THE ECONOMIC VALUE OF RIVER RESTORATION: THE EFFECT OF PEAK-FLOW RESTORATION ON NON-MARKET VALUES FOR THE GUNNISON RIVER

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SUMMARY

The Black Canyon of the Gunnison provides a diverse set of local and regional benefits. These can be broadly divided into market or consumptive benefits, and non-market or in-stream benefits. Changing water level in the river results in trade-offs between consumptive and in-stream uses. A peak-flow restoration project in the Black Canyon of the Gunnison will change the flow levels of the river for a portion of each year. Analyzing the economic impact of these water level changes can be accomplished with cost benefit analysis. This study evaluates the annual impact of restoring peak-flows to the Gunnison River using benefit-transfers from existing studies. Results show that only under the most limiting scope costs outweigh benefits. Under this scenario, where passive-use values are assigned only to households in Gunnison County, losses are approximately $384,000. In contrast, when passive-use values are extended to all Colorado households there is an estimated total benefit of $48 million. Finally, if passive-use values are extended to U.S. households the total benefit is over $3 billion.

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1.0 Introduction and Overview

The Black Canyon of the Gunnison provides a diverse set of local and regional benefits. These can be broadly divided into market and non-market benefits. Market benefits refer to consumptive uses such as electricity generation and water sales. Non-market benefits refer to in-stream uses such as recreation, natural habitat and ecosystem services. Changing water level in the river results in trade-offs between consumptive and in-stream uses.

In 2001 the United States filed an application to quantify a reserved water right for Black Canyon of the Gunnison National Park (BLCA) (Upper Gunnison River Water Conservancy District, 2006). The primary purpose of the application is to restore peak-flows to the Gunnison River.[1] In turn, peak-flows will scour vegetation from the inner canyon and return the riparian ecosystem to more natural conditions. The proposed flow increase would begin May 15th of each year and last between one and thirty-three days. The duration and profile of the flow depends on the forecast annual runoff to Blue Mesa Reservoir.[2] During the designated period, in-stream flows through BLCA would be expected to increase by as much as nine times the normal level. Peak-flow restoration will not be conducted during years with extremely low run-off to Blue Mesa Reservoir.

Peak-flows will impact both market and non-market factors. Market impacts include those associated with water availability for hydroelectric generation, the sale of water for agricultural uses, as well as those for the impact on agricultural production. Non-market

[1] Peak-flows refer to in-stream flow patterns that mimic natural water cycles; particularly the increase in flow levels that occur during the spring.
[2] M. Dale, NPS, personal communication, July 4, 2008.

impacts include the impact on ecosystem services and recreational uses.[3] Empirical evidence suggests that people place considerable non-market value on riparian ecosystems (Sanders, 1985, and HBRS, 1995). This suggests that in order to fully understand the economic impact of a policy change it is necessary to account for changes in both market and non-market benefits. If non-markets benefits are not taken into account then the impact of the policy change will be incorrectly estimated.

This study focuses on assessing the intrinsic value of in-stream flows by assessing the benefit (or cost) of each type of water use. Analyzing the economic impact of changes in the level of water left in the river can be accomplished through a benefit-cost analysis. Employing a benefit-cost framework and using a series of benefit transfers, we focus primarily on the non-market impacts of peak-flow restoration for the area; however, we do include initial estimates for market impacts from the 2009 Bureau of Reclamation Draft Environmental Impact Statement for the Aspinall Unit Operations (DEIS). We consider only those costs and benefits that accrue from the BLCA and down river. Any impacts on Blue Mesa Reservoir are not considered in the analysis.

In conducting the benefit-cost analysis we distinguish between use and passive-use values. Use values refer to the value of recreational activities, while passive-use values refer to value placed by individuals on the existence of an improved ecosystem or the bequest of the river and species to future generations. With respect to passive-use values we conduct a benefit-transfer using Welsh, Bishop, Phillips, and Baumgartner (1997) [hereafter WBPB]. Results indicate that the average household in Gunnison County is willing to pay $36.57 per

[3] There is not a clear definition of "ecosystem services." For our purposes, we will use the Boyd and Banzhaf (2006) "colloquial" definition of "the benefits of nature to households, communities, and economies." This would include values associated with river system, as well as the impacts on flora and fauna.

year for peak-flow restoration. Results also indicate that the average U.S. household is willing to pay $26.03 per year for peak-flow restoration.

With respect to use values we evaluate the effect of peak-flow restoration on three activities common to BLCA: fishing, hiking, and whitewater rafting. We limit this analysis to the peak-flow period and assume that the values of recreational activities do not change during the rest of the year. Specifically, the analysis is conducted by estimating the value of each activity under normal-flow and peak-flow conditions. The difference between the normal-low and peak-flow value provides the estimated change in the value of recreation due to river restoration. Results indicate that, on average, the value of fishing is (-$48.53) per person per day of the peak-flow cycle. Likewise, the change in the value of hiking is (-$5.62) per person per day, while the change in the value of rafting is $64.40 per person per day.

Finally, with respect to market values we include the impact of reduced hydroelectric production during the peak-flow period, as developed in the DEIS, for the scenario that most closely matches the flow pattern we assess. The total estimated cost in $2006 is approximately (-$600,000).

Combining the hydroelectric costs from the DEIS and aggregated individual values for use and passive-use impacts yields final results for the benefit-cost analysis. Estimates range from a cost of (-$384,000) to a benefit of over $3 billion annually. Key to these results is the geographic location that is considered for aggregating the passive use values. The lower value considers only a single county, while the upper value considers a national value. In actuality, the value is, most likely somewhere in between. Notably, these estimates are based on only the primary benefits and costs that can be tied to the peak flow and do not include secondary or tertiary impacts.

The remainder of this report is organized as follows. Section 2 provides background information on non-market valuation. Section 3 describes the benefit-transfer method. Finally, Sections 4 and 5 discuss the benefit-transfer process for use and passive-use values.

2.0 Evaluation Methodologies

We develop a benefit-cost analysis for the economic impacts associated with peak-flow restoration. Simply put, we estimate a dollar value for activities and factors impacted by peak-flows. The positive values are potential benefits, while the negative values are potential costs. The advantage of using this method is that it provides a format for comparing the magnitudes of benefits and costs. This method also allows for comparing the uncertainty and caveats associated with each impact, which provides direction for additional analysis.

In this study we employ benefit-transfer (BT) models to determine how peak-flow restoration affects use and passive-use values. BTs are often used to estimate values for ecosystem services by transferring information either in the form of a value or a function from a study completed at a different location.[4] Primary studies are cost prohibitive in both time and dollars and so BTs are widely used. However, their accuracy depends on the validity of the initial study, as well as the applicability of the original site and characteristics of the evaluation in question. In the case of estimating the values of the peak-flow in the BLCA, this includes not only the accuracy of the characteristics of the human and economic element, but also of the hydrologic element.

Environmental resources provide a wide variety of goods and services. In conducting the BTs we primarily focus on the value of non-market goods and services. Non-market values are values not captured through market transactions. As previously noted economists separate these values into two categories: use and passive-use. Use values refer to values associated with recreational activities; passive-use values refer to values placed on environmental resources independent of use. People may hold passive-use values for a

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[4] An extensive evaluation of aspects of BT can be found in Navrud and Ready (2007).

variety of reasons. These reasons include option values (the satisfaction of preserving a resource for potential personal future use), existence values (the satisfaction of knowing the resource exists as a natural habitat for fish, plants, wildlife, etc.), and bequest values (the satisfaction of endowing future generations with a resource).

Economists have developed a number of tools to quantify non-market values. These tools can be broadly classified as stated preference or revealed preference approaches. Stated preferences include contingent valuation (CV) and conjoint analysis. Revealed preference methods include hedonic pricing and travel cost methods. Non-market values that have been quantified using these methodologies are often referred to as willingness-to-pay (WTP) values. WTP values indicate the maximum dollar value an individual is willing to pay for the environmental good or service. For example, an individual may have a WTP of $30 for fishing on the Gunnison River. Notably, this value represents the individual's WTP under a specific set of environmental conditions. Under different conditions the individual will have a different WTP.

Contingent Valuation (CV) is a primary method used to determine non-market values—particularly when estimating passive-use values. CV is a survey-based technique that estimates WTP using hypothetical markets. These markets describe a hypothetical scenario (e.g. a change in an environmental good or service), the institutional context in which the change will occur, and the mechanism through which the change will be financed. Once the market is described, respondents are asked to express their maximum WTP for the hypothetical change. WTP can be elicited either through open-ended (i.e., "How much would you be willing to pay for —?") or closed-ended (i.e., "Would you be willing to pay $X for

—?") questions. The data gathered from the survey can then be used to estimate a WTP, generally using parametric regression methods; often employing a standard logit.

It should be noted that the CV method is not without its detractors. In particular there is considerable debate about whether people behave the same in a hypothetical market as they would in a real market. Nevertheless, CV surveys are generally considered valid when the hypothetical market is accurately described, the context is incentive-compatible, and respondents are reminded of their budget constraints (WBPB, 1997).

More recently, conjoint analysis, another survey methodology, has been used with increasing frequency to value environmental goods (Pearce and Barbier, 2000). Conjoint analysis requires respondents to make a series of trade-offs between multi-attribute choices. The researcher can then statistically estimate a preference function. If price is included as an attribute, the preference function can be used to derive WTP.

Revealed preference approaches, which used observed data, include hedonic pricing techniques and travel cost methods. Hedonic pricing is based on consumer behavior and the theory that consumers value characteristics of a good—not the good itself. Housing prices, which are based on attributes of the house (e.g., number of bedrooms, bathrooms, neighborhood amenities, environmental attributes, etc), are a classic example of hedonic pricing (Kahn, 1998). Given a number of assumptions concerning, among other things, the continuity of the data and information in the market, the value of a house (V) can be estimated with the linear function

$$V = \beta_0 + \sum \beta_i x_i + \varepsilon \quad (1)$$

where β_0 is a constant term, x_i represents characteristic i, β_i is the implicit price of characteristic i, and ε is an error term. This results in each characteristic being associated with a unique implicit price.

A second revealed preference approach is the travel cost method. This method is often used to value environmental goods that are associated with recreational activity. The basic premise behind the travel cost approach is to construct a demand curve for a particular environmental site, such as a national park, using the data on the cost of accessing the environmental site (i.e., the cost of traveling to the site) and the number of visitors.

