COLORADO RIVER TOTAL VALUE STUDY

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EXECUTIVE SUMMARY

Previous research has established that there are significant values associated with environmental services provided by the Grand Canyon. These include direct on-site use such as fishing and whitewater boating. There are also significant passive use values provided by Grand Canyon resources. Passive use values do not derive from an individual's direct on-site use, but rather are associated with motives such as the desire to conserve resources for use by future generations (bequest motive) and the satisfaction of knowing that a unique ecosystem is in a protected, healthy state (existence motive). Contingent valuation methods, in which survey respondents are asked about the value they place on a given use, have been previously applied to estimate willingness to pay to improve native vegetation, native fishes, game fish (such as trout), and cultural sites in Glen Canyon National Recreation Area downstream of Glen Canyon Dam and in Grand Canyon National Park (Welsh et al. 1995). The 1995 Welsh study was a total valuation survey in the sense that both direct use values and passive use values were estimated. This 1995 study utilized a population survey, including households in the entire U.S., to identify willingness to pay to reduce flow fluctuations from Glen Canyon Dam in order to protect wildlife, beaches, and cultural sites. Because these resources are of national significance, this research was reviewed by a National Research Council panel (National Research Council 1996). The panel concluded that the research was high quality, but would need to be periodically updated.

The contingent valuation approach applied by Welsh et al. (1995) is well accepted, has been published, and has been thoroughly peer reviewed. However, a 2005 National Research Council publication examined the full range of methods currently available for estimating total economic values, including passive use, for ecosystem services. The recommendation of this panel, and the direction of more recent economics literature, is to use stated choice methods, also referred to as attribute-based stated preference methods (Holmes and Adamowicz 2003). Stated choice methods were applied in the current study.

Using the lessons learned from the Welsh study's surveys as a starting point, in 2016 National Park Service (NPS) sponsored a national survey to provide the data necessary for a total value estimation of household willingness to pay (WTP) associated with a broad range of ecological outcomes anticipated from alternatives analyzed in the Glen Canyon Long-Term Experimental and Management Plan (LTEMP) Draft Environmental Impact Statement (DEIS). The work reported here provides the core modeling and WTP estimation results from the data collected in the NPS sponsored national survey, the Glen Canyon Total Value Survey (Glen Canyon Survey, as referred to in the following sections), as well as associated LTEMP Final Environmental Impact Statement (FEIS) alternative-specific WTP estimates.

The primary objective of the 2016 Glen Canyon Survey was to provide information needed to estimate per household WTP values associated with different outcomes from dam-flow management related to endangered species (humpback chub populations), sandbars in the Grand

Canyon (river beaches), and populations of large (over 16 inches) trout in the Glen Canyon. Respondents to the survey were faced with two discrete choice valuation questions with different levels of these key river attributes included in the choices presented. Additionally, the effect of the changes in related hydropower operations were (along with increased taxes) included in the survey as the payment vehicle to represent the tradeoff of improved resource conditions with costs.

Data Collection

The current study utilized a repeat contact mail-back survey method to gather survey responses. We used a modified Dillman (2007) method to maximize the response rate. In November-December of 2014 a pretest of the survey instrument was sent to a random sample (n=200) of U.S. households. The pretest was designed to help assess the upper end of the bid range for the discrete choice questions as well as identify any understandability issues with the survey, and had a response rate of 24%.

We began the main survey process in January 2016 by sending an initial postcard to notify respondents that they should expect a copy of the survey in the mail within the next week or so. All potential respondents were then mailed a survey packet that included a cover letter, questionnaire, and a self-addressed stamped envelope. Ten days following the mailing of the survey packet, we sent a reminder postcard; two weeks after that, a packet including a replacement survey, cover letter, and a postage paid return envelope was mailed to all non-respondents.

The response rate for the current study was 18% for the local area sample (which included respondents from the eight counties contiguous to the Colorado River from Lake Powell downstream to Hoover Dam) and 12% for the national sample. These responses are comparable to a recent national mail household survey on National Parks by Harvard-Colorado State University (Haefele et al. 2016) which used a very similar survey protocol and achieved a 17-18% response rate. One difference between the Haefele et al. (2016) protocol and the current study was that the Harvard-CSU study was privately funded and offered some respondents a financial incentive to complete the survey. The current study was funded by NPS, was required to be reviewed by Office of Management and Budget (OMB), and was not budgeted to include financial incentives.

Recently, the Pew Research Center reported their rates of response to telephone surveys had dropped from 36% in 1997 to 9% (Pew Research Center for the People and the Press 2012). Although in that case the method of data collection (phone calls) was different from that employed by this study (mail-back surveys), it is indicative of a wider trend; the American Association for Public Opinion Research notes that “[l]argely due to increasing refusals, response rates across all modes of survey administration have declined, in some cases precipitously” (AAPOR 2016). The somewhat lower than anticipated response rate in this study is representative of these trends. However, the resulting sample size provides adequate data to conduct a robust analysis.

The most substantial threat posed by lower rates of participation is the possibility of non-response bias, which occurs when the data collected is not representative of the population surveyed due to a higher rate of non-response among segments of the population whose answers would have differed non-trivially from those collected. For example, a common type of non-response bias is that of age—older individuals are generally more likely to respond to a survey, so younger people can be underrepresented in the data. In the past, high response rates were considered the most important safeguard against non-response bias, and surveys with low rates of participation were thought to be necessarily unreliable. Recent studies, however, have shown that lower response rates are not inherently correlated with a higher incidence of non-response bias (AAPOR 2016; Keeter 2000). Furthermore, any bias that is found to exist in a given study can be corrected for through monitoring and weighting of key factors among the respondents. Accordingly, the decline in survey participation has not undermined the reliability of surveys as a method of statistical prediction, but rather demonstrated the effectiveness of statistical research's best practices (Keeter 2000). In accordance with those best practices, the design of this study aims to address the major sources of survey error not only by maximizing our response rate through use of the Dillman protocol, but also by identifying and correcting for non-response bias after the completion of data collection.

Analysis of Potential Non-Response Bias

Due to the increasing difficulty in achieving high response rates in national household surveys in recent years and the overall 13.2% response rate for the Glen Canyon Survey, a random phone survey of non-respondents was undertaken by Responsive Management of Harrisonburg, VA, a professional survey research firm. From previous NPS survey research (Haefele et al. 2016) we identified a number of survey questions which were likely to identify non-response bias in the survey. These questions largely concerned the respondent's familiarity with and use of National Parks in general, and Glen Canyon and Grand Canyon NP in particular. A comparison of responses from the mail and non-response phone survey showed some general stability between the samples, but statistically significant differences between respondents and non-respondents were evident for the national sample (in particular) for whether the respondents had ever visited a National Park. Non-respondents were less likely to have visited a national park compared to respondents. Inclusion of an indicator variable for this question in preliminary willingness to pay modeling runs showed it to be statistically significant in explaining WTP. Therefore, in order to control for this non-response bias, weights were constructed to more closely align the respondent sample with the estimated total population with regard to the percentage of the sample who had visited a National Park.

