This chapter presents case studies that demonstrate how non-power benefits can be valued and integrated into the relicensing decision. The focus is on reviewing and applying the economic valuation methods discussed in Chapters 5 and 6. Some of these cases describe primary research performed by resource economists while others demonstrate benefits transfer applications. Specifically, we examine the following cases:

- The use of benefits transfer to value increased instream flow below the Morris Sheppard Dam in Texas.

- The use of contingent valuation to estimate total benefits (use and non-use) associated with removal of the Elwah and Glines Canyon dams in Washington State.

- Estimation of recreational fishing and rafting benefits associated with removal of Edwards Dam in Maine, relying on both original research and benefits transfer.

- The use of contingent valuation to assess willingness to pay for increased flow over a scenic waterfall in Idaho.

MORRIS SHEPPARD DAM: VALUATION OF INSTREAM FLOW USING BENEFITS TRANSFER

The Brazos River Authority (BRA) operates the Morris Sheppard Dam Water Power Project on the Brazos River in north-central Texas (FERC Project No. 1490-003). Constructed in 1941, the project consists of a 155-foot dam, Possum Kingdom Lake (the project reservoir), an intake structure, powerhouse, and several other minor components. The project's primary purpose is to supply water for municipal, industrial, and agricultural use. Power generation is a secondary service of the project and is supplied in peaking mode. The project has an annual energy output of 37.6 gigawatt hours (GWh) and BRA sells the power to a regional electrical cooperative.[1]

BRA filed for a new license in 1985, and following a series of application supplements, a license was awarded in 1988. The environmental assessment (EA) for the project provides a detailed analysis of the central consideration in the relicensing action: establishing the optimum level of minimum flows required for the river below the dam. The licensing action and the analysis applied in FERC's EA represent a useful case study for the following reasons:

- The analysis demonstrates FERC's acceptance of non-power values as a legitimate consideration in making relicensing decisions. Indeed, the analysis performed has been cited as an example of FERC's willingness and ability to balance competing uses of a resource, partly through consideration of non-power economic benefits.[2]

- The analysis demonstrates FERC's acceptance of benefits transfer techniques in estimating non-power benefits.

- The EA provides a good example of the competing considerations associated with instream flow restoration when the project has multiple purposes (e.g., hydropower, water supply, and recreation).

This case study focuses on the use of benefits transfer to value the recreation associated with increased instream flow and on the competing economic considerations that FERC weighed in licensing the Morris Sheppard project.

Licensing Alternatives

As is frequently the case, the Morris Sheppard relicensing called on FERC to develop a compromise set of operating conditions that combined the concerns of two key parties: the licensee (BRA) and state and federal resource management agencies. Two considerations dominated the analysis performed. First, most of the EA focused on the need to increase the minimum level of instream flow in the Brazos River. DOI and the Texas Parks and Wildlife Department (TPWD) argued for increased flows to enhance fish, wildlife, recreation, and aesthetic resources downstream from the dam. Leakage from the dam maintains minimum instream flows of between only 15 and 25 cfs. When water is released for power generation, flows typically reach about 2,600 cfs and can reach as high as 18,000 cfs; such releases occur only periodically given the secondary nature of hydropower at the project. These conditions reduce habitat for many fish species and stress downstream areas through effects on dissolved oxygen levels and water temperature.

The major competing concern was the depth of Possum Kingdom Lake. With over 17,000 surface acres and 310 miles of shoreline, the reservoir is a major recreational resource in the area. BRA argued that higher reservoir levels were essential to reliable power and water supplies. In addition, an organization representing landowners around the reservoir argued that changes in the water level would impede reservoir recreation and affect home values.

These competing concerns resulted in the following license alternatives:

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[1] Unless otherwise noted, all information in this case is drawn from FERC, *Environmental Assessment for Hydropower License: Morris Sheppard Dam Water Power Project*, FERC Project No. 1490-003, December 22, 1988.

[2] See Grimm, Lydia T., "Fishery Protection and FERC Hydropower Relicensing Under EPCA: Maintaining a Deadly Status Quo," *Environmental Law*, Vol. 20:929, pp. 929-073, 1990.

- The resource agencies proposed requiring minimum flows on a seasonal schedule, as follows:

  - March through June – 100 cfs
  - July through September – 75 cfs
  - October through February – 50 cfs

- BRA accepted the need for minimum flows but sought requirements regarding when the flow should be suspended to conserve reservoir storage. Specifically, BRA agreed to the agency-proposed flows when reservoir levels are above 997 feet (msl). The required flows would drop to half the agency proposal when reservoir levels are between 997 and 995 feet, and no release would be required for reservoir levels below 995 feet.

- FERC balanced the two proposals by requiring the proposed minimum flow levels while adopting a less restrictive set of reservoir level conditions. Specifically, flows would be maintained when reservoir levels exceeded 994.5 feet. At levels between 994.5 and 990 feet, required flow would be half the agency proposal, and at levels below 990 feet, flow requirements would be suspended.

<u>Non-Power Benefits Analysis</u>

In the Morris Sheppard EA, FERC applied much the same approach to valuing instream flow as was reviewed in Chapter 6. As noted, economists have developed a number of studies that value instream flow on the basis of recreation and other uses of rivers. In Chapter 6, we reviewed these studies and discussed how estimates of the marginal value per acre-foot of water can be used in a benefits transfer framework. Specifically, FERC estimated the annual amount of flow that would be restored under the various licensing alternatives and multiplied this quantity by the marginal value of instream flow to estimate the total annual value of downstream recreational activity.