In the process of conducting the BT we consider studies that use many of the non-market valuation methods describe above. Broadly speaking we use a four-step process when conducting the BTs. First, we review and identify the most appropriate values and activities to include in the BT. As noted earlier, we select passive-use values, fishing, hiking, and whitewater rafting. Second, we identify existing studies that estimate WTP values for these activities. Third, we determine which of these studies are the most suitable for conducting a BT to the Gunnison River. The criteria used in this process include a comparison of environmental services, physical attributes of the site, and demographic characteristics of the site. Fourth, we transfer WTP values from the selected studies to the Gunnison River. When possible we adjust WTP to reflect the demographic characteristics of the Gunnison study site.

3. 0 Benefit Transfer for Passive-Use Values

This section presents the benefit-transfer of passive-use values, which include the value of ecosystem restoration and the impact on plant and animal species. These values reflect the potential for continued existence of the river system and bequests to future generations.

3.1 River Restoration and Passive-Use Values Literature

A large body of literature exists that estimates the passive-use value of riparian ecosystems. Of these studies, a small subset estimates the value of restoring or protecting river environments. While we did not find a study that specifically evaluates the impact of peak-flows, there are a number of studies that are relevant. The most relevant studies are reviewed below.

Berrens et al. (1996) estimate the value of protecting the endangered silvery minnow in New Mexico. In order to protect the minnow in-stream flows must remain above a critical level. Respondents to the CV survey are asked if they would pay a specified amount to maintain the minimum flow. Findings from this study indicate an average household WTP of $28.73 per year to maintain the minimum flow in the Rio Grande. Findings also indicate an average WTP of $89.68 to maintain flows in all major New Mexico rivers.

Holmes et al. (2004) conduct a benefit-cost analysis for riparian restoration projects along the Little Tennessee River. Restoration activities include planting trees and grasses, installing fences, and developing alternative water systems for livestock. These activities are expected to improve five aspects of ecosystem services: fish habitat, wildlife habitat, erosion control, recreational uses, and ecosystem integrity. Results from the study suggest that restoration projects are economically feasible. Specifically, the study finds a benefit-cost ratio of 4.03 for two miles of restoration and 15.65 for six miles of restoration.

Loomis et al. (2000) use CV to estimate the value of increasing ecosystem services along 45 miles of the South Platte River. Respondents are asked if they would pay a specified amount to increase in-stream flows, reestablish native vegetation near the river, and create riparian buffer zones. Respondent are told that these actions will improve five types of ecosystem services: dilution of wastewater, natural purification of water, erosion control, habitat for fish and wildlife, and recreation. Results indicate an average household WTP of $21 per month.

Sanders (1985) analyzes the value of protecting rivers in the Colorado Rocky Mountains. The study uses CV to estimate WTP for use and passive-use values. Respondents are given a list of eleven rivers and asked to identify the four rivers they feel are most important. Respondents are then asked to state their maximum WTP to preserve each of these rivers. With respect to passive-use values, the study finds an average household WTP of $32.26 to protect the three most valuable rivers. The study also finds an average WTP of $77.00 to protect all eleven rivers.

WBPB (1997) use CV to determine passive-use values for three alternative in-stream scenarios on the Colorado River. The three alternatives are: moderate fluctuating flows, low fluctuating flows, and seasonally adjusted steady flows. WTP values are estimated for national and local samples. For the national sample, average WTP values are respectively $13.56, $20.15, and $20.55 for the three scenarios. Likewise, average WTP values for the local sample are $22.06, $21.45, and $28.87.

3.2 Benefit Transfer Model

From these studies we elect to conduct the benefit-transfer using WBPB. The remainder of this section reviews this study in detail.

3.2.1 Survey Procedure and Implementation: WBPB use a CV to estimate the value of reducing daily fluctuations of in-stream flows along the Colorado River.[5] More specifically, the analysis is conducted for a section of the Colorado River, below Glen Canyon Dam, that runs through Grand Canyon National Park. Fluctuations are a result of dam operations, which maximize profit by concentrating water release during periods of highest electrical demand. With respect to river conditions, these fluctuations tend to reduce sediment levels below Glen Canyon Dam. In turn, lower sediment levels tend to reduce beach size and alter habitats for terrestrial and aquatic organisms.

WBPB perform extensive pre-testing before implementing the final CV survey. Specifically, they conduct focus groups and personal interviews in order to explore alternative methods of describing the impact of various dam operations. A pilot test is also conducted. The purpose of the pilot test is to evaluate the survey instrument, assess the survey implementation procedure, and examine the validity of WTP values. Results from the pilot test, which are analyzed by an independent panel of experts, suggest that the survey yields valid WTP estimates.

In the final experimental design WTP is estimated for three alternative dam operations: moderate fluctuating flows, low fluctuating flows, and seasonally adjusted steady flows. Under the moderate fluctuating flow alternative there is a modest reduction in the

[5] Daily fluctuations range from 3,000 cubic feet per second (cfs) to 31,500 cfs between Easter and Labor Day and 1,000 cfs to 31,500 cfs between Labor Day and Easter (WBPB, 1997).

magnitude of daily in-stream flow fluctuations. Under the low fluctuating flow alternative there is a substantial reduction in the magnitude of daily fluctuation. Finally, under the seasonally adjusted steady flow alternative the daily flow levels are held constant but adjusted seasonally to mimic natural hydrologic patterns. When evaluating each alternative respondents are given a brief description of how the river's ecosystem will be affected.

The study uses local and national samples to estimate WTP for the three dam-operation scenarios—making a total of six survey versions. The local sample is defined as households that receive power produced at Glen Canyon Dam. There are two differences between the local and national surveys. First, the national and local surveys use different payment vehicles. The payment vehicle for the national survey is an increase in annual taxes while the payment vehicle for the local sample is an increase in monthly utility bills. Second, the national survey provides respondents with a description of how changing dam operations will impact the natural environment and the cost of electricity. In contrast, the local survey only provides respondents with a description of changes to the natural environment.

The experimental design consists of an initial mailing of 850 questionnaires for each version of the survey. Telephone interviews are used to follow-up on non-respondents. A total of 1,443 and 1,572 questionnaires are completed for the national and local surveys respectively. After adjusting for undeliverable surveys the overall response rate is approximately 79%.

3.2.2 Seasonally Adjusted Flow Scenario and Valuation Question: Of the three alternatives evaluated by WBPB, the seasonally adjusted steady flow scenario most closely resembles peak-flow restoration on the Gunnison River. This scenario states that daily fluctuation in the river would be eliminated but seasonal releases would be altered so that the highest release would occur during the spring. These seasonal fluctuations are intended to imitate pre-dam hydrologic cycles, although the average springtime release would still be lower than the pre-dam flow level. The questionnaire describes six changes that will result from seasonally adjusted steady flows. These changes are:

1. In the long-term, the number and size of beaches would remain at present levels.
2. The risk of erosion to Native American traditional-use areas, sacred sites and archeological sites would decrease substantially.
3. The area available for vegetation would increase by about 10% so that habitat available to birds and other forms of wildlife would increase by about 10%.
4. There would be a major improvement in the conditions for fish.
5. Native fish, including one of the endangered species, would most likely increase in numbers. However, competition from non-native fish may still limit the growth of native fish populations.
6. There would be a major improvement in conditions for trout. The size and number of trout would increase. Maintenance of the trout population would no longer require annual stocking.

Although this scenario most closely resembles peak-flow restoration on the Gunnison River there are several important differences between the two. The main difference pertains to changes in daily flow levels. The seasonally adjusted steady flow scenario entails a reduction in daily flow fluctuations, in addition to seasonal flow adjustments. In contrast, peak-flow restoration only entails seasonal flow adjustments. As a result there are important differences between the environmental impact described in the WBPB study and the impact on the Gunnison River. For example, peak-flow restoration is expected to reduce beach area, vegetation, and trout populations along the Gunnison River—which are opposite to the

WBPB scenario. In both cases, however, flow changes lead to an increase in native fish populations.

To elicit WTP values WBPB use a modified dichotomous choice survey format. Under a dichotomous choice format respondents are presented with a proposal and asked whether or not they would support the proposal. A typical proposal will describe an environmental change and ask respondents if they are willing to pay a specified amount to finance the change. The specified amount is varied across the population. This variation allows researchers to estimate an average WTP without requiring each respondent to answer multiple valuation questions. The valuation question used for the national sample is given below.

> Would you vote for this proposal if passage of the proposal would cost your household $____ in increased taxes every year for the foreseeable future?
>
> 1. Definitely No – I would definitely vote against the proposal
> 2. Probably No – I would probably vote against the proposal
> 3. Not Sure – I am not sure if I would vote for the proposal
> 4. Probably Yes – I would probably vote for the proposal
> 5. Definitely Yes – I would definitely vote against the proposal

Likewise, the valuation question used for the local sample is given below.

> Would you vote for this proposal if passage meant your utility bill would increase by $____ every year (that would be about $____ per month) for the foreseeable future?
>
> 1. Definitely No – I would definitely vote against the proposal
> 2. Probably No – I would probably vote against the proposal
> 3. Not Sure – I am not sure if I would vote for the proposal
> 4. Probably Yes – I would probably vote for the proposal
> 5. Definitely Yes – I would definitely vote against the proposal

3.2.3 Results for original Study (Glen Canyon Dam): WBPB present WTP estimates for each scenario in the national and local surveys.[6] Several techniques are employed to reduce the impact of hypothetical bias on WTP estimates.[7] First, WTP estimates are based on respondents that choose the "Definitely Yes" category in the valuation question. It is assumed that respondents choosing other categories, including "Probably Yes," would vote against the proposal. Second, respondents who indicated they would vote against the proposal at zero cost are assigned a WTP value of zero. Third, respondents who choose not to vote on the proposal are assigned a WTP value of zero. Fourth, WBPB include a question asking respondents if they really believed they would pay, either through taxes or utility bills, if the proposal passed. In the regression analysis this variable is set to indicate that respondents believed they would pay. Including this variable in the analysis lowers WTP estimates.

With the data gathered, WBPB estimate a statistical regression for WTP, based on the responses of the participants as well as their characteristics. For the national survey, per household WTP is estimated at $13.56, $20.15, and $20.55 per household per year for the moderate fluctuating flow, low fluctuating flow, and seasonally adjusted steady flow scenarios respectively. The corresponding WTP values for the local survey are $22.06, $21.45, and $28.87 per household per year. Results also indicate that WTP values are positively correlated with higher expectations of visiting the Grand Canyon, attitudes favoring the environment, higher income, and higher education. Likewise, results are negatively

[6] WTP estimates represent a weighted average between respondents and non-respondents. Estimates are calculated using logistic regression techniques.