Analysis Methods

The choice of the structure of the discrete choice (DC) question and survey format used in this study was informed by previous successful, and similar, studies. The current study utilized a survey which presented respondents with two DC questions (choice tasks) each offering a choice between current management of the dam and its implication for long term changes in attribute levels, and alternatively "proposed plans" which offer different resulting changes in attribute outcomes.

The three primary ecosystem attributes included in the DC questions were changes in river sediment, and more specifically the buildup or erosion of beaches (or sandbars) along the river, changes in native fish (humpback chub) populations, and changes in the populations of large trout. An additional attribute was the cost of the proposed plans. This cost attribute was explained as being a result of higher electric bills in the 6-state Colorado River Basin and increased federal taxes for all U.S. residents needed to pay for the costs associated with the proposed plans.

Just as the primary ecological attributes utilized in the DC survey questions were chosen to inform impact from and differences between the action alternatives developed for the Glen Canyon LTEMP FEIS, attribute level choices went through several layers of review by LTEMP scientists to ensure that the changes in levels tested in the choice questions were generally consistent with the anticipated alternative-specific changes in these same attributes from yet to be completed FEIS analysis modeling.

Given that the final design of the DC questions used 4 attributes with as many as 4 attribute levels (implying a full factorial design of 192 question versions), a set of SAS Macros was used in order to identify an efficient allocation of attribute levels across a manageable number of survey/question versions. Choice sets were grouped into 12 blocks (survey versions) of 2 choice questions each with 2 alternatives (including a current management alternative). Figure ES1 shows an example of the DC questions included in the survey, and Figure ES2 shows the attribute levels both for the "Current Management Plan" and for the "Proposed Plans."

Ask yourself whether you believe the improvements offered under Proposed Plan A are worth $40 each year to your household for the next 20 years. Voting for Proposed Plan A would mean you would have $40 less each year to spend on other things. You would be making a commitment to pay this additional amount each year for the next 20 years. Please check ONE box at the bottom of the table to indicate whether you prefer Proposed Plan A, or the Existing Management Plan

Resources impacted by policies	Existing Management Plan—conditions over the next 20 years	Proposed Plan A—conditions over the next 20 years
River Beaches (Size and number) 	20% decrease in size and number	20% increase in size and number
Native fish (humpback chub) populations 	Remain at present levels	25% decrease in humpback chub populations
Trout populations 	Remain at present condition	50% increase in large trout populations
Cost to your Household $	$ 0	$40 per year for 20 years
I would vote for (check only one ✓)	❑	❑

Figure ES1. Sample Discrete Choice (DC) Question Format.

Attribute Levels for Current Management Plan (fixed across all questions)

Erosion of sandbars

- 20% deterioration of sandbars

Populations of Native Fish within the Grand Canyon Corridor, including the endangered humpback chub

- Remain at present levels of native fish populations

Large Trout populations in the river

- Remain at present levels of large trout

Cost to your household

- $0

Alternative Attribute levels for Proposed Plans (One attributed level is chosen for each attribute for a given plan)

Erosion of sandbars

- 20% deterioration number of sandbars
- Rate of change in the number of sandbars remains at present levels
- Potential for 20% increase in the number of sandbars

Populations of Native Fish within the Grand Canyon Corridor, including the endangered humpback chub

- 25% decrease in native fish populations
- Remain at present levels of native fish populations
- 25% increase in native fish populations
- 50% increase in native fish populations

Trout populations in the river

- 25% decrease in large trout populations
- Remain at present levels of large trout populations
- 25% increase in large trout populations
- 50% increase in large trout populations

Cost to your household

- $12
- $40
- $110
- $280

Figure ES2. Glen Canyon Survey Attribute Levels

All data was analyzed using SAS statistical software. The software was also used to perform statistical tests on responses to key survey measures among the two primary subpopulations (national and local).

We generated statistics to summarize and compare responses, response rates, and individual characteristics across groups defined in the sampling plan. A post-stratification adjustment was also generated to correct any detected non-response bias.

Estimating Household's Total Willingness-to-Pay (WTP)

To analyze the data from the conjoint/discrete choice experiment questions, we applied a random utility modeling (RUM) framework (McFadden 1986), which assumes that survey respondents implicitly assign utility to each choice option presented to them. This utility can be expressed as

$$U_{ij} = V(X_{ij}, Z_i; \beta^i) + e_{ij},$$

- U_{ij} is individual *i*'s utility for a choice option (i.e., restoration option) *j*
- $V(\cdot)$ is the non-stochastic part of utility, a function of X_{ij}
- X_{ij} represents a vector of attribute levels for the option *j* (including its cost) presented to the respondent
- Z_i, a vector of personal characteristics
- β^i, a vector of attribute-specific preference parameters
- e_{ij} is a stochastic term, which captures elements of the choice option that affect individuals' utility but are not observable to the analyst. On each choice alternative, respondents are assumed to select the option that provides the highest level of utility. By presenting respondents with a series of choice tasks and options with different values of X_{ij}, the resulting choices reveal information about the preference parameter vector.

Conditional Logit Estimation

To estimate the parameters of the conjoint model, we used a standard conditional logit (CL) model, which assumes the disturbance term follows a Type I extreme-value error structure and uses maximum-likelihood methods to estimate the attribute parameters. The conditional logit is a computationally straightforward estimation approach that can provide useful insights into the general pattern of respondents' preferences, trade-offs, and values.

The parameter estimates from the CL model was then used to estimate the average marginal value of each non-cost attribute. They were also used to estimate the average WTP for acquiring the combination of attributes associated with one management scenario (X_i) compared to the attributes of another scenario (e.g., the no action alternative) ($X_{No\ Action}$):

$$WTP_i = (\hat{\beta}_j / \hat{\beta}_{Cost})(X_{i,j} - X_{NoAction,j})$$

- β_j represents a vector of attribute *i* preference parameters

- $X_{i,j}$ represents a vector of attribute *i* levels for the management scenario *j*
- WTP_i represents a vector of average WTP for acquiring the combination of attributes associated with management scenario *j*

The standard errors and confidence intervals for these value estimates were estimated using the Krinsky and Robb (1986) simulation method.