As in any benefits transfer, identifying appropriate existing studies for the policy site represents a key step. To value instream flow, FERC relied on Ward's 1987 study of the Rio Chama in New Mexico. Ward used a travel cost model to estimate willingness to pay for increased instream flow. Several aspects of this study made it appropriate for application to the Brazos River and the Morris Sheppard project:

- First, the Ward study focused on issues similar to those at the Morris Sheppard project, i.e., how best to balance competing considerations of instream flow and reservoir management.

- Like the Rio Chama, the Brazos River offers both fishing and boating in areas downstream of the reservoir.

- As with the Rio Chama, the Brazos is a regionally important resource, with few available substitutes and relatively heavy recreational use.

Ward estimated a willingness to pay of $27 ($1986) per acre-foot under low flow conditions. FERC combined this figure with the expected quantity of water released under each licensing alternative.[3] Exhibit 7-1 summarizes the estimated value of increased instream flow under the three alternatives. As shown, the agencies' proposal would lead to the greatest releases (and greatest recreational benefits) because of the absence of conditions under which flow requirements would be suspended. BRA's reservoir level requirements would lead to relatively minor flow increases, with minimum flow released only 28 percent of the time. FERC's intermediate alternative would result in significant flow increases while still preserving reservoir conditions (see below). The total estimated annual recreational benefits associated with the maintenance of minimum flows under FERC's alternative is approximately $400,000 ($1986).

[3] These quantities are a function of the desired minimum flows as well as the anticipated frequency with which flow requirements would be suspended, based on historical reservoir levels.

Exhibit 7-1 INSTREAM FLOW BENEFITS AND ASSOCIATED COSTS FOR MORRIS SHEPPARD DAM RELICENSING ALTERNATIVES			
	Resource Agencies	**BRA**	**FERC**
Description of alternative	Minimum flows: - March-June, 100 cfs - July-September, 75 cfs - October-February, 50 cfs	Same minimum flow requirements but coupled with strict reservoir level requirements that would suspend minimum flows.	Same minimum flow requirements but coupled with modest reservoir level requirements.
Percent of time that minimum flow is released	100%	28%	74%
Total acre-feet released	24,748	1,366	15,114
Value of instream flow ($1986)	$668,196	$36,882	$408,078
Change in reservoir depth (feet)	-1.5	-0.2	-0.4
Effect on reservoir recreation and surrounding property values	Potentially significant	Minor	Minor
Value of lost power generation ($1986)	$33,800	$9,720	$17,720
Value of lost dependable water supply yield ($1986)	$4,044,000	$240,000	$432,000
Percent of total water supply yield	21.5%	1.3%	2.3%
Source: FERC, *Environmental Assessment for Hydropower License: Morris Sheppard Dam Water Power Project*, FERC Project No. 1490-003, December 22, 1988.			

Comparison of Instream Flow Benefits to Adverse Effects

In the Morris Sheppard EA, FERC used quantitative and qualitative information to examine the costs associated with increasing flow to the Brazos River. Exhibit 7-1 summarizes the factors that FERC considered in evaluating the competing proposals. Most notably, FERC examined residents' concerns that increased instream flow and the associated reservoir drawdown would affect recreation at Possum Kingdom Lake and potentially decrease the value of surrounding property. Possum Kingdom Lake is a major recreational resource offering swimming, boating, diving, camping, and other activities. However, available data for the north-central Texas region suggest a surplus of lake-based recreational activity and a severe shortage of river-based opportunities. Furthermore, FERC identified reservoir storage conservation levels that maintain minimum instream flows the majority of the time, without producing large changes in reservoir levels. Therefore, while FERC could not rule out minor effects on reservoir recreation under its preferred alternative, it appropriately acknowledged the shortage of river resources and therefore supported maintenance of instream flows with only modest reservoir level restrictions.

Other impacts of increasing instream flows relate to power generation and water supply. FERC valued the reduced power generation based on the cost of replacement power ($0.04 per kWh). As shown in Exhibit 7-1, the value of lost generation is minor under all alternatives given that power generation is a secondary function of the project. The total value of reduced power generation under FERC's alternative ($17,720) represents only about one percent of the total value of power generated at the Morris Sheppard project.

Finally, FERC considered how minimum instream flow requirements would affect BRA's ability to supply water to municipal, industrial, and agricultural users. In valuing potential losses in water supply, BRA considered losses in "dependable yield". Dependable yield is defined as the amount of water that can be withdrawn from a reservoir during each year of the most severe recorded drought without exhausting the water supply under anticipated future water demand conditions. Therefore, the loss represents the potential worst-case shortfall in water sales for BRA, a relatively conservative measure. As shown in the exhibit, the value of yield losses under the agencies proposal is high, exceeding $4 million. The losses anticipated under the other two alternatives are much smaller, with losses under the FERC proposal of about $430,000.

Overall, FERC observed that their preferred alternative would have little effect on reservoir recreation while causing power and water supply losses roughly commensurate with the recreational benefits of restoring instream flow.

Potential Refinements

The Morris Sheppard relicensing demonstrates FERC's ability to balance developmental and non-developmental considerations, partly through economic analysis of non-developmental benefits. While the economic analysis performed was an improvement on the more qualitative analysis typically developed, other non-power benefits may warrant investigation. Most notably, non-use benefits associated with increased streamflow could be significant. At the time of the EA, the 120-mile stretch of the Brazos River below the Morris Sheppard dam was listed on the Nationwide Rivers Inventory for its scenic, recreational, wildlife, and vegetation value. In general, few (if any) substitutes exist in the area. This status suggests that individuals may hold existence and bequest values for the river and restoration of the resource. The magnitude of such benefits would depend upon the extent of the market and other factors.

