, an opportunity cost of time was estimated at 50 percent of the individual's wage rate. For individual's who didn't work, the price was based purely on travel costs. Since the modeling included information across several rivers and wildlife areas, the authors wanted to use a relative measure of quality that could be compared across sites of varying sizes. To accomplish this, a scaled measure was developed that divided monthly river flows or wildlife area inflows by the peak flows/inflows during the year.

3.4 Hedonic Price Method (HPM)

Hedonic approaches measure the implicit value of the underlying characteristics of a marketed good. With sufficient data on the variation in a good's price and underlying characteristics, statistical approaches can be used to estimate a shadow price for each of the characteristics. For example, variation in housing prices have been used to estimate values for air quality, proximity to water bodies, lake water levels, and other property characteristics. The basic underlying assumption of this approach is that the price of the marketed goods is equal to the sum of the value of its underlying characteristics. Therefore, the price of a house is based on the value of all the characteristics of the house (size, age, number of bedrooms), the property (size, views), and the neighborhood (schools, proximity to recreational facilities, crime). While no studies were found that addressed the issue of valuing instream flows, conceivably one could gather riverside housing data and attempt to determine if flows impact housing prices.

3.5 Mathematical Programming:

Several studies (e.g., Ward, 1984; Amirfathi, 1984) used some form of linear or dynamic programming to evaluate the optimal allocation of water either across the season for a given recreational activity or across competing demands for water within a year. By defining the objective function to maximize total benefits subject to water supply and other constraints, these models are very useful in defining the optimal solutions. However, these models are only as good as the underlying benefit estimates applied in the model. To estimate the recreation values for each level of instream flow, the CVM or TCM approaches must be applied.

4.0 Instream Flow Valuation Results

As evidenced by the previous section, the amount of research devoted to valuing instream flows has been fairly extensive. Attempts were made to provide a reasonably comprehensive coverage of the range of instream flow nonmarket valuation studies; however, omissions undoubtedly have occurred. Therefore, one might also want to refer to some of the other literature review studies conducted on this topic, including Loomis (1987), Brown (1991), Brown et al. (1992), Colby (1993), and Loomis (1998).

The following table presents details and valuation results obtained from the reviewed recreation and nonuse value studies. Selected values were drawn from each study. For a complete review of the valuation results, one would need to consult each of the original studies. No attempt was made to convert the values to a standard measure. While the values may prove useful for comparative purposes, extreme care must be used if trying to apply these results in a benefits transfer context because all the values are site and situation specific.

Table 1: Recreation and Nonuse Value Instream Flow Studies (alphabetically by author):										
Title	Author	Publish Date	Type of Value	Methodology	Date of Data	Recreation Activities	Study Area	Valuation Results: Total	Average	Incremental/Marginal
Estimation of Costs and Benefits of Instream Flow	P. Amirfathi	1984	Recreation use, and other uses (agriculture)	Regional TCM and Linear Programming Model	Aug. - Sept. 1982	General recreation (fishing, camping, shoreline, white water activities)	Blacksmith Fork and Little Bear River, Logan River (northern UT)	For 20% flow: 1) total value ranged from $1.5M to $1.9M 2) recreation benefits ranged from $123.3K to 399.9K		For flow ranges from 25 to 50%: Marginal benefits ranged from $0.29 to $74 per percent change
Valuing the Protection of Minimum Instream Flows in New Mexico	R. Berrens, P. Ganderton, and C. Silva	1996	Nonuse	CVM (dichotomous choice)	February 1995	N/A (nonuse study)	Gila, Pecos, Rio Grande, and San Juan Rivers in NM		Annual household value for protecting minimum instream flows in: 1) Rio Grande: $28.73 2) All four Rivers: $89.68	
Glen Canyon Dam Releases and Downstream Recreation: An Analysis of User Preferences and Economic Values and The Role of Question Order and Respondent Experience in Contingent-Valuation Studies	R. Bishop, K. Boyle, M. Welsh, R. Baumgartner, and P. Rathburn K. Boyle, M. Welsh, and R. Bishop	1987 1993	Recreation use	CVM (dichotomous choice)	1984 - 1985	Trout fishing and whitewater rafting	Glen Canyon NRA & Grand Canyon NP, AZ		Trout fishing: peaked at $126 per trip at 10,000 cfs Whitewater boaters: commercial peaked at $898 per trip (33,000 cfs) and private peaked at $688 per trip (29,000 cfs).	