Willingness to Pay (WTP) Modeling

As noted, the primary objective of the Glen Canyon Survey was to provide information needed to estimate per household WTP values associated with different outcomes from dam-flow management scenarios. Respondents to the survey were faced with two discrete choice valuation questions with different levels of these key river attributes included in the choices presented. Additionally, the effect of the changes in related hydropower operations were (along with increased taxes) included in the survey as the payment vehicle to represent the tradeoff of improved resource conditions with costs. In addition to the physical canyon attributes, respondents were asked to choose between current management at no cost and a changed outcome management plan that would cost between $12 and $280 per year per household over a 20-year period. The levels of the cost parameter and the river outcome attributes were varied among 12 versions of the survey to provide an efficient sampling design.

A key expectation in choice modeling which includes a cost parameter is that, everything else held constant, we expect the percentage of respondents willing to accept an alternative to decline as the price of that alternative increases. As can be seen from the raw cross-tabulation of the survey data (Table ES1), this expected relationship holds true for both the local area and the national samples. This result of a negative price response is consistent with the economic law of demand.

Table ES1. Frequency with which Respondents Voted for Proposed Management Plans, by Cost

Sample	$12	$40	$110	$280
Local Sample	51.4%	39.4%	24.2%	19.5%
National Sample	56.4%	39.5%	32.0%	25.0%

A significant portion of the Glen Canyon Survey was used to explore respondent beliefs and preferences that underlie economic values. These motives, for example related to environmental preferences, provide covariates that may increase the explanatory value of the estimated models and provide insight into the validity of the estimates. The survey used Likert-scaled question blocks which were comprised of questions that asked respondents to rate statements on a scale from 1 to 5, with 1 being “strongly agree” and 5 being “strongly disagree.” These statements were arranged into sections that shared a similar theme, and the tables on the following pages each show one of those blocks, with the responses grouped into two classifications per question: one for the “agree”

responses (combined “agree” and “strongly agree”), and one for “disagree” responses (“disagree” and “strongly disagree”).

One block of questions dealt with respondents’ attitudes about the environment. Here, a clear pattern emerged—85% of those surveyed said they had a “great deal of concern” for habitat protection, and also largely agreed that species should receive protection even if they aren’t useful (71%) or despite the person surveyed never seeing or enjoying them (68%), that nature is delicately balanced (77%), and that protecting rare species is important (77%) (Table ES2).

Table ES2. Respondent Ratings of Statements on Environmental Concerns

	Agree		Disagree	
Statement	**Local Sample**	**National Sample**	**Local Sample**	**National Sample**
I have a great deal of concern for protecting wildlife habitat	88.4%	83.6%	11.6%	16.4%
Endangered species should be protected even if they don't provide any benefit to humans	66.0%	74.7%	13.6%	10.7%
It is important to protect rare plants and animals to maintain genetic diversity	72.8%	78.9%	7.5%	8.0%
I would be willing to contribute to protecting wildlife habitat even if I never see or enjoy the animals	61.2%	72.6%	12.2%	11.7%
I feel I should be doing more to help protect wildlife and fragile ecosystems	49.0%	53.0%	17.7%	13.1%

Another block of questions (Table ES3) asked opinions about hydropower. A basic finding is that most respondents (76% local and 80% national) agreed with the statement that “Hydroelectric dams can have serious impacts on the plants and animals that live in or along the river.” However, they were more evenly split on whether dams should be built in national parks.

Table ES3. Respondent Ratings of Statements on Hydroelectric Dams

	Agree		Disagree	
Statement	**Local Sample**	**National Sample**	**Local Sample**	**National Sample**
The benefits of hydroelectric dams on the Colorado River outweigh the impacts to the natural environment and historical places along the river	39.2%	21.8%	30.1%	45.6%
Hydroelectric dams should not be constructed on any section of a river that flows through a national park	27.8%	37.3%	36.1%	31.9%
Hydroelectric dams can have serious impacts on the plants and animals that live in or along the river	75.5%	79.5%	7.0%	3.7%
Hydroelectric dams should be developed wherever it is economically beneficial, even if it means that some rivers will be changed	29.4%	23.5%	42.7%	53.4%

The next block of questions (Table ES4) illustrates just how strongly respondents feel about national parks. Survey participants overwhelmingly indicated they find national parks valuable (whether they visit them or not) and believe in their mission of preservation. The responses indicate that national parks have a value even if the respondent doesn't visit them (95% agree in the National sample) and that an important function of national parks is to protect native birds, plants, and animals (90% agree). These responses are consistent with the view that the economic value of national parks is not limited to direct recreational use, but that total value of our parks includes significant passive use values (Haefele et al. 2016). For example, the latter study found that 95% of their respondents agreed that it was important to preserve national parks for the use of future generations.

Table ES4. Respondent Ratings of Statements about National Parks

	Agree		Disagree	
Statement	**Local Sample**	**National Sample**	**Local Sample**	**National Sample**
National parks are a "luxury" we cannot afford in difficult economic times	7.6%	5.4%	80.6%	88.6%
National parks help us to remember that our future is tied to the preservation of nature and natural resources	84.1%	86.2%	6.9%	3.7%
An important function of the National Park Service is to protect native birds, plants, and animals	87.6%	89.9%	2.8%	4.0%
I am glad there are national parks, even if I don't visit them	90.3%	95.0%	9.7%	1.0%
People can think a place is valuable, even if they do not actually go there themselves	93.8%	98.3%	1.4%	0. 7%

WTP Modeling Using Discrete Attribute-Level Covariates

Several alternatives were explored for the specification of models of WTP using the Glen Canyon survey responses. One model explored using discrete attribute levels as the model covariates, while another used a continuous covariate specification. These estimates are discussed below, beginning with the discrete attribute level model.

The discrete choice data from the Glen Canyon Survey was initially modeled by inclusion of each alternative attribute level as a covariate in the model along with the cost variable (Table ES5). The limitation of the discrete change model is that it provides a limited amount of information on WTP, with values being directly estimable for only the specific attribute levels modeled (e.g. either 25% decrease in chub, or no change in chub, or 25% increase in chub, or 50% increase in chub). Figure ES3 and Figure ES4 show plots of the WTP per household estimates associated with the calculated marginal changes models in the discrete covariate model.

The modeled impacts on sandbars, chub, and large trout below Glen Canyon Dam are presented in the DEIS as continuous change levels, rather than the few discrete points modeled in Table ES5. Therefore, the models using attribute-level discrete covariates were limited in their use for estimating alternative-specific WTP values unless *ad hoc* interpolation between the discrete points was employed.