ELWAH AND GLINES CANYON DAMS: USING CONTINGENT VALUATION TO ESTIMATE DAM REMOVAL BENEFITS

Located on the Elwah River in Washington State, the Elwah and Glines Canyon dams (FERC No. 2683 and No. 588, respectively) have been the subject of significant controversy. The dams generate about 172 GWh, roughly 43 percent of the power supply needed by the pulp and paper mill that owns and operates the dams. When considered for relicensing beginning in the 1970s, the dams attracted the attention of resource agencies and environmental organizations because of concerns over declining salmon and steelhead populations in the Pacific Northwest. Constructed in 1913 and 1927, the dams have no fish passage facilities and prevent spawning on 70 of the 75 miles of the Elwah River. In addition, the majority of the Elwah river flows through Olympic National Park and is therefore largely unaffected by logging, withdrawals, or other ecological stressors common in the region.[4]

In 1992, the Elwah River Ecosystem and Restoration Act called for federal and state agencies to consider how removal of the Elwah and Glines Canyon dams would aid in the restoration of the Elwah River fisheries. Studies undertaken by FERC and DOI have concluded that removal of the dams would have a significant positive impact on salmon and steelhead populations and the overall river ecosystem.

This case focuses on the economic analysis performed by John Loomis of Colorado State University. Loomis developed a contingent valuation survey to measure the total economic value, both use and non-use, associated with removal of the dams. As we review below, the survey asked local, state, and national respondents to specify their willingness to pay for removal of the dams and restoration of the Elwah River. This study represents a useful case study for the following reasons:

[4] Unless otherwise noted, information presented in this case is drawn from Loomis, John B., "Measuring the Economic Benefits of Removing Dams and Restoring the Elwah River: Results of a Contingent Valuation Survey," *Water Resources Research*, Vol. 32, No. 2, pp. 441-447, February 1996; and Olympic National Park, National Park Service, *Final Environmental Impact Statement, Elwah River Ecosystem Restoration*, June 1995.

- First, the study is one of only two analyses specifically designed to measure the total economic value of dam removal.

- Furthermore, the survey structure and analytic techniques applied are characteristic of a full-scale contingent valuation study and are therefore potentially instructive for parties considering similar studies.

The discussion below is divided into several topics:

- The design and implementation of the contingent valuation survey;

- The results of the survey and the estimate of aggregate willingness to pay; and

- A comparison of the estimated benefits to the estimated costs of dam removal.

Survey Design and Implementation

The preparation and ultimate structure of the survey used by Loomis is representative of the steps involved in contingent valuation. Below, we review the preliminary steps in developing the survey and the content of the final survey instrument.

Survey Development

The development of the survey instrument for the Loomis study demonstrates several essential preliminary steps in assembling an effective contingent valuation survey. The study managers first met with DOI and tribal science experts to accurately characterize the Elwah ecosystem and the anticipated effects of dam removal. This information was used in focus groups designed to elicit information on individuals' perceptions of the Elwah River and similar natural resources.[5] In particular, the study managers explored whether they could clearly convey information about dam removal and its effect on salmon recovery. The focus groups also helped the study managers craft a payment mechanism (i.e., the hypothetical circumstances under which respondents would pay for the river restoration) that respondents would view as balanced and fair.

Finally, the study managers conducted thorough pre-testing of the draft survey instrument on groups both within and outside of Washington State. The pre-test asked respondent to fill out the draft survey as well as answer debriefing questions designed to verify that respondents understood the questions and supporting materials.

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[5] The focus groups were conducted both locally (Port Angeles and Seattle, Washington) and in a remote location (Boston, Massachusetts).

Final Survey Content

The survey ultimately implemented began with information and questions designed to attune the respondent to the resource in question. Respondents were first offered a description of the Elwah River (including maps), the dams, and a brief history of the area. The survey also posed a number of questions to elicit contextual information such as why the respondent cares about river restoration and how he or she feels about hydroelectric dams. Such information is intended to help the study managers better understand the willingness to pay bids provided.

Next, the survey defined the change in the Elwah River to be valued. Specifically, respondents were asked to value the removal of the dams, the restoration of the river to a "pre-dam" state, and increases in several fish species. Maps were used to illustrate the addition to spawning habitat that dam removal would provide. Expected changes in salmon and steelhead populations were summarized in bar charts.

The chosen payment mechanism was a closed-ended or dichotomous choice format. That is, rather than simply asking respondents to state their willingness to pay for the resource, respondents were presented with specific payment amounts on which they "voted" yes or no. Specifically, the question was worded as follows:

> If an increase in your federal taxes for the next ten years costs your household $X each year to remove the two dams and restore both the river and fish populations, would you vote in favor?

Respondents were faced with 15 different bid options, ranging from $3 to $190.

When responding to contingent valuation surveys, many respondents offer bids of zero. Reasons for offering zero bids are diverse. Therefore, the survey posed follow-up questions exploring (where relevant) the respondent's reasons for offering a bid of zero. For example, some respondents indicated an inability to pay, a concern over how the cost burden of dam removal would be distributed over different groups, or a general lack of support for new government programs.

Survey Implementation

The study managers administered the survey by mail to approximately 2,500 randomly selected households in Clallam County (where the dams are located), Washington State, and the U.S. outside of Washington State. Exhibit 7-2 shows the distribution to the different groups and the response rate for each group.