[7] Hypothetical bias refers to the situation where respondents behave differently in a hypothetical market than they would in a real market. Hypothetical bias tends to inflate WTP values.

correlated with a belief that respondents would actually pay if the proposal passed and the cost to the respondent.

WBPB evaluate the validity of these results using the criteria developed from the National Oceanic and Atmospheric Administration (NOAA) Panel on Contingent Valuation (U.S. Department of Commerce, 1993). The criteria are broadly divided into two categories: content and construct validity. Content validity refers to the ability of the survey design to uncover the true WTP value. More specifically, content validity is concerned with how clearly the hypothetical market is specified. If respondents do not fully comprehend the nature of the environmental good being valued or are not reminded of their budget constraints then WTP estimates are invalid. Construct validity refers to the compatibility between contingent valuation results and economic theory. For instance, WTP values are expected to vary with the respondent's socio-economic situation and attitude toward the environment. A CV study demonstrates construct validity if WTP values vary in a manner that is consistent with economic theory. After careful review of survey procedures and results they conclude that WTP results demonstrate context and construct validity.

3.2.4 Critical Review of WBPB: There have been several critical reviews of the WBPB study. A review by the U.S. General Accounting Office (GAO) concludes that WBPB met survey standards set by the NOAA Panel on Contingent Valuation. They note, however, that personal interviews would likely have yielded more accurate WTP results than mail surveys (Breedlove, 1999). In a separate review Jones and Graham (1996) conclude that the national sample used by WBPB is an inaccurate representation of U.S. households (Breedlove, 1999). In particular, Breedlove argues that WBPB over-sampled high-income households. Finally, the WBPB study has been criticized for overstating the change in environmental conditions that result from changes to in-stream flows (Breedlove, 1999). All three criticisms suggest that the estimated WTP values presented in WBPB study are larger than actual WTP values.

Despite these issues there are four key advantages to conducting a benefit-transfer for BLCA using WBPB.

1) The WTP estimates are based on changes to hydroelectric dam operations. This is similar to the tradeoff between peak-flows and hydroelectric generation that occurs along the Gunnison River.
2) WBPB evaluate seasonal fluctuations in the flow level. These fluctuations are intended to partially restore natural hydrologic cycles to the river ecosystem, much like peak-flow restoration on the Gunnison.
3) The study is conducted in the same geographic region as the Gunnison River. This implies that there are many environmental and cultural similarities between the two study sites.
4) WBPB estimate WTP values for local and national samples. As a result, we are able to estimate passive-use values for populations outside the immediate BLCA area.

There are three disadvantages to conducting a benefit-transfer using WBPB. These include:

1) The study analyzes a section of the Colorado River that runs through Grand Canyon National Park. Individuals are likely to place a higher value on ecosystem restoration in the Grand Canyon, an iconic American landmark, than in the Black

Canyon. Thus, transferring WTP values from WBPB may overestimate the passive-use values for the BLCA.

2) The study evaluates changes to in-stream flows that occur over the entire year. In contrast, peak-flows along the Gunnison will occur for a maximum of thirty-one days, which also implies that a benefit-transfer will overestimate passive-use values for BLCA.

3) Finally, WBPB do not separate use and passive-use values in their analysis, which also tends to overstate WTP values. This is a minor issue, however, as use values are estimated to be only 0.7% of total WTP.

3.3 Benefit-Transfer Results for Passive Use

We conduct a single point BT using the WBPB annual WTP estimates from the seasonally adjusted steady flows scenario.[8] These estimates are in $1997. We use the GDP implicit price deflator of 1.266 to transform the values to $2006.[9] The $2006 values are $21.03 per household for the national sample and $36.57 per household for the local sample. WTP ($2006) values are aggregated to local, state, and national levels using

$$V_i = N_i WTP_i, \qquad (2)$$

where V_i is the total value in $ for group i (i = county, state, or national), N_i is the number of households in group i, and WTP_i is the estimated annual household WTP value for group i.

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[8] Although WBPB estimates a multiple variable econometric regression only one variable could be legitimately manipulated for our study. As a result, we are unable to adjust the regression model to reflect the demographic characteristics of the Gunnison River study site.

[9] The GDP implicit price deflator is obtained from the National Income and Product Account of the U.S. Department of Commerce, Bureau of Economic Analysis. Table 1.4.4: Price Indexes. http://www.bea.gov (Last accessed 02/25/09). The GDP deflator used is 1.26 to convert $1997 to $2006.

Population estimates and average household sizes, taken from the 2000 US Census, are used to estimate the total number of households of each type (N_i). Aggregate annual passive-use values for the peak-flow restoration project are presented in Table 1. The value to the county is over $225,000, while at the state level the value is over $8 million. The value at the national level is over $3 billion. As previously stated, the national estimate places the ecosystem value of the BLCA equal to that of the Grand Canyon and is therefore most likely an overestimate. However, the national WTP value from the WBPB study is also used to calculate the WTP at the state level. If the average household in Colorado places higher value on restoring the BLCA than the average household in the United States, which is most likely the case, then the state value is an underestimate.

TABLE 1: WTP FOR PEAK-FLOW RESTORATION IN BLCA

Location	Population	People per Household	N_i	WTP ($1997)$_i$	WTP$_i$ ($2006)	Value (1000$)
Gunnison County	14,331	2.3	6,231	$28.87	$36.57	$227
Colorado State	4,753,377	2.53	1,878,805	$20.55	$26.03	$48,905
United States	299,398,484	2.53	118,597,870	$20.55	$26.03	$3,080,613

4.0 Benefit Transfer for Use Values

We next consider the BT of use values. We begin by reviewing relevant studies and selecting the study most appropriate for BT. Then we develop the peak-flow cycles necessary for the analysis. Finally, we use the BT and the peak-flow cycle to estimate WTP.

4.1 In-stream Flows and Use Values Literature

A thorough literature review found several studies that estimate the value of recreation as a function of in-stream flow. The majority of these studies evaluate the impact of a permanent increase in flow levels. We did not find any study that evaluates the impact of peak-flows on recreation. The most relevant studies are reviewed below.

Daubert and Young (1981) employ a CV survey to estimate total and marginal WTP for in-stream flows on the Cache la Poudre River in Colorado. WTP values are elicited for trout fishing, whitewater boating (kayaking and rafting), and shoreline recreation (picnicking, camping, and hiking).

The survey is conducted using pictures of the river at various flow rates. Respondents are shown a low and a high flow-rate picture; then asked if they would pay a specified amount to visit the river at the higher flow rate. Notably, the flow rates vary across respondents. They range from 50 to 1,150 cubic feet per second (cfs). Interviews are conducted with 49 anglers, 45 shoreline recreationalists, and 40 whitewater boaters.

Findings from Daubert and Young (1981) indicate a quadratic relationship between flow rates and WTP values for anglers and shoreline recreationalists. Specifically, WTP values increase with in-stream flows from 0 to 500 cfs. When flow levels exceed 500 cfs

WTP values begin to decline. For whitewater boaters there is no quadratic relationship (i.e. WTP values increase at all flow levels). Average WTP for individual anglers range from $4.85 to $30.35 per day, depending on flow level. Average WTP for whitewater boaters and shoreline recreationalists are not reported.

Duffield et al. (1992) estimate WTP for in-stream flows on the Big Hole and Bitterroot Rivers in Montana. The Big Hole River is primarily used for trout fishing while the Bitterroot River is used for whitewater boating and shoreline recreation. The study is conducted onsite using the following procedure. First, a series of questions determine the actual trip expenditures of the respondent. Second, the respondent is asked if they would still visit the site if expenditures exceeded their actual expenditures by a specified amount. Third, respondent's answers are paired with the actual flow rates at the time of the survey.

Findings indicate a quadratic relationship between WTP values and in-stream flows. Specifically, WTP values increase with in-stream flows up to 2,000 cfs and 1,800 cfs for the Big Hole and Bitterroot Rivers respectively. Average WTP ranges from $21,000 to $53,000 on the Big Hole River, depending on flow levels. Likewise, average WTP ranges from $4,000 to $15,000 on the Bitterroot River.

Loomis and Creel (1992) use a random utility model (RUM) to estimate site selection and trip frequency to the San Joaquin and Stanislaus Rivers in California. Trip frequency is estimated for fishing, hunting, and wildlife viewing. The study also estimates the marginal value of in-stream flows under various water management strategies. Data used in this study is taken from mail and telephone surveys of 3,029 California households. Results indicate that average marginal value ranges from $10.83 to $116.43 per acre-foot (AF), depending on the river and water management strategy.

Roach et al. (1999) use two different CV methods to estimate the value of in-stream flows for whitewater boaters on Dead River in Maine. The first method, similar to Daubert and Young (1981), is purely hypothetical. Under this method respondents are asked to identify their likelihood of rafting or kayaking on the Dead River at various flow levels. The second method, similar to Duffield et al. (1992), uses a dichotomous choice format to determine if respondents would still visit the site if expenditures were a specified amount greater than actual expenditures. The two methods yield drastically different results. The second method is judged to be more accurate than the purely hypothetical method, which appears to overestimate trip likelihood. In line with previous findings there is a quadratic relationship between flow rates and WTP values. Optimal flow is estimated at 8,600 cfs for commercial boaters and 6,000 cfs for private boaters.

4.2 Benefit Transfer Model

From these studies we elect to conduct the BT using Daubert and Young (1981). However, before conducting a BT it is necessary to construct a peak-flow cycle for the Gunnison River. The remainder of this section discusses the peak-flow cycle and BT process.

4.2.1 The Peak-Flow Cycle: In order to conduct a BT it is necessary to determine normal-flow and peak-flow levels in the Gunnison River. Normal-flows are simply determined by calculating the average release from Crystal Dam for each day of the potential peak-flow period (i.e. May 15th to June 14th) while accounting for diversions into the

Gunnison Tunnel.[10] For convenience we assume the Gunnison Tunnel always diverts its maximum capacity of 1,000 cubic feet per second (cfs).[11]

Peak-flow cycles are constructed in three stages. First, the maximum release rate (from Crystal Dam) is calculated based on annual runoff to Blue Mesa Reservoir. Second, the maximum release rate is used to calculate the duration of the peak-flow. Third, the duration is used to construct a peak-flow cycle, which indicates the flow rate in BLCA for each day flow rates are above their normal level.