The discrete attribute-level covariate approach provided a solid empirical model with highly significant parameters for many covariates and generally theoretically expected signs. For example, the successive estimates for a 20% increase in beaches, or sandbars, and the parameters on a 40% increase (from a 20% decrease to a 20% increase) show the impact is approximately linear with WTP also doubling. The exception with regards to statistically significant covariates was for positive changes in trout populations. Respondents in both samples seemed to value the status quo for trout populations most highly, and the discrete-level models provide no solid trend for interpreting increasing trout populations.

Table ES5. Estimated Attribute-level Discrete Choice Willingness to Pay Model

Attribute	Parameter Estimate	Standard Error	P-Statistic
National Sample (Sample Size: 594)			
COST	-0.00564	0.000933	<.0001
BEACHES0	0.3956	0.2072	0.0562
BEACHES20	0.8276	0.2095	<.0001
CHUBNEG25	-0.6982	0.2580	0.0068
CHUB25	0.4996	0.2626	0.0571
CHUB50	0.6213	0.2161	0.0040
TROUTNEG25	-0.8631	0.2363	0.0003
TROUT25	-0.9089	0.2370	0.0001
TROUT50	-0.0597	0.2479	0.8098
Local Sample (Sample Size: 284)			
COST	-0.00939	0.00177	<.0001
BEACHES0	0.3628	0.3375	0.2824
BEACHES20	0.9778	0.3319	0.0032
CHUBNEG25	-0.6201	0.4183	0.1382
CHUB25	0.4271	0.4201	0.3094
CHUB50	0.9277	0.3292	0.0048
TROUTNEG25	-1.0619	0.3847	0.0058
TROUT25	-0.4740	0.3370	0.1596
TROUT50	-0.0856	0.3876	0.8253

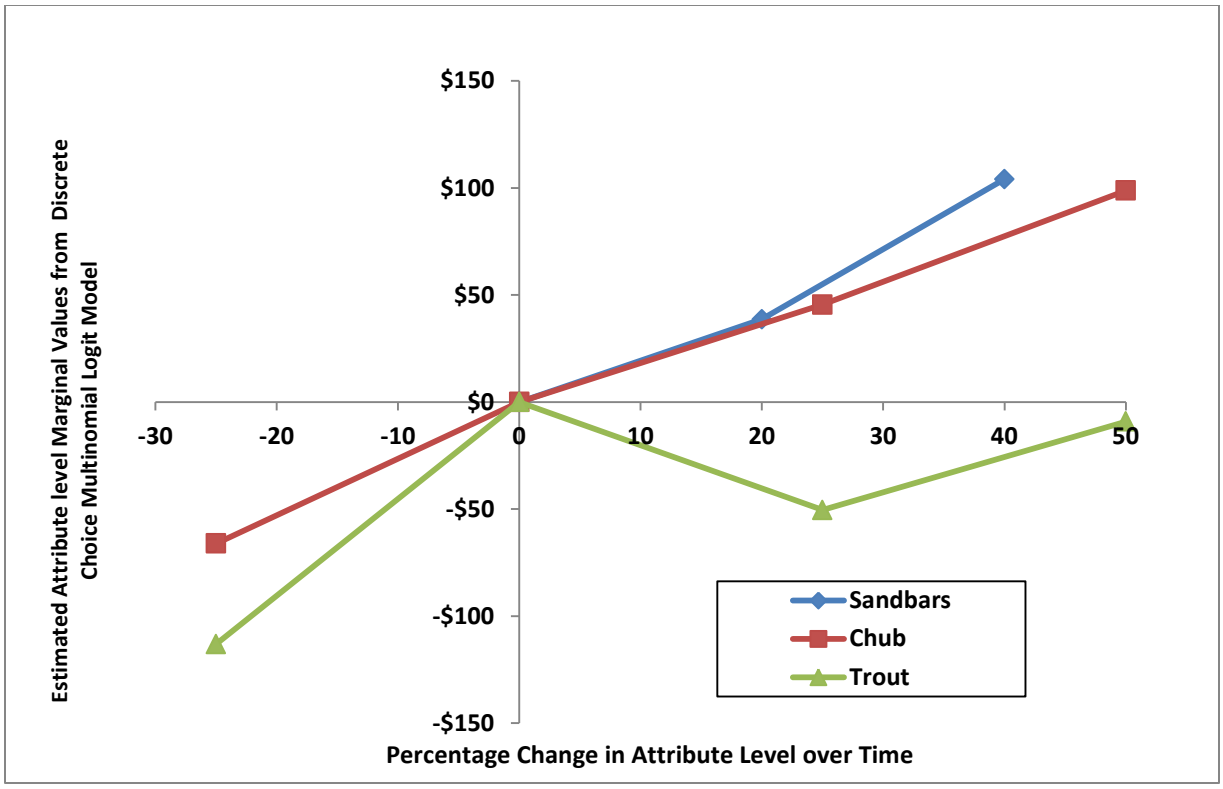


Figure ES3. Estimated Attribute Level Marginal Values from Discrete Level Modeling: Local Area Sample