Exhibit 7-2

SAMPLE FRAME AND RESPONSE RATES

Respondent Group	Number of Surveys Issued	Response Rate
Clallam County	600	77 percent
Washington State	900	68 percent
U.S. (other than WA)	1,000	55 percent
Source: Loomis, 1996.		

Response rates are essential because of the potential for non-response bias. That is, if only a small subset of those receiving the survey respond, the characteristics of this responding group may produce biased results. This would be true, for example, if individuals with a higher willingness to pay are systematically more likely to return the survey. Overall, the response rates for Clallam County and the rest of Washington are good, although Loomis acknowledges that the 55 percent response rate for the rest of the U.S. presents some potential for non-response bias.

Results of the Contingent Valuation Survey

The analysis developed for the survey estimated a mean willingness to pay per household for the three different sample groups.[6] As noted, these figures represent average total value -- use and non-use -- associated with removal of the dams and restoration of the fish populations. The mean willingness to pay (WTP) for each group is presented in Exhibit 7-3. As shown, Clallam County residents had the lowest mean WTP. This is likely due to the higher proportion of zero bids from this group. Follow-up questions suggested that Clallam County residents were more likely to express skepticism over the effects of dam removal and the value of the expected changes.

Exhibit 7-3

ESTIMATED WILLINGNESS TO PAY PER HOUSEHOLD AND ASSOCIATED AGGREGATE WILLINGNESS TO PAY

Respondent Group	Mean Annual WTP per Household ($1996)	Aggregate Annual WTP ($1996)	
		Low	High
Clallam County	$59	$94 million (all of Washington)	$138 million (all of Washington)
Washington State	$73		
U.S.	$68	$3.376 billion	$6.137 billion
	TOTAL:	$3.470 billion	$6.275 billion
Source: Loomis, 1996.			

The estimates of mean WTP were multiplied by the relevant populations to arrive at aggregate WTP estimates. The study author developed a conservative lower-bound estimate by assuming that those not responding to the survey had a WTP of zero. The higher estimate assumes that non-respondents would have the same WTP as respondents. As shown, the aggregate willingness to pay for Washington residents only is estimated to be between $94 and $138 million per year for 10 years (consistent with the wording of the survey question). The extrapolation to the remainder of the U.S. population yields very large estimates of annual willingness to pay, between $3.4 and $6.1 billion.

Comparison of Benefits to Costs

[6] Specifically, the author used logistic regression to estimate the probability of a "yes" response based on the dollar amount in question.

The benefits of removing the Elwah and Glines Canyon dams can be compared to the two major categories of removal costs: (1) the costs of acquiring and physically removing the dams; and (2) the cost of foregone gross power benefits (i.e., the increased cost to society of generating the electricity formerly generated at the dams). As shown in Exhibit 7-4, the dam removal costs, including property acquisition and water quality and flood protection costs, total between $75 and $101 million. The present value of increased power generation costs realized over 30 years ranges between $55 million and $106 million depending upon the discount rate used. Therefore, the present value of dam removal costs is between $130 and $207 million.

Exhibit 7-4

COMPARISON OF BENEFITS AND COSTS ASSOCIATED WITH REMOVAL OF ELWAH AND GLINES CANYON DAMS

		Lower Bound Present Value[1] ($1996)	**Upper Bound Present Value[2] ($1996)**
Benefits[3]	Washington State	$660 million	$1.2 billion
	Rest of U.S.	$23.7 billion	$55.1 billion
Costs	Dam Removal	$75 million	$101 million
	Foregone Power Benefits[4]	$55.5 million	$106.1 million
	TOTAL COSTS:	$130.5 million	$207.1 million

1. Lower bound uses a seven percent discount rate and lower annual benefit and cost estimates.
2. Upper bound uses a two percent discount rate and higher annual benefit and cost estimates.
3. Benefits are discounted over the ten year period specified in Loomis survey.
4. Foregone power costs represent power costs under the preferred dam removal alternative minus costs under the no action alternative, based on annual figures presented in Table 8 of the NPS FEIS. Costs are discounted over 30 years.

Source: Olympic National Park, National Park Service, *Final Environmental Impact Statement, Elwah River Ecosystem Restoration*, June 1995.

The present value of dam removal costs are only a small fraction of the benefits estimated in the Loomis study. The annual aggregate willingness to pay figures discussed above can be placed in present value terms by discounting across the 10 years specified in the willingness to pay survey question.[7] Exhibit 7-4 shows that the present value of the benefits *for Washington State only* greatly exceeds the estimated costs; adding in willingness to pay from households nationwide leads to extremely large benefit estimates. This is important because questions regarding the extent of the market for the Elwah River ecosystem can be largely disregarded. That is, state residents are likely to know the resource better and therefore have more reasoned and reliable statements of willingness to pay. Based only on these more reliable estimates for in-state respondents, the benefits of dam removal still appear to exceed the costs.

[7] We assume that the benefits will accrue in years one through 10 of the present value calculation. It is noteworthy that even if benefits do not accrue until years 21 through 30, benefits still exceed costs.

EDWARDS DAM: APPLYING PRIMARY AND SECONDARY METHODS TO COMPARE DAM REMOVAL COSTS TO RECREATIONAL BENEFITS

The planned removal of Edwards Dam in Maine represents perhaps the most visible and publicized relicensing decision that FERC has made. Located on the lower Kennebec River, the dam was constructed in 1837 to provide power for local mills. Recently, the dam owners (Edwards Manufacturing) have sold the power to the Central Maine Power Company. Federal and state agencies, environmentalists, academics, and other groups have studied the project extensively, primarily because of its effects on the passage of anadromous fish native to the area.[8]

FERC has recommended dam removal for several reasons. First, Edwards Dam is the furthest downstream in a series of hydropower projects on the Kennebec. Dam removal would allow several fish species access to 17 miles of spawning habitat between Edwards Dam and dams further upstream. Second, while fish passage facilities would potentially achieve fishery restoration goals, the cost of these facilities was found to be greater than the cost of dam removal and the associated power losses. Overall, FERC recognized that dam removal would have substantial benefits for anglers, boaters, and other recreationalists.