Title	Author	Publish Date	Type of Value	Methodology	Date of Data	Recreation Activities	Study Area	Valuation Results: Total	Average	Incremental/Marginal
Testing Part-Whole Valuation Effects in Contingent Valuation of Instream Flow Protection	T. Brown and J. Duffield	1995	Recreation use and nonuse	CVM (dichotomous choice and open-ended)	1988-89	Not activity specific	Five Montana Rivers		Average annual value for one or five rivers: 1) Recreation Users: one river = $10.18 five rivers = $18.02 2) Nonusers: one river = $3.55 five rivers = $2.02	
Valuing Riparian Areas: A Southwestern Case Study	K. Crandall, B. Colby, and K. Rait	1992	Recreation use	Zonal TCM, CVM (payment card)	March - April 1990	Bird watching, hiking	Hassayampa River Preserve, AZ	TCM: $613.4K annually for the site CVM: $520K annually for the site Regional: $88.2K of total activity	TCM: $97annually per visit/trip CVM: $65 per visit/trip	
Recreational Demands for Maintaining Instream Flows: A Contingent Valuation Approach	J. Daubert and R. Young	1981	Recreation use	CVM (iterative bid)	Summer 1978	Trout fishing, whitewater rafting and kayaking	Cache la Poudre River, CO		Value per day peaked at $30.35 at 500 cfs	For 100 cfs, increases starting at 100cfs, value per day increased from $.10 to $.02 per cfs up to 500 cfs
The Economic Value of Trinity River Water	A. Douglas and J. Taylor	1999	Recreation use and nonuse	CVM (payment card and open-ended)	Winter 1993-94	Salmon and steelhead fishing, whitewater boating	Trinity River, CA	Annual existence and use value increased with flows (maximum flow scenario: $803.6M and $185.8M, respectively, at 840,000 acre feet (AF))		

Title	Author	Publish Date	Type of Value	Methodology	Date of Data	Recreation Activities	Study Area	Valuation Results: Total	Average	Incremental/Marginal
Recreation Benefits of Instream Flow: Application to Montana's Big Hole and Bitterroot Rivers and The Economic Value of Instream Flows for Recreation: A Contingent Valuation Approach	J. Duffield, C. Neher, and T. Brown S. Butkay	1992 1989	Recreation use	CVM (dichotomous choice)	May - August 1988	Trout fishing	Big Hole and Bitterroot Rivers, MT			Marginal values per AF: Bitterroot: ranged from $10.31 at 100 cfs to - $0.48 at 2000 cfs Big Hole: ranged from $25.45 at 100 cfs to $1.11 at 2000 cfs
Instream Flows in the Missouri River Basin: A Recreation Survey and Economic Study	J. Duffield, C. Neher, D. Patterson, and S. Allen	1990	Recreation use and nonuse	CVM (dichotomous choice), contingent behavior	summer - fall 1989	General recreation (fishing)	Upper Missouri Basin (above Ft. Peck Dam)		Average value per AF of flow for July and August: Upper subbasin: 50%: $50.28 75%: $67.98 100%: $35.40 Middle subbasin: 50%: $28.05 75%: $26.83 100%: $19.46 Lower subbasin: 50%: $9.46 75%: $10.63 100%: $5.81	

Title	Author	Publish Date	Type of Value	Methodology	Date of Data	Recreation Activities	Study Area	Valuation Results: Total	Average	Incremental/Marginal
Single-Stage and Two-Stage Decision Modeling of the Recreational Demand for Water and National Estimates of the Recreational Value of Streamflow	L. Hansen and J. Hallam	1990	Recreation use	Use estimation modeling applied to values from 1980 FHWAR Survey	1980 FHWAR	Fishing	Nation		Values per AF for bass and trout by WRC's Aggregated Subareas (ASA) ranged from: Trout: $0.12 to $140.97 Bass: $0.13 to $105.70	
A Methodology for Quantifying and Valuing the Impacts of Flow Changes on a Fishery	D. Harpman, E. Sparling, and T. Waddle	1993	Recreation use	CVM (dichotomous choice), biological model (links flows to catch)	October 1989	Trout fishing	Taylor River, CO			Marginal value of a change in catch per day ranged from $1.98 (at 2 fish caught) to $0.31 (at 12 fish caught)
Benefits of Increased Streamflow: The Case of the John Day River Steelhead Fishery	N. Johnson and R. Adams	1988	Recreation use	CVM (open-ended), Total Benefits Function	1986-87	Steelhead fishing	John Day River, OR			Marginal value of an additional AF from mean flows: spring: - $0.32 summer: $2.36 winter: $0.18
Economic Benefits of Instream Flow to Fisheries: A Case Study of California's Feather River	J. Loomis and J. Cooper	1990	Recreation use	TCM (zonal)	1981-85	Fishing	Feather River, CA	Initial: $108.5K 20 cfs increase: $109.9K 100 cfs increase: $114.1K 200 cfs increase: $117.6K		20 cfs increase: $72.90 100 cfs increase: $56.72 200 cfs increase: $45.70