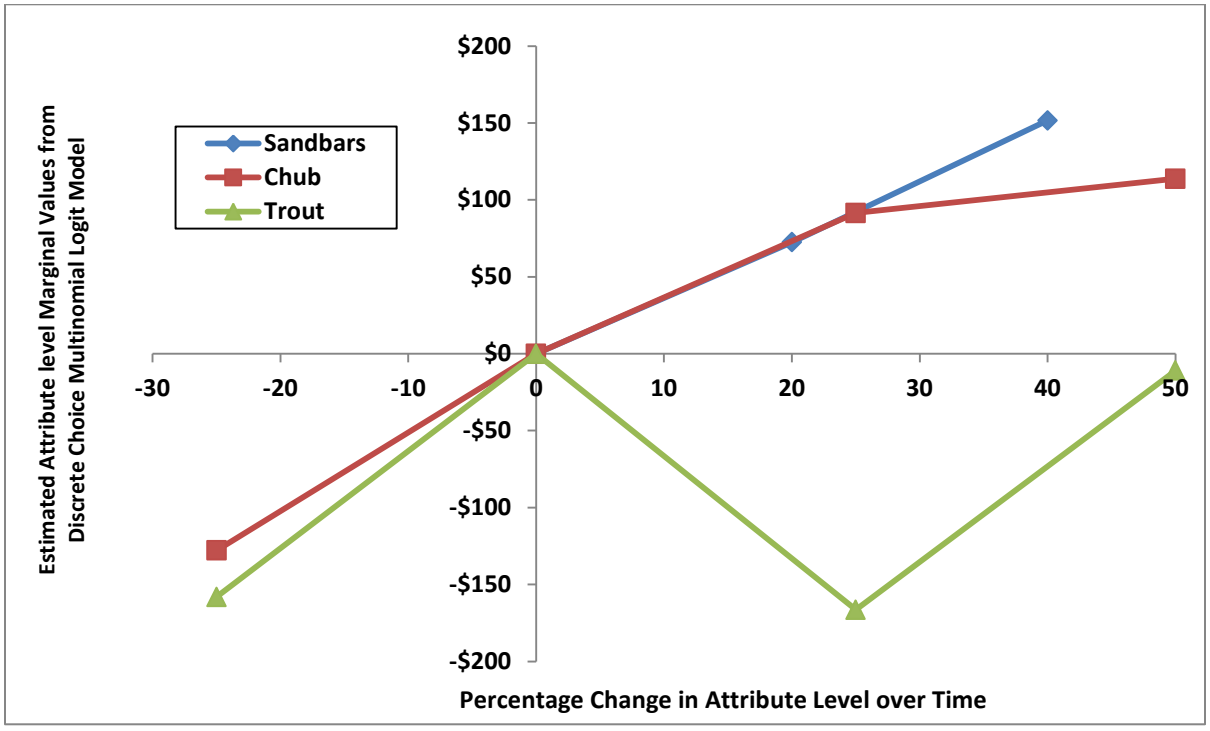


Figure ES4. Estimated Attribute Level Marginal Values from Discrete Level Modeling: National Sample

WTP Modeling Continuous Attribute Covariates

While the attribute-level discrete covariate models were problematic in terms of estimated DEIS alternative-specific welfare levels, they did (in the cases of sandbars and chub populations) inform the functional forms of the covariates that might be used to estimate the attributes as continuous functions of WTP. The suggested functional forms for sandbars and chub are both roughly linear. Lacking statistically significant information on respondent preferences for changes in trout populations, a continuous covariate model of WTP was estimated using information from three of the four attributes (sandbars, chub populations and costs). Table ES6 shows the estimated discrete choice model using continuous attributes for sandbars and chub as covariates. The continuous attribute model has all covariates with the expected signs and all but one statistically significant at the 95% level of confidence or greater.

Table ES6. Estimated Discrete Choice Willingness to Pay Model using Continuous Attribute Covariates

Attribute	Parameter Estimate	Standard Error	P-Statistic
National Sample (Sample Size: 594)			
Cost	-0.00665	0.000857	<.0001
Sandbars	0.0105	0.00436	0.0160
Chub Population	0.0130	0.00309	<.0001
-2 Log Likelihood	722.16		
Local Sample (Sample Size: 284)			
Cost	-0.0097	0.00159	<.0001
Sandbars	0.0118	0.00686	0.0867
Chub Population	0.0170	0.00459	0.0002
-2 Log Likelihood	316.75		

Estimated WTP per Household Values for Alternative Attribute Levels

As noted previously, to estimate the parameters of the discrete choice models, we used a standard conditional logit (CL) model (McFadden 1986), which assumes the disturbance term follows a Type I extreme-value error structure and uses maximum-likelihood methods to estimate β_1 and β_2. The conditional logit is a computationally straightforward estimation approach that can provide useful insights into the general pattern of respondents' preference, trade-offs, and values.

The parameter estimates from the CL model were then used to estimate the average marginal value of each non-cost attribute:

$$MWTP_i = (\hat{\beta}_j / \hat{\beta}_{Cost})$$

- β_j represents a vector of attribute *i* preference parameters

Table ES7 shows the estimated marginal values for all attribute-level coefficients estimated using the discrete attribute level functional form of the conditional logit model. Overall, marginal values for specific attribute level changes are lower for the local area sample than for the national sample.

Table ES7. Estimated Marginal WTP Values from Attribute-Level Model

Attribute	Change Relative to Baseline	National Sample		Local Sample	
		Parameter Estimate	Marginal Household WTP	Parameter Estimate	Marginal Household WTP
COST	--	-0.0055		-0.0094	
BEACHES0	20% increase	0.3956	$72.45	0.3628	$38.64
BEACHES20	40% increase	0.8276	$151.58	0.9778	$104.13
CHUBNEG25	25% decrease	-0.6982	-$127.88	-0.6201	-$66.04
CHUB25	25% increase	0.4996	$91.50	0.4271	$45.48
CHUB50	50% increase	0.6213	$113.79	0.9277	$98.80
TROUTNEG25	25% decrease	-0.8631	-$158.08	-1.0619	-$113.09
TROUT25	25% increase	-0.9089	-$166.47	-0.4740	-$50.48
TROUT50	50% increase	-0.0597	-$10.93	-0.0856	-$9.12

Just as marginal change values can be calculated for the discrete attribute level model (Table ES7), marginal values can also be calculated based on the results of the continuous attribute model coefficients. The estimated marginal values of a one-percent change in the attribute levels for BEACHDIFF (sandbars) and CHUB (native humpback chub populations) are shown in Table ES8. These marginal values are consistently more conservative than those estimated using the discrete attribute level model results. It is not surprising that the marginal values of the discrete and continuous model specifications differ. The continuous specification imposes a more restrictive functional form than the discrete model in that marginal values are the same across all levels of the attribute for the continuous model. The discrete form is more like a piecewise regression that allows the slope to change across different levels of the attributes.

Table ES8. Estimated Marginal WTP Values from Continuous Variable Models

National Sample		
Attribute	**Parameter Estimate**	**Marginal value per household of 1% increase in attribute level**
COST	-0.00665	
BEACHDIFF	0.0105	$1.58
CHUB	0.013	$1.95
Local Sample		
Attribute	**Parameter Estimate**	**Marginal value per household of 1% increase in attribute level**
COST	-0.0097	
BEACHDIFF	0.0118	$1.22
CHUB	0.017	$1.75

Aggregate Annual Value Analysis

The marginal values of changes in individual attribute levels provides some insight into how respondents value resources along the Colorado River. These can be applied to the set of changes that the LTEMP DEIS presents for alternative dam management proposals. These proposals each have different impacts on all the key attributes modeled in this analysis. The LTEMP DEIS presents a No Action alternative (Alternative A) in addition to six action alternatives (B through G). The key objectives of the action alternatives are described in the DEIS as follows:

- The objective of Alternative B is to increase hydropower generation while limiting impacts on other resources and relying on flow and non-flow actions to the extent possible to mitigate impacts of higher fluctuations.
- The objective of Alternative C is to adaptively operate Glen Canyon Dam to achieve a balance of resource objectives with priorities placed on humpback chub, sediment, and minimizing impacts on hydropower.
- The objective of Alternative D (the preferred alternative) is to adaptively operate Glen Canyon Dam to best meet the resource goals of the LTEMP (Section 1.4). Like Alternative C, Alternative D features condition-dependent flow and non-flow actions that would be triggered by resource conditions.
- The objective of Alternative E is to provide for recovery of the humpback chub while protecting other important resources including sediment, the rainbow trout fishery at Lees Ferry, aquatic food base, and hydropower resources. Alternative E features a number of condition-dependent flow and non-flow actions that would be triggered by resource conditions.