Although FERC elected for dam removal, the EIS for the project did not explicitly incorporate estimates of the economic value of recreational benefits. A number of intervenors developed economic studies and sought to introduce the findings into the relicensing process, however. Therefore, the purpose of this case study is to review some of these findings and develop additional estimates to illustrate how non-power values could have been more fully contrasted with dam removal costs. Specifically, the case study objectives include the following:

- Review the results of a contingent valuation study estimating the benefits of improved recreational fishing on the Kennebec River;
- Use benefits transfer to develop screening-level estimates of the benefits associated with whitewater rafting opportunities created by dam removal; and
- Compare these recreational benefits to the costs of dam removal.

[8] Unless otherwise noted, information on Edwards Dam is drawn from FERC, *Final Environmental Impact Statement, Kennebec River Basin, Maine*, FEIS-0097, July 1997.

Value of Improved Recreational Fishing

As noted, Edwards Dam has been the subject of extensive study. Among the analyses produced is a contingent valuation study by Boyle, et al. that estimates anglers' willingness to pay for the fishery improvements associated with removal of Edwards Dam.[9] While a variety of benefits transfer approaches may be feasible for characterizing fishing benefits on the Kennebec, this original research is targeted specifically on the site and commodity in question, and therefore probably provides the most reliable estimates of potential economic benefits. This section reviews the results of the Boyle, et al. study as well as critiques suggesting that the study may underestimate the economic benefits of dam removal.

Structure of Boyle, et al. CV Study

The key economic benefit associated with dam removal is the restoration of anadromous fisheries on the Kennebec. Boyle, et al. developed a contingent valuation study to gauge anglers' willingness to pay for the addition of riverine fishing areas and the enhanced catch rates for key species. Specifically, the study presented respondents with information on how species would recover under two scenarios: (1) installation of fish passage facilities; and (2) dam removal. For example, the survey described dam removal effects on Atlantic salmon, striped bass, and other species, noting the point in time at which a sport fishery would likely be supportable.

The survey used an "open-ended" question format to elicit willingness to pay. Respondents were asked to state their maximum willingness to pay to purchase membership in a non-profit corporation that would accomplish the objectives of the given scenario (e.g., dam removal).

The survey was administered to anglers holding a Maine inland fishing license. The sample included anglers from three groups: anglers living adjacent to the Kennebec, Maine resident anglers not adjacent to the Kennebec, and anglers from out of state. A total of 810 anglers received the survey.

Boyle, et al. Findings

For the dam removal scenario, Boyle et al. estimated a total aggregate willingness to pay of about $1.4 million per year ($1990). This estimate is derived by multiplying the total number of anglers offering non-zero bids (based on the sample for each angler subgroup) by the average bid for each angler subgroup. The average willingness to pay per angler ranged from a low of $10.45 for non-residents to a high of about $16 for anglers living adjacent to the river. Exhibit 7-5 presents the estimates in more detail.

Exhibit 7-5

WILLINGNESS TO PAY FOR REMOVAL OF EDWARDS DAM AS ESTIMATED BY BOYLE, ET AL.

Angler Group	Average Annual WTP ($1990)	Angler Population Represented	Percent Offering Bid of $0	Aggregate Annual WTP ($1990)
Adjacent	$15.97	12,771	45%	$112,174
Non-Adjacent Residents	$12.09	202,166	62%	$928,791
Non-Residents	$10.45	98,063	67%	$338,170

[9] Boyle, Kevin J., Mario F. Teisl, John R. Moring, and Stephen D. Reiling, *Economic Benefits Accruing to Sport Fisheries on the Lower Kennebec River from the Provision of Fish Passage at Edwards Dam or from the Removal of Edwards Dam*, prepared for Maine Department of Marine Resources, July 1991.

TOTAL:	$1.38 million
Source: Boyle, et al., 1991.	

Uncertainties

Reviewers have noted key aspects of the Boyle, et al. study that may lead to underestimation of recreational fishing benefits created by removal of Edwards Dam.[10] Two issues are most important. First, the population addressed by the survey may not represent all anglers holding values for dam removal. Specifically, Boyle, et al. sampled individuals holding inland fishing licenses. An inland fishing license is not required to fish tidal waters in Maine. Individuals who fish in tidal waters and do not hold an inland license include salmon and striped bass anglers who would benefit from dam removal, but who are not represented in the Boyle, et al. study.

Second, Boyle, et al. did not identify and characterize "protest zero" bids in the contingent valuation survey. A respondent's rationale for expressing a willingness to pay of zero for dam removal may range from true lack of interest in the commodity to rejection of a specific aspect of the survey. Individuals in the latter category may actually value dam removal and fishery restoration, but may express a willingness to pay of zero in protest of the aspect of the survey with which they disagree. Contingent valuation surveys frequently exclude these zero values when estimating average willingness to pay. To the extent that they exist in the Boyle, et al. survey data, these protest zeros will decrease the average estimated willingness to pay for dam removal.

[10] See Freeman, A. Myrick, *The Economic Benefits of Removing Edwards Dam*, May 31, 1995 (unpublished).