Title	Author	Publish Date	Type of Value	Methodology	Date of Data	Recreation Activities	Study Area	Valuation Results: Total	Average	Incremental/Marginal
Recreation Benefits of Increased Flows in California's San Joaquin and Stanislaus Rivers	J. Loomis and M. Creel	1992	Recreation use	TCM (individual)	1989	Fishing, hunting, wildlife viewing	San Joaquin, Stanislaus Rivers, CA			San Joaquin (add'l 62,800 AF): ranges from $45.22 to $116.43 depending on when water is obtained Stanislaus (add'l 10,000 AF): ranges from $10.83 to $13.45
An Economic Approach to Giving "Equal Consideration" to Environmental Values in FERC Hydropower Relicensing	J. Loomis and M. Feldman	1995	Recreation use	CVM (payment card and open-ended), contingent behavior	June 1994	Sightseeing	Withheld			Annual marginal benefits for a one unit change in cfs ranged from nearly $1100 at 100 cfs to just over $200 at 900 cfs.
Evaluation of Recreational Benefits of Instream Flows	R. Narayanan	1986	Recreation use	TCM (zonal), and contingent behavior	July - Sept. 1982	Fishing, picnicking, camping, hiking	Blacksmith Fork River, UT			Marginal benefits associated with an AF reduction in flows ranged from $0.01 at 100% of 1982 flows to $0.86 at 50%.
The Economic Value of Instream Flows in Montana: A Travel Cost Model Approach	C. Neher	1989	Recreation use	TCM (zonal)	1982, 1983, 1985	Fishing	19 Montana trout streams			Values per AF associated with a 25% decrease in flows from 1985 levels: Bitterroot: $6.54 Clark Fork: $0.61 Flathead: $0.22 Yellowstone: $5.09

Title	Author	Publish Date	Type of Value	Methodology	Date of Data	Recreation Activities	Study Area	Valuation Results: Total	Average	Incremental/Marginal
Toward Empirical Estimation of the Total Value of Protecting Rivers	L. Sanders, R. Walsh, and J. Loomis	1990	Recreation Use and Nonuse	CVM (open-ended)	1983	General recreation (activities not specified)	15 Colorado Rivers		Annual value per household: (1) Three most valuable rivers (Poudre, Elk, Colorado): recreation use: $7.54 nonuse: $32.26 total: $39.80 (2) Fifteen most valuable rivers: recreation use: $19.16 nonuse: $81.96 total: $101.12	
An Empirical Application of a Model for Estimating the Recreation Value of Instream Flow	R. Walsh, R. Ericson, D. Arosteguy, and M. Hansen	1980	Recreation Use	CVM (open-ended), Contingent Behavior	June - August 1978	Trout fishing, rafting, kayaking	Nine West Slope Colorado rivers			Marginal value per AF per day (60 miles): fishing: $13.08 kayaking: $3.60 rafting: $2.36

Title	Author	Publish Date	Type of Value	Methodology	Date of Data	Recreation Activities	Study Area	Valuation Results: Total	Average	Incremental/Marginal
Optimally Managing Wild Rivers for Instream Benefits and Economics of Water Allocation to Instream Uses in a Fully Appropriated River Basin: Evidence From a New Mexico Wild River	F. Ward	1984, 1987	Recreation Use	TCM (individual), Total Benefits Function, and Dynamic Programming	May to August 1982	Fishing, rafting/tubing, kayaking	Rio Chama, NM	Fishing: total annual benefits peaked at 500cfs ($607K) Boating: total annual benefits peaked at 2000 cfs ($2056.9K)		
Glen Canyon Environmental Studies Non-Use Value Study	M. Welsh, R. Bishop, M. Phillips, and R. Baumgartner	1995	Nonuse	CVM (dichotomous choice)	October 1994 to January 1995	N/A (nonuse study)	Glen Canyon NRA & Grand Canyon NP, AZ	National Sample: (also surveyed a regional sample) 1. Moderate Fluctuating Flow: $2,286.4M annually 2. Low Fluctuating Flow: $3,375.2M annually 3. Seasonal Steady Flow: $3,442.2M annually	National Sample: 1. Moderate Fluctuating Flow: $13.56 per household annually 2. Low Fluctuating Flow: $20.15 per household annually 3. Seasonal Steady Flow: $20.55 per household annually	