- The objective of Alternative F is to a provide flows that follow a more natural pattern while limiting sediment transport and providing for warming in summer months.
- The objective of Alternative G is to maximize the conservation of sediment, in order to maintain and increase sandbar size.

The LTEMP DEIS presents modeled estimates of changes in 20-year sand load index values and percentage changes in humpback chub populations relative to the no-action alternative (Alternative A) for each of the action alternatives B-G (Table ES9). These statistics are based on the primary modeling metrics used in the LTEMP EIS for these resource areas. As noted, for sediment, the metric used was the sand load index. For humpback chub, the metric used was from the coupled rainbow trout–humpback chub model. However it should be noted that there were limitations to these models and there were additional quantitative and qualitative analyses considered for these resources that are fully discussed in the LTEMP EIS sections 4.3 and 4.5.

Table ES9. Long Term Changes from Alternative A, by Alternative and Attribute

Attribute	A (No Action)	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F	Alternative G
Sandbars	0	2	31.4	30.4	23.8	33.4	35.2
Chub Population	0	8	0	4	6	-12	-6

The continuous attribute models of respondent WTP were also used to estimate the average WTP for acquiring the combination of attributes associated with one management scenario (X_1) compared to the attributes of another scenario (e.g., the no action alternative) ($X_{No\ Action}$):

$$WTP_i = (\hat{\beta}_j / \hat{\beta}_{Cost})(X_{i,j} - X_{NoAction,j})$$

- β_j represents a vector of attribute *i* preference parameters
- $X_{i,j}$ represents a vector of attribute *i* levels for the management scenario *j*
- WTP_i represents a vector of average WTP for acquiring the combination of attributes associated with management scenario *j*

The standard errors and confidence intervals for these value estimates were estimated using the Krinsky and Robb (1986) simulation method.

LTEMP DEIS Alternative-Specific WTP Results

Household and aggregate WTP estimates were modeled with two approaches:

1) Direct application of the estimated continuous attribute WTP coefficients to the long term percentage changes in attribute levels by alternative. This approach assumes that the non-

response weighting corrected for all potential differences in WTP between respondents and non-respondents.

2) Direct application of the estimated continuous attribute WTP coefficients as above, and identification of the potential share of the population with zero WTP (rather than a WTP value imputed from the model), and adjustment of estimated WTP to account for the potential impact of these individuals on the estimates.

Both approaches are described in the text of the report. For this summary, results from the more conservative approach (2) are presented.

Estimated WTP by Direct Application of Model Coefficients with Adjustment for Assumed "Zero Value" Non-Respondents

As noted, the previous estimation of household and aggregate WTP by alternative was based on the assumption that the weighting for non-response bias discussed previously compensated for all non-response bias in WTP estimation. In their 1995 study of Glen Canyon total value, Welsh et al. (1995) examined the same resource using a different WTP question format. They followed up all "no" responses to their WTP questions with asking respondents if they would support the proposed dam operation change if the cost was "zero." Welsh et al. (1995) then weighted their WTP values by imputing a value of zero to the share of their respondents who said they would not support the changed scenario even at a zero cost.

While the current survey did not present the follow up question in the same way, we did ask those who chose the "status quo" plan at zero cost over the "proposed plan" at a positive cost questions related to why they chose this way. Overall, there were 38.8% of the Local sample and 30.3% of the National sample who agreed that they voted against the proposed plan because "I am against any more taxes or government spending." This is similar to the approach used by Haefele et al. (2016) who also set values for these non-respondents to "zero." These results were used to scale the WTP results presented above downward to adjust for potential "hard zero" WTP in 38.8% of the Local and 30.3% of the National populations. This approach provides a conservative estimate of value that is similar in method for aggregation to Welsh et al. (1995). Table ES10 and Table ES11 show the per household and aggregate annual WTP values based on this adjustment.

Table ES10. Conservative per Household Net Economic Value of Alternatives (Standard Errors in Parentheses)

Sample	A (No Action)	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F	Alternative G
National Sample	0	$ 13.11 (2.54)	$ 34.57 (12.73)	$ 38.92 (11.91)	$ 34.38 (9.12)	$ 20.41 (15.48)	$ 30.57 (15.13)
Local Sample	0	$ 10.07 (2.25)	$ 23.38 (12.44)	$ 26.93 (11.64)	$ 24.16 (8.91)	$ 12.00 (14.99)	$ 19.77 (14.73)

Table ES11. Conservative Aggregate Net Economic Value of Alternatives (in Millions of 2015 Dollars)

Sample	A (No Action)	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F	Alternative G
National Sample (aggregate WTP/year)	0	1,511	3,985	4,486	3,963	2,353	3,524
95% C.I.		950 to 2,100	1,062 to 6,816	1,760 to 7,141	1,880 to 6,002	-1,219 to 5,777	43 to 6,878
Ranking	**7**	**6**	**2**	**1**	**3**	**5**	**4**
Local Sample (aggregate WTP/year)	0	9	22	25	23	11	19
95% C.I.		5 to 14	-2 to 44	3 to 46	6 to 39	-17 to 38	-10 to 45
Ranking	**7**	**6**	**3**	**1**	**2**	**5**	**4**

Ranking of WTP Estimates across Alternatives

The LTEMP DEIS selected Alternative D as the preferred alternative. Both the modeling from the national and the local samples also show D as the most highly valued of the alternatives presented. Further, the ranking of alternatives in terms of WTP is generally consistent between the local and the national sample models (Table ES10). The alternative rankings are emphasized in Table ES11 since from a "decision analysis perspective" the policy question within the overall EIS process is which alternative to pick as the Preferred Alternative. This process fundamentally involves ranking of alternatives as the primary method of comparison.

Alternative D is an adaptive management alternative to further the goals for four key resources: sediment, chub, trout, and hydropower. These goals are included as outcomes (attributes) in our discrete choice models, where hydropower costs and taxes are the cost or payment variable. The next highest rated alternatives are "C" and "E" which were in part the basis for developing the preferred alternative "D". Alternatives "F" and "G" returned estimated WTP values per household (and aggregate) that were lower than "C" "D" and "E" and that are not statistically different from zero. These alternatives differ from the primary outcome-based alternatives in specifying flow scenarios, such as variations of natural flows and steady flows. Alternative "B" is relatively precisely estimated and is the lowest valued action alternative. This alternative was designed to maximize the value of hydropower subject to the constraint of meeting goals for other resources. Compared to alternatives primarily based on natural flows or steady flows, these results provide some support for the idea that adaptive management can most efficiently achieve the most highly valued LTEMP DEIS outcomes.