Value of Whitewater Rafting

Several sources have noted the increased whitewater boating opportunities that would be created by removal of Edwards Dam.[11] However, no estimates of the economic value of this increased activity have been developed. Below, we discuss a simple benefits transfer analysis that provides screening-level estimates of the value of increased whitewater boating.

Estimate of Increased Rafting Activity

We can derive an estimate of the number of increased boating trips by considering boating activity along other stretches of the Kennebec. The Bowker, et al. study presented in our review of whitewater rafting analyses (see Chapter 6) considered whitewater rafting on the upper Kennebec river. This study estimated 36,000 commercial boating trips per year for a 28-mile reach of the upper Kennebec. This translates to about 1,300 trips per run mile of river.

In the final EIS, FERC describes the boating areas that would be created by removal of the dam. Four new areas of Class I and II rapids totaling 5.25 miles would be created. To develop an upper bound estimate of the number of rafting trips added by addition of the new whitewater areas, we can multiply the average trips per run mile from the upper Kennebec by the new rafting miles created. This yields an estimate of about 6,800 additional rafting trips per year.

This estimate should be considered an upper bound for two reasons. First, the new Class I and II rapids may not be as attractive as the more challenging Class III and IV rapids present in the upper Kennebec runs. Second, increased rafting on the lower Kennebec may simply reduce rafting on the upper Kennebec or other Maine rafting areas such that net activity does not change. In recognition of this uncertainty, we apply a lower bound estimate of rafting activity increase that is 50 percent of the upper bound estimate, i.e., 3,400 trips per year.

Value Per Rafting Trip

The next step in developing a benefits transfer estimate of the value of increased rafting is to determine the proper per-trip consumer surplus value. As with rafting activity estimates, the degree of uncertainty in the available data suggests that we should develop a range of surplus estimates. As an upper bound, we can use the per-trip consumer surplus estimate ($268) from Bowker, et al. for the upper Kennebec. This is likely to be an overestimate for two reasons, however. First, as noted, the Bowker estimates apply to a higher class of rapids than would be created in the lower Kennebec. Second, the Bowker estimates apply to trips of one to two days in length. The size of the lower Kennebec runs and their proximity to population centers (Augusta, Waterville) suggests that one-day trips would be more common than multiple-day trips.

To develop a lower bound estimate of the value per rafting trip, we rely on the full set of rafting studies reviewed in Chapter 6. The median per-trip value found in these studies was $156. Because most of the studies reviewed focus on sites with more challenging classes of whitewater (Class III and IV), this median estimate may still be too high for the lower Kennebec. Therefore, we use one half of the median estimate ($78 per trip) to value rafting on the Class I and II rapids that would be created.

Range of Annual Rafting Benefits

Combining the rafting activity and per-trip surplus estimates discussed above yields a relatively broad range of potential annual rafting benefits from removal of Edwards Dam. As shown in Exhibit 7-6, we estimate

[11] See Freeman, 1995 and FERC, FEIS-0097, p. 4-169.

annual benefits of between $265,000 and $1.8 million. This range reflects the uncertainty associated with key parameters in the benefits transfer, including the net increase in rafting activity and the consumer surplus associated with rafting in the newly created areas.

Exhibit 7-6 VALUE OF WHITEWATER RAFTING ON LOWER KENNEBEC FROM REMOVAL OF EDWARDS DAM (BASED ON BENEFITS TRANSFER)					
Rafting Activity (annual trips)		**Per-Trip Consumer Surplus ($1997)**		**Aggregate Annual Increase in Consumer Surplus ($1997)**	
Lower	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**
3,400	6,800	$78	$268	$265,200	$1,822,400
Source: IEc analysis.					

Comparison of Costs and Benefits

To examine the cost effectiveness of the removal of Edwards Dam, we can compare the benefits discussed above with the cost of dam removal. As discussed in the Elwah case, dam removal costs typically include the cost of planning and implementing the physical dam removal as well as the added cost of generating the power at another facility. Note, however, that FERC estimates that the existing project has a negative net annual benefit, i.e., replacement power could be more cheaply generated elsewhere. Therefore, we treat the cost of dam removal as solely the

cost of planning and implementing the physical removal.[12] While this estimate has been the subject of significant controversy, FERC's FEIS for Edwards Dam estimates a cost of $2.7 million ($1997) for dam removal.

To compare dam removal costs to benefits, we need to estimate the present value of the annual benefit streams discussed above. Using a discount rate of seven percent in combination with the lower bound annual benefit estimates for recreational fishing and rafting yields an estimated present value (over 30 years) of about $24 million. Using a discount rate of two percent in combination with the upper bound annual benefit estimates leads to a present value estimate of about $78 million. As shown in Exhibit 7-7, most of this variation is attributable to uncertainty in valuing whitewater rafting benefits.

Exhibit 7-7 COMPARISON OF BENEFITS AND COSTS ASSOCIATED WITH REMOVAL OF EDWARDS DAM			
		Lower Bound Present Value[1] ($1997)	**Upper Bound Present Value[2] ($1997)**
Benefits	Recreational Fishing	$20.5 million	$37.1 million
	Whitewater Rafting	$3.3 million	$40.8 million
	TOTAL:	$23.8 million	$77.9 million
Costs	Dam Removal	$2.7 million	$2.7 million

[12] Two other potential costs of dam removal are lost flatwater fishing in the impoundment above Edwards Dam and the cost of environmental externalities associated with generating replacement power at a fossil fuel facility. Freeman (1995) suggests that these costs would be minimal. Specifically, he notes that lake fishing substitutes are abundant in the area and that environmental externalities would amount to only about $6,000 to $8,000 per year.