Title	Author	Publish Date	Type of Value	Methodology	Date of Data	Recreation Activities	Study Area	Valuation Results:		
								Total	Average	Incremental/Marginal
Angling and recreation values of low-flow alleviation in rivers	K. Willis and G. Garrod	1999	Recreation use and nonuse	CVM (open-ended, iterative bid, dichotomous choice), Contingent Behavior	1996	Fishing, swimming, shoreline uses (hiking, sightseeing)	Seven rivers in England		Value for moving from low flow to natural flow: Anglers: £71.34 or £25.28 (syndicate vs club) per year	Marginal value of one less mile of low flow river: Combined anglers and nonanglers: £0.058

5.0 CONCLUSIONS

This paper deals with the economic valuation of instream flows. Contrary to the often held position that water leFt. in a stream goes wasted, the economics literature clearly suggests that instream flows can be quite valuable. Instream flow may provide benefits to recreation, hydropower, navigation, fish and wildlife, water quality, nonuse values, etc. As a result, allocation of water between instream uses and off-stream uses, such as agricultural and municipal/industrial uses, can be very important. This is particularly true in the arid western United States where water is scarce. While reallocations of water in the West are somewhat hampered by legally held water rights, the creation of water markets in recent years has begun to allow for the transfer of water toward its highest valued use, including instream flows.

Economic analysis can play a useful role in water allocation decisions. Economic theory provides guidance for both determining optimal allocations (equal marginal rule) and assisting decision makers in moving toward more optimal allocations (positive net benefits). The most complex part of the economic analysis is estimating the values for each competing use. This paper deals with two of the more difficult valuations: recreation and nonuse benefits. Nonuse benefits refer to the values that people hold for preserving a resource even when they never expect to use it. Recreation and nonuse values are especially difficult to estimate because they are not exchanged within a market setting. Fortunately, over the past 30 years, sophisticated nonmarket valuation approaches have been developed.

Two nonmarket approaches, the travel cost method (TCM) and the contingent valuation method (CVM), have been approved for use by Federal Government analysts in estimating recreation values. While still somewhat contentious, nonuse values can be estimated only by using CVM. Careful use of CVM for nonuse valuation has been approved in Department of the Interior environmental damage assessments. TCM studies must rely on either the pooling of data across sites or a sufficiently long time series of data to estimate a recreation demand model. While CVM requires the use of Office of Management and Budget approved surveys, it has the advantage of gathering value responses from individuals across a wide range of flow issues. Given the need in recreation valuation to measure changes in both value per trip and number of trips, CVM surveys often also incorporate contingent behavior questions to determine how recreator visitation might be affected by instream flow changes. Most instream flow valuation studies, to date, have relied on the CVM approach because of its inherent flexibility and ability to address both recreation use and nonuse values.

The range of literature is fairly extensive on the economic valuation of instream flow from a recreation and nonuse perspective. Virtually all the effort to date has gone into original research, with very little ink devoted to the concept of benefits transfer. Benefits transfer refers to the reuse or transfer of values or statistical models from the original study to a policy application at a different site. Government analysts often pursue benefit transfers because they are less time consuming and costly than original research. However, benefit transfer applications would need to be conducted with great care because instream flow values are very site and situation specific. The question arises whether benefit transfers of nonuse values is a legitimate exercise, even when dealing with the same fish or wildlife species. Despite the difficulties, use of benefits transfer may be possible within the context of instream flow valuation. One benefits transfer study dealt with the problem of flow differences between the study and policy sites by indexing flows as a percentage of optimal flows for each activity before transferring values.

Both TCM and CVM approaches can be used to estimate statistical relationships between flow and recreation visitation or value. The relationship for recreation is typically assumed to reflect a bell shape. As a result, recreation activities are normally pursued only within a certain flow range, the extremes of which represent thresholds where visitation/value ceases. As flows increase from the lower flow threshold, visitation/value also increases. At some point, visitation/value reaches its optimum. Upon reaching the optimum, additional flows reduce visitation/value until the upper flow threshold is achieved and visitation/value drops to zero. This relationship generally holds for all activities, regardless of whether they are water dependent (fishing, boating, swimming) or water influenced (camping, picnicking, sightseeing). The threshold flows and optimal flows normally vary by recreation activity, river, and even reach of river.

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MISSION STATEMENTS

The Mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to tribes.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.