The maximum release rate for the peak-flow in BLCA would vary each year depending on the forecasted runoff to Blue Mesa Reservoir. Forecasts are issued monthly by the Colorado Basin River Forecast Center located in Salt Lake City, Utah.[12] The maximum release (*Rmax*) in cfs for a given year is calculated using the May forecast (*F*) and a series of maximum-flow equations developed by the Bureau of Reclamation. These equations are presented in Table 2. Historical data for the years 1965 to 2005 indicate that there is a wide range of potential forecasts—from 240,000 to 1,250,000 AF. According to the equations presented in Table 2 the corresponding maximum release for this range is 829 to 13,555 cfs.

TABLE 2: MAXIMUM RELEASE EQUATIONS

Forecast Range (1000 AF)	*Rmax* in cfs equals
100 – 372	$1.44F+482.95$
373 – 715	$15.24F-4652$
716 – 925	$1.15F+5449$
926 – 1001	$14.6F-6975$
1002 – 1050	$70.4F-62866$
>1050	$10.7F+180$

10 Average release is calculated for the period 1995 to 2005.
11 A list of average flow rates can be found in Table 9.
12 M. Dale, NPS, personal communication, July 14, 2008

Using the equations provided in Table 2 we calculate the *Rmax* for all forecasts between 100,000 and 1,100,000 AF.[13] Subsequently, we use these results to calculate the amount of time needed to complete each peak-flow cycle. This is done using Equations (3) and (4), which estimate the time (*T* in number of days) needed to ramp up in-stream flows to the *Rmax* rate.[14] For example, according to equation (3), Crystal Dam requires 7 days to reach a maximum flow of 4,200 cfs. Once the maximum release is reached Crystal Dam will ramp down for another 7 days. Thus, the entire peak-flow cycle requires 14 days.

$$T = \frac{R\max - 1700}{500} \text{ if } R\max \leq 4500 cfs \tag{3}$$

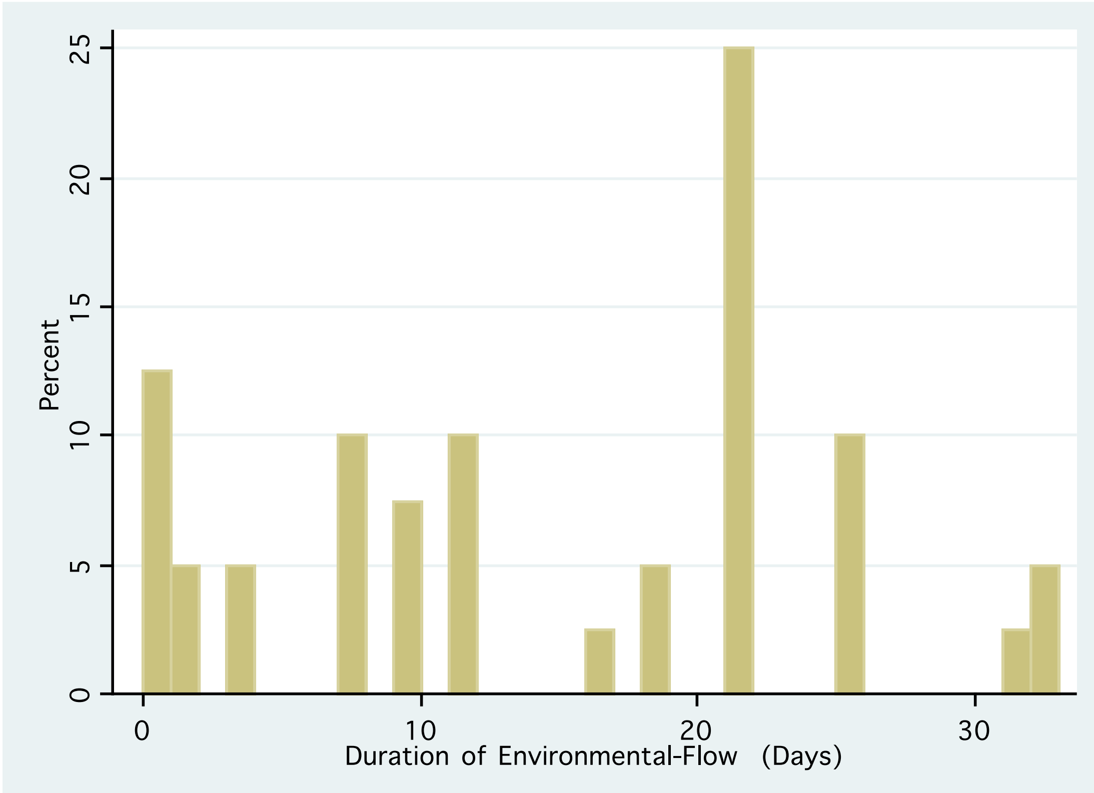
$$T = \frac{\ln\left(R\max/4500\right)}{\ln(1.1)} + 6 \text{ if } R\max > 4500 cfs \tag{4}$$

We employ this same process to calculate the hypothetical peak-flow duration of each year between 1965 and 2005. Results from this analysis indicate that there are sixteen possible peak-flow cycles; ranging from one to thirty-three days. Figure 1 displays the distribution of the results. Most importantly, this analysis indicates that the average peak-flow cycle will last 14 days.

[13] We limit the forecast to 1,100,000 AF based on the assumption that 11,700 cfs is the maximum possible release that will be considered for environmental purposes (M. Dale, NPS personal communication, July 14, 2008).

[14] Equations (3) and (4) are developed using information on the Bureau of Reclamation's method of adjusting flow rates (M. Dale, NPS personal communication, July 14, 2008).

FIGURE 1: DISTRIBUTION OF HYPOTHETICAL CYCLE DURATION (1965 TO 2005)



Mean≈14.15 Standard Deviation≈9.8

Once peak-flow duration is determined the complete peak-flow cycle may be constructed. We construct peak-flow cycles for all sixteen possible scenarios. Beginning on May 15th, Crystal Dam will ramp up its release at a rate of 500 cfs per day. The ramp up rate changes to 15% per day when the release rate becomes greater than 4,500 cfs. After the maximum release is reached Crystal Dam will begin to ramp down at 10% percentage per day. The ramp down rate switches to 400 cfs per day when the release rate drops below 4,500 cfs. Table 3 presents the peak-flow cycles for the sixteen possible scenarios. These cycles are based on an initial starting release of 1,700 cfs, which is the average flow level on May 14th, and have been adjusted to account for diversion into the Gunnison Tunnel.[15] Thus, they provide an estimate of the in-stream flow through BLCA.

[15] The base release rate of 1,700 cfs is used to derive Equations (3) and (4). If the base release differs substantially from 1,700 cfs then the duration equations must be adjusted.

TABLE 3: PEAK-FLOW CYCLES

Date	Duration of Peak-Flow Cycle in Days											
	1 Day	3 Days	5 Days	7 Days	9 Days	11 Days	14 Days	16 Days	18 Days	21 Days	23 Days	25 Days
15-May	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
16-May		1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700
17-May		1300	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
18-May			1800	2700	2700	2700	2700	2700	2700	2700	2700	2700
19-May			1400	2300	3200	3200	3200	3200	3200	3200	3200	3200
20-May				1900	2800	3700	3700	3700	3700	3700	3700	3700
21-May				1500	2400	3300	4200	4200	4200	4200	4200	4200
22-May					2000	2900	3700	4700	4700	4700	4700	4700
23-May					1600	2500	3300	4200	5300	5300	5300	5300
24-May						2100	2900	3700	4700	5900	5900	5900
25-May						1700	2500	3300	4200	5300	6600	6600
26-May							2100	2900	3700	4700	5900	7300
27-May							1700	2500	3300	4200	5300	6600
28-May							1300	2100	2900	3700	4700	5900
29-May								1700	2500	3300	4200	5300
30-May								1300	2100	2900	3700	4700
31-May									1700	2500	3300	4200
1-Jun									1300	2100	2900	3700
2-Jun										1700	2500	3300
3-Jun										1300	2100	2900
4-Jun										900	1700	2500
5-Jun											1300	2100
6-Jun											900	1700
7-Jun												1300
8-Jun												900
9-Jun												
10-Jun												
11-Jun												
12-Jun												
13-Jun												
14-Jun												
15-Jun												
16-Jun												

*Flow rate have been rounded to the nearest hundred because Crystal Dam adjusts release levels in increments of 100 cfs.

4.2.2 Model Selection: After establishing the peak-flow cycle it is possible to conduct a BT for use values. The first step in this process is to identify an appropriate transfer model. Once identified the model is adjusted to reflect the demographic characteristics of recreationalists along the Gunnison River. Finally, the adjusted models are used to estimate WTP under normal and peak-flow conditions.

For the BT we elect to use the 1981 Daubert and Young (D&Y) study, which estimate WTP values for recreational activities along the Cache la Poudre River in northern Colorado. There are three advantages to using the D&Y study. First, the study estimates separate WTP values for fishing, shoreline activities (i.e. hiking and picnicking), and whitewater rafting. Second, the study presents a regression model for each recreational activity. These models can be modified to reflect the demographic characteristics of recreationalists in BLCA. Third, the study is conducted in the same geographic region as the Gunnison River. As a result, there are many environmental and cultural similarities between the two study sites.

Although there are many similarities between the Cache la Poudre and Gunnison Rivers it is necessary to recognize that there are also important differences. For instance, ideal fishing conditions, according to D&Y on the Cache la Poudre River occur at 467 cfs. In contrast, ideal conditions on the Gunnison River occur at approximately 1,000 cfs.[16] As a result, WTP values transferred to the Gunnison Rivers are biased downwards. With this in mind, we evaluate the extent of bias in each of the three BT models. We conclude that bias has a minimal effect in the hiking and rafting models but is a serious concern in the fishing model. In order to account for this bias we transform the fishing model to more accurately

[16] M. Dale, NPS, personal communication March 18, 2008.

reflect hydrological conditions on the Gunnison River. Section 4.2.4 discusses this process in detail.

4.2.3 Demographic Characteristics: An advantage to using regression models for BT is that they can be modified for a specific context. In this case, we replace demographic information in the D&Y models with information that more accurately reflects the characteristics of individuals in BLCA. Unfortunately, there is no record of demographic characteristics for visitors to BLCA. Instead we proxy demographic characteristics using information from three outdoor recreation surveys:

1) The National Survey of Hunting, Fishing, and Wildlife (NSHFW), which provides average characteristics for anglers and hikers in Colorado;
2) The Boating and Fishing Attitude Segmentation Study (BFASS), which provides average characteristics for anglers from Kansas City, Denver, Philadelphia, and Fort Lauderdale; and
3) The Institute for Tourism and Recreation Research (ITRR), which provides information on whitewater rafters in Montana.