1. Lower bound uses a seven percent discount rate and lower annual benefit estimate.
2. Upper bound uses a two percent discount rate and higher annual benefit estimate.
Source: FERC, FEIS-0097, p. 2-84, July 1997; and IEc analysis.

Overall, while the benefit estimates are subject to significant uncertainty, the benefits created by dam removal appear to greatly exceed the costs. Even when lower bound assumptions are applied, fishing and rafting benefits are about an order of magnitude greater than costs.

ASSESSING AESTHETIC BENEFITS OF INCREASED STREAMFLOW

Apart from effects on recreational activities such as rafting and fishing, dams can affect the aesthetic enjoyment of rivers. In particular, reduced flows can diminish the visual and auditory impact of scenic waterfalls. Concerns over such aesthetic resources frequently play a central role in licensing decisions. For example, in the case of the North Georgia project, flows through Tallulah Gorge were a central point of debate during relicensing.[13]

The purpose of this case study is to demonstrate methods for assessing the value of changes in the aesthetics afforded by scenic waterfalls. We focus on a study by Loomis and Feldman that used contingent valuation methods to elicit willingness to pay for increased flow to a waterfall on the Snake River in Idaho. After examining the benefits analysis, we review how this study compared the estimated marginal willingness to pay to the marginal cost of foregone power.

Overview of Loomis and Feldman Study

A recent study by Loomis and Feldman examined a potential methodology for balancing power and environmental concerns in hydropower relicensing.[14] The study analyzed individuals' willingness to pay for increased flow over a scenic waterfall on the Snake River near a dam owned and operated by Idaho Power. Impounded water is routed around a significant bypass reach, reducing flow to falls that are a popular regional sightseeing destination, attracting about 57,000 visitors annually. The study used contingent valuation techniques to determine willingness to pay for increased flow, and compared the marginal willingness to pay (i.e., willingness to pay for increments to flow) to the value of flow in hydropower production. The ultimate objective was to identify the optimal river flow level at which the marginal benefit for waterfall viewers equals the marginal cost of foregone power.

Survey Design

Loomis and Feldman used contingent valuation techniques to evaluate how flow changes would influence: (1) individuals' willingness to pay for viewing the falls; and (2) the number of trips individuals would take to the site.[15] The survey focused on use value only; that is, the survey respondents included only individuals visiting the falls. In addition, a listing of site visitors provided the basis for focus groups and pre-tests conducted during the survey instrument development.

Loomis and Feldman's survey focused on willingness to pay and anticipated trips associated with different flow levels at the falls. The authors used photographs of the falls at four different flow levels -- 50, 250, 790, and 2,000 cubic feet per second -- to convey the potential range in flows and the impact on the appearance of the falls. The central valuation questions were worded as follows:

> "…If you could spend money to be certain that the falls look like photos A, B, C, and D, how would it affect the additional amount your party would have spent to make the trip to the Falls on your last visit?"

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[13] FERC, *Final Environmental Impact Statement, North Georgia Hydroelectric Project*, FEIS-0098, June 1996.

[14] Loomis, John, and Marvin Feldman, "An Economic Approach to Giving 'Equal Consideration' to Environmental Values in FERC Hydropower Relicensing," *Rivers*, Vol. 5, No. 2, pp. 96-108, 1995.

[15] To estimate changes in visitation, the study employs a "contingent behavior" approach. Similar to contingent valuation, the contingent behavior portion of the survey asks respondents to state how they would change their behavior under hypothetical alternative situations.

> "…If you could be certain that the falls looked like photos A, B, C, and D, how would it affect the additional number of trips to the Falls you would make each year?"

Other parts of the survey gathered information on respondent characteristics such as income, age, and recreational behavior. The response rate to the mail survey was 63 percent, providing 886 usable sets of responses for the statistical analysis.

Willingness to Pay Results

Loomis and Feldman used the data gathered through the contingent valuation survey to estimate willingness to pay per person per day and the change in the number of trips to the falls, both as a function of flows. Separate models were developed for three distinct groups of visitors: local residents, other Idaho residents, and visitors from the rest of the U.S. Exhibit 7-8 presents the regression equations estimated for each of the three groups. As shown, willingness to pay was estimated as a function of flow, as well as several other variables (e.g., income, spending per visit). Likewise, the change in the number of visits was estimated as a function of flows as well as other factors.[16]

The authors then estimated total aggregate willingness to pay to view the falls at different flow levels. Two steps were involved in this calculation. First, the authors summed total willingness to pay at different flow levels across the three visitor groups, multiplying per-person willingness to pay estimates by the total number of visitors in each category. The estimated change in the number of visits per person was then applied to the baseline number of actual visits for each group to estimate the revised aggregate number of visits and total benefits at different flow levels.

[16] In all the estimated equations, the flow variable was significant at greater than 99 percent confidence. However, R^2 statistics are low for all equations (ranging from 0.025 to 0.154), indicating that only a small portion of the variance in willingness to pay and visits is explained by flow or the other variables.