The primary finding, as summarized in Table ES11, is that the agency Preferred Alternative (D) is most highly valued by both the national and local respondents. The national aggregate annual value is $4,486 million (95% confidence interval 1,760-7,141) and the local aggregate annual value is $25

million (95% C.I. 3 million-46 million). The values for alternative D are higher than the next two most highly ranked alternatives (C and E). The latter are quite similar to D which was actually developed relatively late in the EIS process in part by drawing on the best features of both C and E alternatives. While the point estimates for both household and aggregate WTP associated with Alternatives C, D, and E show preferences, considering their 95% confidence intervals, these three estimates are not statistically different from one another.

Comparing WTP Results from the Current Study to those from Welsh et al. 1995

A major impetus for the NPS to commission the current study of total values associated with operational impacts of Glen Canyon Dam was to update the groundbreaking study of the same resource by Welsh et al. (1995) 20 years previously. The current study differed from the earlier Welsh study in many ways, including value elicitation method and descriptions of the impacts of alternative flow scenarios. While the Welsh study used a dichotomous choice contingent valuation question format for the key valuation questions, the current study used a choice model framework. The Welsh study described alternative flow release scenarios in terms of both how the flows would be released and how that release pattern corresponded to natural pre-dam flows, and in terms of what impact those release patterns would have on downstream resources.

The current study did not describe flow release patterns to respondents but rather focused only on "outcomes," or impacts to the resources which were used as attributes in the choice questions. In both studies, choices were made to exclude respondents who had a relatively low level of certainty in their responses to the valuation questions from the WTP analysis. In any case, while there are differences between the alternatives analyzed by the Welsh study and the current LTEMP DEIS, some alternatives are similar to moving to some variant of natural river flows or steady flow. Despite many differences between the two studies and the fact that over 20 years have passed since the original survey, the range of per household WTP estimates from the two studies are relatively consistent. Adjusting the preferred estimates from the Welsh study report using a simple Consumer Price Index (CPI) adjustment for price changes between the times of the two studies (1.60) results in estimates from the 1995 Welsh study in 2016 dollars ranging from $22 to $46 per household per year, depending on the sample frame and the scenario modeled. These estimates are similar to the estimates from our calculation of WTP with no "zero value" adjustment, and generally higher than our conservative estimates with a "zero value" adjustment for a share of respondents assumed to have zero WTP.

Model Validation

The estimated WTP models shown in Table ES10 and Table ES11 show a number of characteristics that provide validation for the models and associated WTP estimates.

1. There is a strong price response seen in both the local and the national samples. As predicted by theory, increasing levels of the cost parameter leads to a decreased probability of the respondent choosing the scenario. This indicates households were paying close attention to the dollar amount they were asked to pay, and took the dollar amount seriously.
2. The models for two very different populations (the 8-county Colorado River region and the U.S. as a whole) showed strong consistency in parameter estimates and significance.
3. Covariates showed generally expected signs in all models and strong statistical significance.
4. The attribute level model contained a built in “scope test” which showed distinct differences in preferences for different levels of change in attributes for both sediments and chub.
5. The binary WTP question format used was a referendum format that used taxes as payment vehicle, as recommended by the Arrow et al. (1993) blue ribbon commission on contingent valuation.
6. Estimated WTP values were in the same general range as the earlier Welsh et al. (1995) estimates for values computed with generally parallel assumptions and adjusted for inflation.

1.0 INTRODUCTION

1.1 Introduction and Historic Setting

Glen Canyon Dam is located on the Colorado River approximately 15 miles upstream from Lee's Ferry, the point used by most floaters to begin their Grand Canyon float trips. The reach of the Colorado River between the dam and downstream to Lee's Ferry is a heavily used trout fishery, which also sees substantial use from day-trip commercial floaters. As the river level control for the Colorado River through the Grand Canyon, Glen Canyon Dam and its operation has a significant impact on the ecosystem below the dam, and upstream of Lake Mead.

Previous research has established that there are significant passive use values associated with environmental services provided by the Grand Canyon. Contingent valuation methods have been applied to estimate willingness to pay to improve native vegetation, native fish, game fish (such as trout), and cultural sites in Glen Canyon National Recreation Area downstream of Glen Canyon Dam and in Grand Canyon National Park (Welsh et al. 1995). The 1995 Welsh study utilized a population survey, including households in the entire U.S. to identify willingness to pay to reduce flow fluctuations from Glen Canyon Dam to protect wildlife, beaches, and cultural sites. Because these resources are of national significance, this research was reviewed by a National Research Council panel (National Research Council 1996). The panel concluded that the research was high quality, but would need to be periodically updated.

A 2005 National Research Council publication examined methods for estimating total economic values for ecosystem services. The recommendation of this panel, and the direction of more recent economics literature, is to use stated choice methods, also referred to as attribute-based stated preference methods (Holmes and Adamowicz 2003). However, the contingent valuation approach undertaken by Welsh et al. (1993) is well accepted, has been published, and has been thoroughly peer reviewed.

Using the lessons learned from the Welsh study's surveys as a starting point, in 2016 National Park Service (NPS) sponsored a national survey to provide the data necessary for estimation of household willingness to pay (WTP) associated with a broad range of ecological outcomes anticipated from alternatives analyzed in the Glen Canyon Long-Term Experimental and Management Plan (LTEMP) Draft Environmental Impact Statement (DEIS). This report provides the core modeling and WTP estimation results from the data collected in the Glen Canyon Total Value Survey (Glen Canyon Survey), as well as associated LTEMP Final Environmental Impact Statement (FEIS) alternative-specific WTP estimates.

Current water operations at Glen Canyon Dam are dictated by the 1995 FEIS on Glen Canyon Dam (U. S. Bureau of Reclamation 1996). The 1995 FEIS and associated record of Decision (ROD)

outlined generalized operating rules governing dam releases under the preferred alternative of modified low fluctuating flows (MLFF).

Table 1 shows the general range of operating parameters for water releases from Glen Canyon Dam as outlined in the 1996 ROD. In comparison to earlier management practices, the MLFF scenario adopted in the ROD places limitations on daily fluctuations, minimum and maximum flow levels, and ramping rates during flow changes. The primary goals of the modified releases were to stabilize flows in order to reduce sediment loss within the riparian zone, protect native fish, and provide more predictability for river recreationists.

Table 1. Glen Canyon Dam Operating Limits as outlined in FEIS.