Table 4 describes the variables used in the BT models. The D&Y transferred models, along with summary statistics of the demographic characteristics, are presented in Table 5, Table 6, and Table 7. These tables provide the mean, minimum, and maximum values for each demographic variable used in the analysis. Notably, only the mean values are used to estimate WTP in the final analysis. The minimum and maximum values are used to conduct a sensitivity analysis. The purpose of the sensitivity analysis is to determine which variables have the greatest impact on WTP values. This is particularly important when there is a large degree of uncertainty regarding the demographic characteristics of a population. According to the sensitivity analysis the most influential variables are years of recreational experience, education, and age. Of these variables we have obtained reliable demographic information on education and age. As a result, it is unlikely that either variable will substantially bias WTP values. However, we have not obtained reliable information on experience. It is possible that this variable will bias results.

TABLE 4: DESCRIPTION OF VARIABLES*

Variable	Description	Units
Flow	River stage in cubic feet per second (cfs)	cfs
Activity days	Total number of annual recreation days in activity i by respondent j in Poudre Canyon	Days
Experience	Years of participation in activity i by respondent	Years
Income	Annual household income and respondent	$US
Age	Age of respondent	Years
Education	Years of schooling of respondent	Years
Site	Site of photograph (four sites)	0-1**
Sex	Gender of respondent	0-1**
Occupation	(a) Professional; (b) business owner; (c) skilled worker; (d) sales; (e) clerical; (f) unskilled; (g) housewife; (h) retired; (k) student	0-1**
Employer	(a) Manufacturer; (b) construction; (c) retail, (d) financial; (e) health; (f) education; (g) public sector; (h) agricultural; (k) unemployed	0-1**
Previous residence	Size of previous residence (a) large city; (b) medium city; (c) small city; (d) town; (e) rural and farm	0-1**

*Descriptions are taken from Daubert and Young (1981).
**0-1 indicates the use of a binary variable to describe the individual. If the individual possesses the characteristic in question, the value is one. For all others, the value is zero. Thus, for Occupation, there are a series of none possible binary variables, to account for each occupation.

TABLE 5: BENEFIT-TRANSFER MODEL: FISHING

Variable	Coefficient	Value Range to be Used in Transfer			Source
		Minimum	Mean	Maximum	
Constant	2.14		2.14		Daubert and Young
Flow	0.129	1000	5850	10700	Daubert and Young
$Flow^2$	-0.000138	1000000	34222500	114490000	Daubert and Young
Activity Days	-0.130	1	5.63	10.26	NSHFW
Activity $Days^2$	0.0021	1	31.70	105.27	NSHFW
Experience	0.430	1	20.5	40	No source
Education	-0.710	10.00	14.82	19.64	NSHFW
Site 2	-0.36	0	.25	1	Daubert and Young
Occupation: Clerical	-1.28	0	.25	1	BFASS
Occupation: Housewife	-1.37	0	.07	1	BFASS
Employment: Manufacturer	0.810	0	.03	1	BFASS
Employment: Financial	0.854	0	.18	1	BFASS
Employment: Health	1.140	0	.12	1	BFASS
Previous Resident: Town	0.564	0	0.04	1	NSHFW

TABLE 6: BENEFIT-TRANSFER MODEL: HIKING

Variable	Coefficient	Value Range to be Used in Transfer: Minimum	Mean	Maximum	Source
Constant	1.40		1.40		Daubert and Young
Flow	0.015	1000	5850	10700	Daubert and Young
$Flow^2$	-0.0000105	1000000	34222500	114490000	Daubert and Young
Activity Days	0.20	1	8.75	16.5	NSHFW
Activity $Days^2$	-0.0097	1	76.56	272.25	NSHFW
Experience	-0.10	1	20.5	40	No source
Income	-0.0086	22,500	50,000	100,000	NSHFW
Age	0.066	18.10	49.08	80.06	NSHFW
Education	-0.28	10.27	15.01	19.75	NSHFW
Sex	0.32	0	.49	1	NSHFW
Occupation: Sales	0.76	0	.10	1	BFASS
Occupation: Housewife	1.91	0	.07	1	BFASS
Occupation: Retired	1.51	0	.17	1	BFASS
Employment: Manufacturer	-0.55	0	.03	1	BFASS
Employment: Health	0.59	0	.12	1	BFASS
Employment: Education	0.20	0	.12	1	BFASS
Previous Resident: Medium City	0.73	0	.5	1	No source
Previous Resident: Town	1.01	0	.04	1	NSHFW

*Several differences exist between the hiking model presented in Daubert and Young (1981) and the model presented in the dissertation (Daubert, 1979) on which the article is based; leading to substantially different WTP values. After evaluating both models it is determined that the dissertation model produces more reasonable WTP values. Accordingly, Daubert (1979) replaces Daubert and Young for this model.

TABLE 7: BENEFIT-TRANSFER MODEL: WHITEWATER RAFTING

Variable	Unit	Coefficient	Value Range to be Used in Transfer			Source
			Minimum	Mean	Maximum	
Constant	N/A	0.50		0.50		Daubert and Young
Flow	cfs	0.019	1000	5850	10700	Daubert and Young
Activity Days	Day	0.18	1	2.5	4	No source
Activity Days^2	Day^2	-0.004	1	6.25	16	No source
Experience	Years	0.042	1	20.5	40	No source
Age	Years	-0.55	15	46.6	65	ITRR: Montana
Site 4	0-1	-0.34	0	0.25	1	Daubert and Young
Occupation: Unskilled	0-1	0.61	0	0.5	1	No source
Employment: Construction	0-1	1.59	0	.03	1	BFASS
Employment: Education	0-1	-0.87	0	.12	1	BFASS
Previous Resident: Medium City	0-1	0.49	0	.5	1	No source

4.2.4 Adjusted Fishing Model: Due to hydrologic differences between the Cache la Poudre and Gunnison study sites it is impossible to directly transfer WTP values from the D&Y fishing model to the Gunnison River. In particular, transferring the D&Y model directly to the Gunnison river results in negative values for fishing during normal-flow conditions. A result that is inconsistent with economic theory, in that individuals with negative WTP values would not participate in fishing activities.

We correct for this problem by transforming the D&Y model to more accurately reflect hydrologic conditions on the Gunnison River. The transformation is based on the minimum, optimal, and maximum flows for streamside fishing. We surveyed several outfitters along each river to determine the approximate level of these flows. Results from the survey, which are presented in Table 8, indicate that in-stream flows in the Gunnison River are on average 2.39 times larger then the equivalent flow in the Cache la Poudre River.

TABLE 8: TRANSFORMATION OF THE FISHING MODEL

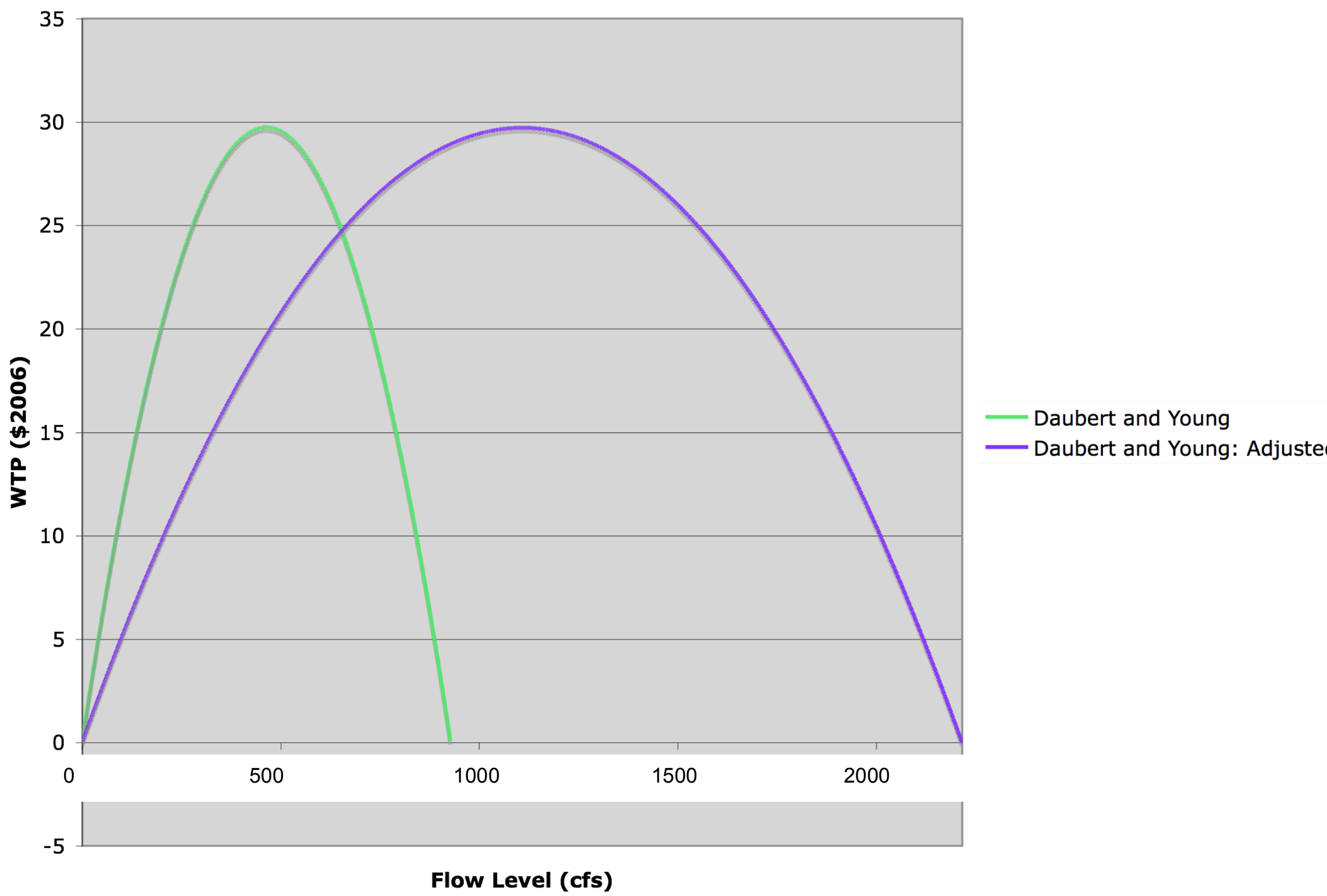
	Cache la Poudre River	Gunnison River	Relationship Between the Two Rivers
Minimum Flow	170 cfs	400 cfs	400/170=2.35
Optimal Flow	467 cfs	1000 cfs	1000/467=2.14
Maximum Flow	932 cfs	2500 cfs	2500/932=2.68
Average			2.39

Equation (5), which represents the regression model presented in D&Y, demonstrates the transformation process. Here the coefficients for the variables *flow* and *flow-squared* are divided by the transformation value of 2.39. The remaining variables on the right hand side of the equation ($\beta_i x_i$) refer to the additional arguments of the regression.

$$WTP = \beta_0 + \beta_1 \left(\frac{Flow}{2.39} \right)^2 + \beta_2 \frac{Flow}{2.39} + \beta_3 x_3 + ... + \beta_{11} x_{11}, \qquad (5)$$

Figure 2 compares the transformed and untransformed functions. As can be seen from the figure, the transformation keeps the same shape, but moves the peak to a higher flow level.