Exhibit 7-8

EQUATIONS ESTIMATED FOR WILLINGNESS TO PAY PER DAY AND CHANGE IN THE NUMBER OF TRIPS PER PERSON

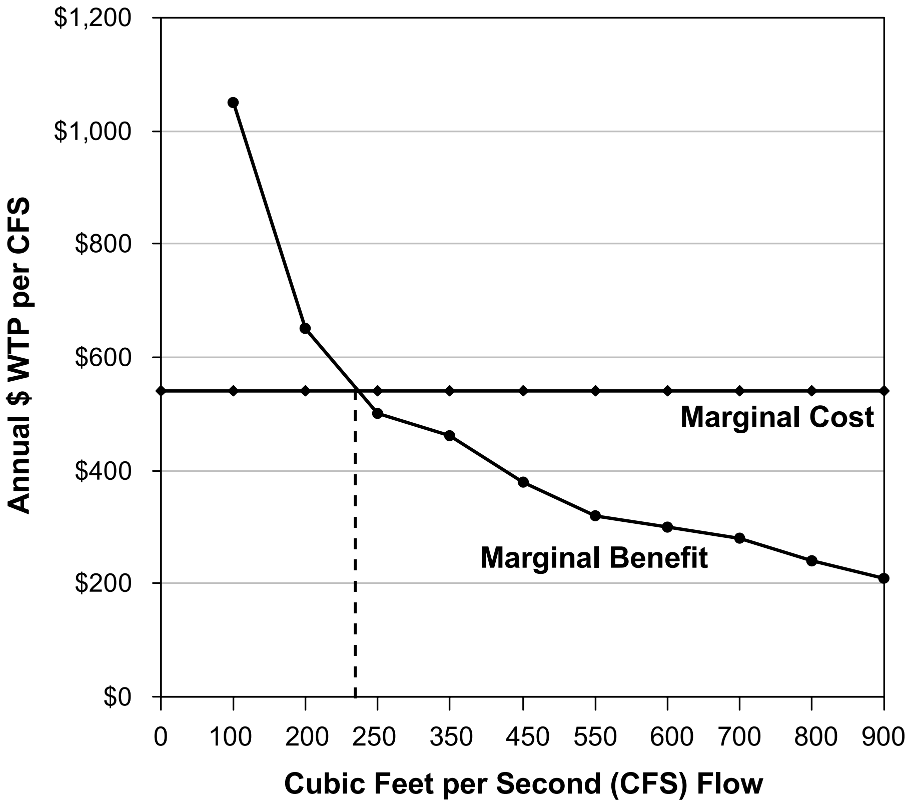
	Local Residents	Rest of State	Out of State
Willingness to Pay per Person per Day	-6.855 + 1.136 ln(FLOW) + 0.0203(INC) + 0.00946(SPEND) + 0.00943(AGE)	-3.489 + 0.65774 ln(FLOW) + 0.0494(INC) + 0.00193(SPEND) + 0.001787(AGE)	-6.438 + 1.3418 ln(FLOW) + 0.00403(INC) + 0.00158(SPEND) - 0.00097(AGE)
Change in Number of Visits	-1.8712 + 0.4022 ln(FLOW) + 0.06554 ln(ACTIVITIES) + 0.04707 ln(INC)	-3.3839 + 0.67513 ln(FLOW) + 0.15485 ln(ACTIVITIES) - 0.01728 ln(INC)	0.11423 + 0.18247 ln(FLOW) - 0.03936 ln(ACTIVITIES) - 0.27015 ln(INC)

Where:
ln(FLOW) = natural log of flow (cfs)
INC = per capita income ($1,000s)
SPEND = expenditures to visit the falls
AGE = age in years
ln(ACTIVITIES) = natural log of the number of recreational activities pursued during visit

Source: Loomis and Feldman, 1995.

The estimated total change in benefits can be placed on a marginal basis as demonstrated in Exhibit 7-9. This curve is derived by dividing the aggregate change in benefits at each flow level by the change in flow (expressed in cubic feet per second). Therefore, the curve maps the annual aggregate marginal willingness to pay at each flow level, i.e., the sum that all annual visitors would pay for an additional unit of flow. For example, when flows are at 200 cfs, the marginal willingness to pay for an additional cfs of water is $650. As is typical, the marginal benefit derived from moderate flow levels is high and decreases as flow levels increase; i.e., the added increment to aesthetic enjoyment is small at very high flow levels.

Exhibit 7-9
COMPARISON OF MARGINAL BENEFITS AND COSTS OF FLOW



<u>**Comparison of Marginal Benefits and Costs**</u>

As reviewed in Chapters 5 and 6, the marginal cost of increased flows can be compared to the marginal benefits to determine the optimal flow level that balances power generation with non-power concerns. Loomis and Feldman developed such an analysis by determining the marginal cost of power foregone as a result of increasing flows below the study dam. The methodology used is similar to that described in Chapter 6. Available data indicated that the avoided cost associated with replacement power was $0.0165 per kWh. The dam in question has 207 feet of head; therefore, each acre-foot of water generates 180 kWh of electricity. As a result, each acre-foot of water added to flow has a cost of about $2.97. The authors estimate that about 18,000 acre-feet of water per year are needed to maintain a minimum of 100 cfs during the daylight hours of the six-month recreation season at the study area. This translates to an annual cost of about $54,000, or about $540 per cfs. That is, the marginal cost of increased flow is $540 per cfs.

This marginal cost information can be integrated with the marginal benefit estimates from above to estimate optimal flow levels. Exhibit 7-9 above depicts marginal cost as a horizontal line at $540. The marginal cost and benefit curves intersect at a flow of about 235 cfs. This is the optimum flow level for the falls (assuming that no other categories of benefits should be considered). At lower flows, the benefits of increased flow exceed the costs, while at higher flows, the costs exceed the benefits.[17]

[17] This is the optimum flow for the entire six-month recreational season. Loomis and Feldman note that monthly optimum levels could be established that incorporate monthly variations in power demand and replacement costs.