FIGURE 2: COMPARISON OF ORIGINAL AND TRANSFORMED FISHING MODEL



4.2.5 Determining WTP: The WTP values for fishing, hiking, and rafting during normal-flow and peak-flow conditions are determined by inputting flow rates into the BT models. In the case of fishing and rafting it is necessary to account for hydrological limits. Fishing becomes impractical when flow rates exceed 2,500 cfs.[17] Likewise, whitewater rafting will be suspended when flow rates exceed 6,000 cfs. Accordingly, when flow rates increase beyond these limits we assume a negative WTP equal to the value of the activity under normal-flow conditions. This negative WTP value represents the cost of not being able

[17] M. Dale, NPS, personal communication March 18, 2008.

to participate in the recreational activity. WTP values are determined for all sixteen peak-flow periods. Table 9 presents WTP for each activity under normal-flow conditions. Table 10 presents WTP values under peak-flow conditions for the average 14-day cycle.

TABLE 9: AVERAGE WTP VALUES UNDER NORMAL-FLOW CONDITIONS

Date	Flow Rate (cfs)	Fishing ($2006)	Hiking ($2006)	Rafting ($2006)
May 15	751	62.28	12.52	32.67
May 16	831	65.24	12.21	36.24
May 17	876	66.58	11.89	38.25
May 18	920	67.67	11.49	40.21
May 19	1035	69.48	9.98	45.35
May 20	1107	69.84	8.70	48.56
May 21	1297	67.98	4.12	57.04
May 22	1384	65.76	1.43	60.93
May 23	1371	66.14	1.85	60.35
May 24	1401	65.22	0.86	61.69
May 25	1410	64.92	0.55	62.09
May 26	1372	66.11	1.82	60.39
May 27	1263	68.61	5.07	55.53
May 28	1188	69.55	6.97	52.18
May 29	1156	69.76	7.69	50.75
May 30	1160	69.74	7.60	50.93
May 31	1161	69.73	7.58	50.97
June 1	1066	69.71	9.46	46.73
June 2	966	68.57	10.96	42.27
June 3	908	67.4	11.61	39.68
June 4	834	65.34	12.19	36.37
June 5	825	65.04	12.24	35.97
June 6	821	64.91	12.26	35.79
June 7	817	64.77	12.29	35.61
June 8	833	65.3	12.20	36.33
June 9	834	65.34	12.19	36.37
June 10	839	65.49	12.16	36.59
June 11	841	65.56	12.15	36.68
June 12	831	65.24	12.21	36.24
June 13	841	65.56	12.15	36.68
June 14	814	64.67	12.30	35.48
June 15	821	64.77	12.26	35.79
June 16	823	64.91	12.25	35.88

TABLE 10: AVERAGE WTP VALUES UNDER PEAK-FLOW CONDITIONS (14-DAY CYCLE)

Date	Flow Rate (cfs)	Fishing ($2006)	Hiking ($2006)	Rafting ($2006)
May 15	1200	7.16	-5.84	20.05
May 16	1700	-14.81	-12.21	38.80
May 17	2200	-63.59	-11.89	59.12
May 18	2700	-67.67	-11.49	79.48
May 19	3200	-69.48	-9.98	96.67
May 20	3700	-69.84	-8.70	115.78
May 21	4200	-67.98	-4.12	129.62
May 22	4700	-65.76	-1.43	103.41
May 23	5300	-66.14	-1.85	86.13
May 24	5900	-65.22	-0.86	66.93
May 25	6600	-64.92	-0.55	48.67
May 26	7300	-51.36	-1.82	32.51
May 27	8200	-18.18	-5.07	19.51
May 28	9100	-1.63	-2.93	5.00

The differences between WTP values under normal-flow and peak conditions provide an estimate of the change or difference in WTP resulting from peak-flow restoration. That is

$$\Delta WTP = WTP_{norm} - WTP_{peak} . \quad (6)$$

The difference in the values are then averaged across each of the sixteen possible peak-flow periods.

$$\Delta WTP_{AVG} = \frac{\sum \Delta WTP}{days} , \quad (7)$$

This creates a single change in WTP value for each peak-flow cycle. This value is interpreted as the average change in WTP per person per day due to peak-flow restoration.

4.3 Benefit-Transfer Results

BT results for the three recreational activities are presented in Table 11. They represent the average difference in the WTP between normal-flow and peak-flow conditions for a 14-day cycle—the average duration of the peak-flow cycle based on the 1965-2005 historical forecast data. All WTP values have been adjusted to $2006 using the GDP implicit price deflator.

TABLE 11: AVERAGE CHANGE IN WTP/PERSON/DAY DUE TO PEAK-FLOW RESTORATION

	Change in WTP ($2006)	95% Confidence Interval ($2006)
Fishing	-48.53	-56.79 to 7.16
Hiking	-5.62	-10.10 to 0
Rafting	64.40	0 to 93.60

Findings indicate that WTP for fishing decreases by an average of $48.53 per person per day of peak-flows. Because of the considerable uncertainty in this analysis we also develop a 95% confidence interval.[18] The confidence interval for fishing indicates that there is a 95% chance the change in WTP lies between -$56.79 and $7.16. With respect to hiking we find that average WTP declines by $5.62 per person per day. The confidence interval is -$10.10 and $0. Finally, results indicate that change in WTP for whitewater rafting increases by an average of $64.40 per person per day. The confidence interval is $0 to $93.60.

These results are consistent with what one might expect. Higher flows of water increase the average WTP for rafting, while increased flows for hiking and fishing are not as desirable and result in negative changes in WTP.

[18] Confidence intervals are based on the number of days in the peak-flow cycle (Figure 1). On average the peak-flow cycle will last 14 days with a standard deviation of 9.8. Thus, the 95% confidence interval is -5.6 to 33.6 days of peak-flow restoration. Since the peak-flow cycle cannot be less than 0 or greater than 33 days we adjust the 95% interval to be 0 to 33.

4.4 Caveats to the Benefit-Transfer

The results presented in Section 4.3 represent the best possible estimates given the available resources. Nonetheless, there are several caveats to these results. In general, these pertain to one of three categories: the peak-flow cycle, the BT model, or secondary ecological impacts.

4.4.1 Caveats to the Peak-Flow Cycle: In the process of constructing peak-flow cycles we make several simplifying assumptions about hydrologic conditions along the Gunnison River. There are two key assumptions.

1) We assume the Gunnison Tunnel always diverts its maximum capacity of 1,000 cfs. In reality, diversions thorough the Gunnison Tunnel fluctuate. The average diversion, based on historical data, is 870 cfs for the proposed peak-flow period.
2) In addition, we assume fishing and rafting activities will cease when flow rates reach 2,500 and 6,000 cfs respectively. While these figures are reliable with respect to commercial outfitters there is evidence that some individuals continue fishing and rafting above these thresholds. Since these individuals are not included in the BT analysis the WTP presented in Table 11 will be biased.

4.4.2 Caveats to the Benefit-Transfer Model: There are several concerns regarding the D&Y model. The most important of these is whether recreationalists in 1979 held similar preferences for in-stream flows as recreationalists in 2008. Unfortunately, there is no empirical evidence to indicate the degree to which preferences change over time. As a result, we assume the preferences remain constant. A secondary concern is that of congestion effects. Congestion effects refer to the impact of the number of other recreationalists on WTP values. For example, if there is a substantial increase in the number of anglers along the Gunnison River it is likely that the enjoyment, and WTP, of individual anglers will decline. The D&Y study does not account for congestion effects. Consequently, the change in WTP for hiking and fishing is biased downwards and the change in WTP for rafting is biased upwards. However, the number of recreationalists in, and around, BLCA is small relative to other Colorado rivers. This implies that congestion effects are negligible.

There are also several concerns regarding the BT process. A primary issue is the difference in flow rates between the Cache la Poudre and Gunnison Rivers. As noted earlier, optimal flows in the Cache la Poudre River are substantially lower than those in the Gunnison River. In response to these differences we transform the fishing model to more accurately represent hydrologic conditions on the Gunnison River. To the best of our knowledge there is no previous instance of this type of transformation in BT literature. As a result, the legitimacy and accuracy of this technique is debatable.[19] With respect to hiking and rafting we conclude that the models presented in D&Y provide reasonable BT results. However, hydrologic differences are likely to bias hiking results downward and rafting results upward.

Another concern pertains to demographic characteristics used in the BT process. Although there is no record of demographic characteristics for visitors to BLCA the information obtained from the NSHFW, BFASS, and ITRR is a suitable substitute for most variables. There are three variables, however, for which no information could be obtained: years of recreational experience, previous residence, and activity days (rafting model only). If the mean values assigned to these variables are inaccurate than WTP values are biased. As

[19] The methodology used for this transformation is also problematic. Specifically, the optimal flow rates for the Cache la Poudre and Gunnison Rivers are determined through a survey of local outfitters. The surveys are informal and unsystematic.

mentioned earlier a sensitivity analysis is conducted for each demographic variable. Results from this analysis indicate that the effect of this bias is minimal.

Finally, the results presented in Section 4.3 are limited to three recreational activities: fishing, hiking, and whitewater rafting. They do not indicate the impact of peak-flow restoration on other popular activities such as kayaking, camping, wildlife viewing, driving, and rock climbing. Despite obvious differences between activities we choose to correct this problem by assigning BT results to similar types of recreation. For instance, kayaking is assigned the same value as whitewater rafting. Likewise, wildlife viewing and camping within the canyon are assigned the same value as hiking. No values are assigned to driving, camping on the rim, and rock climbing. If the value of these activities responds to changes in in-stream flow then their omission will bias the BT results.

4.4.3 Caveats Concerning Secondary Ecological Impacts. The third category of caveats involves secondary ecological impacts. Secondary impacts refer to changes in environmental conditions that affect recreational activities beyond the peak-flow period. These impacts include changes in landforms, fish stock, and aesthetics. Although these changes will affect all three activities the greatest impact will occur to fishing. Evidence from controlled flow increase along the Colorado River indicates that peak-flow restoration increases the number and size of backwater areas (Schmidt et al., 2001). An increase in backwater areas improves the habitat of certain fish species and should improve fishing in the Gunnison River. On the other hand, evidence also suggests that peak-flow restoration will benefit native fish species at the expense of non-native species (Valdez et al., 2001). This should reduce the value of fishing along the Gunnison River, which is renowned for its non-native trout. In the absence of further research, the overall effect of secondary impacts is ambiguous. The present study does not attempt to quantify these impacts.

4.5. Recreational Visits

To determine the total change in WTP it is necessary to aggregate the individual WTP values presented in the previous section by the number of recreational visits during the peak-flow period. Recreational activities along the Gunnison River are naturally divided into three geographic regions: BLCA, Gunnison Gorge National Conservation Area (NCA), and the Lower Gunnison River. The remainder of this section describes recreational visitation in each of these regions.

4.5.1 Visitation Data: BLCA receives approximately 225,000 visitors per year [Bureau of Reclamation (BR), 2009]. However, due to harsh canyon terrain only a small fraction of these visitors enter the inner canyon. In 2007, there were 1,925 overnight stays in the inner canyon; approximately 90% were for fishing purposes (BR, 2009). In addition, an estimated 171 kayakers passed through the canyon. Information on the number of day visitors could not be obtained (BR, 2009).

The Gunnison Gorge NCA is maintained by the Bureau of Land Management (BLM). It is divided into the Gunnison Gorge Wilderness Area and the Gunnison and North Fork Rivers Special Recreation Management Area. Recreational activities in the region include boating, fishing, camping, and hiking. The conservation area has between 12,500 and 16,500 visitor days per year. The BLM estimates that 40% of these are for commercial rafting or float fishing, 26% for private rafting or float fishing, 26% for shoreline fishing and hiking, 8% for commercial shoreline fishing (BR, 2009).

The Lower Gunnison River refers to the region between the Gunnison Gorge NCA and the confluence of the Gunnison and Colorado Rivers. Recreational activities in this area include boating, fishing, camping, and hiking. Unfortunately, little is known about the number of recreational visits in this area. As a result, this region is excluded from the final analysis.

4.5.2 Peak-Flow Visitation: Recreation data for the BLCA and the Gunnison Gorge NCA pertains to annual visitation—disaggregated data, at the seasonal or monthly level, could not be obtained. Consequently, the number of visitors during the peak-flow period is determined using annual data. We assume, in accordance with a survey conducted at the Currecanti National Recreation Area, that 75% of recreation occurs between May and September (BR, 2009).

For BLCA the number of peak-flow visitors is estimated using the annual figures from 2007. Notably, the number of overnight stays, which do not include day visits, underestimates the number of inner canyon visitors. However, in the absence of better information we assume a total annual visitation of 1,925. The number of visitors per activity is determined by multiplying the total visits by the portion of visits occurring between May and September, the portion of visits relating to the recreational activity, and the portion of peak-flow days between May and September. We assume that 90% of the 1,925 inner canyon visits are fishing-related while the other 10% are hiking-related. For example, the number of fishing visits for a 33- and 14-day peak-flow cycle is determined as follows:

$$1{,}925 * (.75) * (.90) * (.216) = 280.26$$
$$1{,}925 * (.75) * (.90) * (0.09) = 118.90$$

Here the first component (1,925) of these equations refers to the number of annual visits. The second component (.75) refers to the visits that occur between May and September. The third component (.90) refers to the visits related to fishing. The final component refers to the percentage of days between May and September that are peak-flow days. There are 153 days between May and September. The first equation evaluates a peak-flow period of 33 days (33/153=.216). Results indicate that about 280 fishing visits occur during this period. Likewise, the second equation evaluates a peak-flow period of 14 days (14/153=.09). Results indicate that about 119 fishing visits occur during this period. The same method is used to determine the number of hiking and kayaking visits. Results are presented in column 2 of Table 12.

The same method is used to determine the number of peak-flow visits at the Gunnison Gorge NCA. Notably, visitor data for the conservation area is not separated by recreational activity. Instead it is separated into the following categories: commercial rafting or float fishing, private rafting or float fishing, private shoreline fishing and hiking, and commercial shoreline fishing. To address this problem we distribute the number of visitors within each category equally across activities. For instance, commercial rafting and fishing comprise 40% of total recreational activities. We distribute these visits such that 20% pertains to rafting and 20% pertains to fishing. We then re-categorize the activities as fishing, whitewater rafting, or hiking. Overall, we estimate 54% of visits are for fishing, 33% for rafting, and 13% for hiking. The final figures are presented in column 3 of Table 12.

TABLE 12: TOTAL CHANGE RECREATION VALUE FOR A 14-DAY PEAK-FLOW CYCLE ($2006)

Activity	Visitation BLCA	Visitation Gunnison Gorge NCA	Total Visitation	Average Individual Change in WTP	Total Change in WTP	Lower Confidence Interval	Upper Confidence Interval
Fishing	118.90	537.35	656.25	-48.53	-31847.81	-$37268	$4699
Hiking	13.21	129.36	142.57	-5.62	-801.24	-$1440	0
Rafting	11.74	328.38	340.12	64.40	21903.73	$0	$31825
Total	143.85	995.09	1138.94	N/A	-10745.32	-$38708	$36534

The estimated average impact on recreation from the altered flows is slightly less than $11,000 in a given year, with a 14-day flow. The range, however, is between a loss of $38,700 and a gain of $36,500. Regardless, the impact of the peak flows on recreational activities is small relative to the passive use values estimated in the previous section.

5.0 Market Use: Hydroelectric Power

In addition to non-market values it is necessary to account for the impact of peak-flow restoration on market-based goods and services. The most important of these impacts occurs to hydroelectric power operations at the Aspinall Unit. The Aspinall Unit is a series of three reservoirs: Blue Mesa, Morrow Point, and Crystal, each of which produces hydropower. Water levels in the three reservoirs are coordinated in order to maximize profits from hydropower production and to comply with downstream water obligations. The introduction of peak-flows will reduce the amount of water available for hydropower. This reduction will be offset by increased electricity production at other, more expensive, generation facilities. The increased cost of producing electricity at other facilities represents the economic loss associated with peak-flows (BR, 2009).

We estimate the effect of peak-flows on hydropower production using the Aspinall Unit Draft Environmental Impact Statement [(BR, 2009), hereafter DEIS]. This report, produced by the Bureau of Reclamation, evaluates the impact of modifying water releases to protect endangered fish species (i.e. the humpback chub, pikeminnow, razorback sucker, and bonytail). Notably, the peak-flow cycles used in DEIS analysis do not perfectly match the BLCA cycles developed for this analysis. Nevertheless, they are similar enough that estimates presented in the DEIS provide a good indication of how BLCA peak-flows affect the electricity market. The remainder of this section describes the Aspinall Unit and its operations, discusses the DEIS report, and presents estimates for the economic loss associated with peak-flow cycles.

5.1 Aspinall Unit and Hydropower Operations

The Aspinall Units consists of a series of three reservoirs: Blue Mesa, Morrow Point, and Crystal Dam. Blue Mesa Reservoir is primarily used for water storage, Morrow Point for power generation, and Crystal Dam to stabilize downstream flows—although Blue Mesa and Crystal Dam Reservoirs also produce hydroelectricity. Reservoir operations are coordinated in order to meet electric power demand and other downstream water obligations (i.e. minimum flow requirements, flooding constraints, and water rights). One aspect of reservoir coordination is to optimize water levels at each location. In large part, hydropower generation is determined by the difference in elevation between the reservoir and the water below the dam (BR, 2009). By coordinating water levels the Aspinall Unit is able to optimize electricity production.

A related aspect of coordination concerns electricity demand. Throughout any given day, week, or year there are considerable fluctuations in the demand for electricity. Demand is highest during the daytime and on weekdays when households and firms are the most active (BR, 2009). Likewise, demand is highest during the summer and winter months when there is a high demand for air-conditioning and heating. Hydroelectric power is ideally suited for meeting these changes in demand. In contrast to other forms of power generation, hydropower is capable of increasing and decreasing power generation almost instantaneously (BR, 2009). With respect to the Aspinall Unit this implies that water levels in three reservoirs are managed in order to produce electricity during periods of high demand.

Introduction of peak-flows along the Gunnison River will alter the Aspinall Unit's current management practices. In particular, the Aspinall Unit will reduce water releases at certain times of year in order to compensate for increased releases during May and June.

These changes will alter the quantity and timing of water available for electricity generation. Ultimately, this will reduce the supply of hydroelectricity. A more detailed description of the Aspinall Unit, its operational procedures, and how it will be affected by peak-flows is presented in the DEIS.

5.2 DEIS Release Schedules

The DEIS evaluates four release schedules based on recommendations by the Upper Colorado River Endangered Fish Recovery Program. In general, the release schedules call for a more natural hydrologic cycle with a high peak-flow during the spring and a moderate base-flow throughout the year. This is similar to the federal reserved water right under consideration for BLCA. As a result the DEIS provides a good indication of how the federal reserved water right will affect Aspinall Unit operations. Brief descriptions of the four alternatives, as well as the status quo operations, are presented below. A review of the BLCA response to the four scenarios is also presented.

- *No Action Alternative*: Under the no action alternative the Aspinall Unit would not modify release rates in order to protect endangered species. Spring peak releases could still occur under this alternative, however, the decision would be made on an annual basis and would be subject to other operational considerations.
- *Risk of Spill Alternative (Alternative A)*: Under the risk of spill alternative excess water (i.e. water not needed for other Aspinall Unit operations) is managed for the express purpose of a spring peak-flow. Specifically, water

intended to be spilled at the Crystal Reservoir would be managed in order to generate a spring peak between May 15th and June 15th.

- *Fish Peak with Duration Alternative (Alternative B)*: Under the fish peak with duration alternative the Aspinall Unit meets a specific downstream flow target designed to protect endangered fish species. This target includes peak-flow and flow duration. The flow duration refers to the number of days of high flow levels. Between April 1st and May 10th water will not be allowed to bypass Crystal Dam. Instead this water will be stored for the peak release, which will typically occur between May 10th and June 1st. Under this alternative possible peak-flow at the Whitewater gage ranges, depending upon forecasted inflows, from 900 to 14,350 cfs and the duration ranges from 0 to 60 days.
- *Fish Peak with Increased Duration Alternative (Alternative C)*: This alternative is similar to the previous scenario except the flow duration targets are increased. Specifically, the duration ranges from 0 to 100 days depending upon forecasted inflows.
- *Fish Peak with Revised Target Alternative (Alternative D)*: This alternative is similar to the Fish Peak with Duration scenario except that peak targets are determined slightly differently. The range of peak flows remains 900 to 14,350 cfs and the range of flow duration remains 0 to 60 days.

5.3 Black Canyon of the Gunnison National Park: Response to Alternatives

The DEIS also contains a detailed evaluation of the four alternatives by BLCA. The evaluation considers how the proposed alternatives meet the scouring needs of the Black Canyon. In order for appropriate scouring to occur the canyon must experience peak flows of 10,000, 6,000, and 3,000 cfs within certain time intervals. The BLCA analysis concludes that alternatives A and D offer only minor benefits to the Black Canyon. In contrast alternatives B and C offer moderate scouring and sediment transport benefits. The probable maximum time interval for 6,000 cfs peak-flows is close to the desired interval. However, the probable maximum time interval between 10,000 cfs peak-flows is 18 years, which is substantially longer than the desired interval of two to four years. Of the two alternatives, the probable maximum time interval for 6,000 cfs peak-flow is slightly better under alternative C.

In addition to this evaluation it is worth noting the two important differences between the four release alternatives described in the DEIS and the peak-flow cycles developed in this report. First, the maximum release rates in the four fish-flow alternatives are less than that required by the BLCA water right. Second, the fish-flow alternatives call for a period of high flow duration. The peak-flow cycles developed in the report do not include a duration period.

5.4 Economic Cost of Hydroelectric Power

The DEIS evaluates the economic impact associated with changing hydropower operations for each alternative. Economic values are estimated using a multi-step process. First, computer simulations calculate how each alternative would have affected Aspinall Unit operations for the years 1975 through 2005. The simulation models, which are developed specifically for the Aspinall Unit, account for reservoir characteristics (e.g. water volumes, spillway elevations, etc.), operation constraints (e.g. maximum/minimum elevations, required flow rates, etc.), and attributes of the hydropower plant (e.g. generation capacity, power conversion rates, etc.). Second, simulation results are entered into a Generation and Transmission Maximization model (GTMax). This model calculates average weekly power conversion factors, power production, and economic values. Third, these results are aggregated into monthly and yearly values. The average annual economic cost associated with each DEIS alternative is presented in Table 13.

TABLE 13: AVERAGE ECONOMIC IMPACT OF DEIS ALTERNATIVES COMPARED TO NO ACTION

Alternative	Average Annual Economic Impact ($2006)
A	-$10,680
B	-$603,883
C	-$1,990,291
D	-$469,902

Given the information provided in the DEIS there are three methods that can potentially be used to estimate the value of hydropower loss associated with the BLCA reserved water right. The first and most preferred method is to adapt the GTMax model to more accurately reflect the BLCA peak-flow cycles. Unfortunately, we do not have access to all the information needed to pursue this method. In particular, we lack information on how peak-flow cycles impact water releases during non-peak-flow periods. The second method is to determine a functional relationship between economic costs and the average quantity of water released under the four DEIS alternatives. This function could then be used, along with an estimate of the quantity of water released under BLCA peak-flows, to determine an appropriate economic cost. Once again, however, we are unable to pursue this method due to lack of information. In this case we require detailed estimates of the average annual power and non-power water releases under peak-flow operations.[20] Without this information it is impossible to construct the functional relationship. The third method is to determine which of the four DEIS alternatives most resembles the average BLCA peak-flow cycle and then directly transfer the economic cost from the alternative to the BLCA peak-flow. We choose to employ this method given the informational constraints present in the first and second options.

In order to determine which alternative most resembles the average BLCA peak-flow cycle we compare flow rates through the Black Canyon. We elect not to consider alternatives A and D since they provide only minor benefits to BLCA. Table 14 displays the change in average monthly flow rates (and the approximate acres feet (AF)) through BLCA under alternatives B and C. Under alternative B flow rates increase during May and June and decrease throughout the rest of the year. Specifically, flow rates increase by 448 cfs in May and 186 cfs in June. The total increase for May and June is 634 cfs or approximately 38,200 AF. Under alternative C flow rates increase between May and August and decrease throughout the rest of the year. The total increase for May and June is 1156 cfs or approximately 69,700 AF. Likewise the total increase between May and August is 1392 cfs or approximately 84,000 AF.

TABLE 14: AVERAGE FLOW RATE AND QUANTITIES FOR DEIS ALTERNATIVES COMPARED TO NO ACTION

Alternative	Month											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
B (cfs)	-23	-15	-66	-172	448	186	-120	-10	-70	-43	-53	-63
(1000 AF)	-1.4	-0.9	-0.4	-10.3	27.0	11.2	-0.7	-0.6	-0.4	-0.3	-0.3	-0.4
C (cfs)	-59	-107	-158	-232	512	644	125	111	-195	-175	-219	-248
(1000AF)	-0.4	-0.6	-0.9	-14.0	30.9	38.8	7.5	6.7	-1.2	-1.1	-1.3	-1.5

[20] Power water releases are releases that are used to produce hydropower. Likewise, non-power releases are releases that are not used to produce hydropower.

Arguably, the pattern and release rates for alternative B most closely resemble the average BLCA peak-flow cycle. To see why the proposed peak-flow restoration in BLCA more closely resembles DEIS alternative B rather than C we compare flow cycles. The peak-flow restoration project is scheduled to occur between May 15th and June 15th. This cycle does not call for increased flows in July or August—as is the case with alternative C. In addition, we estimate the May and June release rates for the average 14-day peak-flow cycle[21]. Results indicate that the average peak-flow cycle leads to a total increase of 652 cfs (~39,300 AF) during May and June. This is similar to the 634 cfs increase observed for alternative B. In light of these similarities, we assume that the economic impact of the average BLCA peak-flow cycle on hydropower generation is approximately -$603,880 (from table 13).

5.5 Caveats to Hydropower Estimation

The method used to determine how peak flows affect the economic value of hydropower generation fails to account for specific characteristics of the BLCA peak-flow cycle. Since the price of electricity fluctuates constantly with demand, an accurate measure of economic impacts would require simulating the affects of peak-flow cycles on the Aspinall Unit over a period of several years. As a result the estimate transferred from alternative B is likely biased. Furthermore, it is impossible to tell the direction in which the estimate is biased.

[21] For this calculation we assume days without peak flows, during May and June, have flow rates equal to the ten-year average.

5.6 Maintenance and Operations Costs

The DEIS includes a discussion of the increased maintenance and operation costs associated with peak-flows. The majority of increased costs pertain to the use of reservoir spillways. Following a spill it is necessary to inspect both the bypasses and the spillways. Costs of this inspection range from $7,500 to $85,000. In addition, each spill requires maintenance to the power transformers. Estimated maintenance at Crystal Dam is $200,000 per spill. Finally, there are periodic repair costs associated with increased spillway use. The cost of repairs depends on the amount of damage caused from the increased spilling. Repairs conducted at Morrow Point Dam in 1996 cost approximately $195,000. On the whole, introducing peak-flows is expected to double the likelihood of a spill for any given year. While these are costs of concern, given the incomplete information we have available, we do not consider them in the final analysis.

6.0 Cost-Benefit Analysis

Finally, we consider the benefits and costs presented in the preceding sections in aggregate. Table 15 presents the base-case results for an average 14-day peak-flow period. As can be seen from the table, costs exceed benefits when passive-use values are limited to Gunnison County households. If passive-use values are extended to the state of Colorado or the entire nation, then the benefits of peak-flow restoration outweigh the costs. We could provide results at the 95% confidence intervals, but the overall findings would remain the same in that benefits would exceed costs in two out of three cases. Findings also remain the same if reasonable levels of maintenance costs are included in the analysis. The stability of these findings is due to the relative size of passive-use benefits to all other factors. In fact, the passive-use benefits for the Colorado model could be reduced by 98% before the benefits would equal the costs. At the national level, the passive benefits could be reduced more than 99% before the breakeven point. Stated differently, WTP could be as little as $0.35 per Colorado household and $0.01 per U.S. household before the cost of peak-flow restoration would exceed the benefits.

TABLE 15: COST-BENEFITS

Benefits		Costs	
Activity	$2006 (1000$)	Activity	$2006 (1000$)
Passive: A) Gunnison B) Colorado C) National	 $227 $48,905 $3,080,613		
Use: Rafting	$22	Use: Fishing	-$32
		Use: Hiking	-$0.8
		Market: Hydropower	-$604
TOTAL A) Gunnison B) Colorado C) National	 $249 $48,927 $3,080,635		 -$633 -$633 -$633
Outcome A) Gunnison B) Colorado C) National			**-$384** **$48,294** **$3,080,002**

7.0 Conclusions, Caveats and Directions

This study provides a preliminary analysis of the benefits and costs of the peak-flow restoration in the BLCA. We've considered use, passive-use, and market-use factors. In all cases, BT was used to estimate WTP values. We find that, using the WBPB (1997) study, passive-use values eclipse all other factors. Expect in the most limited case, when passive-use values are only applied to households within Gunnison County, the benefits of peak-flow restoration always outweigh the costs.

There are a number of costs that are not included. For example, the value of forgone water sales, additional maintenance and operations costs, and the impact on agriculture have not been included. However, given the magnitudes of the differences, it is not likely that these costs would outweigh the benefits. In addition, we do not consider any costs associated with reduced water levels in Blue Mesa Reservoir, although it is likely that this would lower the value of recreational activities on the reservoir.

Further, we do not consider potential changes in WTP over time, such as population growth (i.e. an increase in the number of households) or changes in the number of visitors to BLCA. Again, the magnitude of change necessary for these factors to reverse the outcome of the benefit-cost assessment would have to be enormous.

Results suggest that the valuation of the passive- ecosystem use is the most important, in addition to the least well-defined, aspect of the benefit-cost analysis. There are few studies that have estimated the passive-use value of riparian ecosystems. As a result, there are several differences between the models employed for BT and the Gunnison River. In particular, there are differences in the river system, regional characteristics, and the level of visitation. Due to these differences a high degree of uncertainty or bias has been introduced into the benefit-cost analysis. This suggests that in order to refine the benefit-cost analysis, a primary study of the BLCA, specific to the peak-flow restoration project, is warranted.

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