Glen Canyon Dam operating rules	Monthly release volume for Glen Canyon Dam (af)		
	<600,000	600,000-800,000	>800,000
Minimum releases 7 a.m. - 7 p.m. (cfs)	8,000	8,000	8,000
Minimum releases 7 p.m. - 7 a.m. (cfs)	5,000	5,000	5,000
Maximum peak under diurnal releases (cfs)	25,000	25,000	25,000
Daily fluctuations (cfs/24 hr)	5,000	6,000	8,000
Ramp rate (cfs/hr)	4,000 up, 1,500 down	4,000 up, 1,500 down	4,000 up, 1,500 down

Source: (Grand Canyon Research and Monitoring Center 2005)

While much discussion surrounding policy decisions on adopting or changing flow regimes for Glen Canyon Dam has in the past centered on the impact of any changes on market-based prices and services (power generation, recreational use, power prices, etc.), based on the National Research Council panel on guidelines for valuation of ecosystem services,[1] it is important to include intrinsic or passive use values (aka "non-use" values) in any net economic accounting of benefits. The National Research Council in their 2004 publication "Valuing Ecosystem Services: Toward Better Environmental Decision Making" provided a general overview of the benefits that derive from ecosystem services.

As can be seen in Figure 1, several kinds of services, or uses, derive from natural systems. One dichotomy is between on-site use and passive use. On-site use includes floating the Colorado River or fishing below Glen Canyon Dam. However, individuals who have no expectation to ever visit Glen Canyon or the Grand Canyon may still place a value on knowing that the ecosystem still is being preserved to the extent possible given existing infrastructure. Such values are termed passive

[1] National Research Council. 2005. Valuing Ecosystem Services: Toward Better Environmental Decision Making. National Academy Press, Washington, D.C.

use values and are not dependent on direct on-site use. Several of the possible motives for passive use values were first described by Weisbrod (1964) and Krutilla (1967), and include existence and bequest values. Existence values can derive from merely knowing that a given natural environment or population exists in a viable condition.

While direct use services may or may not have associated developed markets for them, passive use services are exclusively non-market services. When passive use and direct use values are estimated together, the estimate is referred to as total valuation. This concept was first introduced by Randall and Stoll (1983) and has been further developed by Hoehn and Randall (1989).

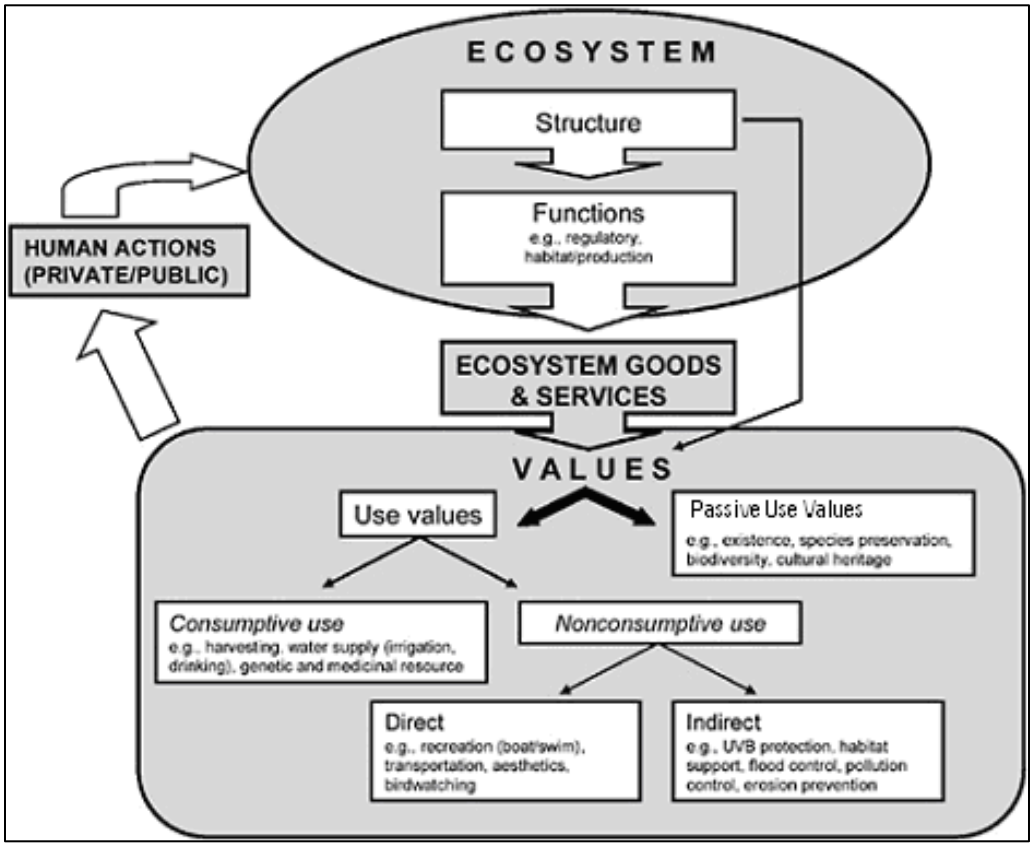


Figure 1. Flows of Ecosystem Services (adapted from NRC 2004)

When certain guidelines are followed, passive use valuation studies are recommended for use in natural resource damage regulations (for example, see Ward and Duffield 1992). Willingness-to-pay analyses have also been upheld in court[2] and specifically endorsed by a NOAA-appointed blue ribbon panel (led by several Nobel laureates in economics).[3] These methods are widely used in

[2] Ohio v. United States Department of Interior, 880 F.2d 432-474 (D.C. Cir.1989)

[3] Arrow, K., R. Solow, P. Portney, E. Leamer, R. Radner, and H. Schuman. 1983. Report of the NOAA Panel on

determining economic losses in the context of natural resource damage assessment (CERCLA, NOAA)[4]. They are also used in regulatory settings (EPA guidelines) and benefit-cost analyses are required for all significant Federal actions by Executive Order 12866.

U.S. Governmental agencies also recognize the importance of including accounting for changes in passive use values in agency decision-making. In 1996, Bruce Babbitt [then Secretary of the Interior] signed the Record of Decision on operations of Glen Canyon Dam. Based on the work of Welsh et al. (1995), included in this decision was an explicit recognition that the non-use (passive use) values of one alternative outweighed the predicted financial benefits of another alternative. The ROD noted:

> [The] Alternative was selected as the preferred alternative because it would provide the most benefits with respect to the original selection criteria, given existing information. This alternative would create conditions that promote the protection and improvement of downstream resources while maintaining some flexibility in hydropower production. **Although there would be a significant loss of hydropower benefits due to the selection of the preferred alternative (between $5.1 and $44.2 million annually) a recently completed non-use value study conducted under the Glen Canyon Environmental Studies indicates that the American people are willing to pay much more than this loss to maintain a healthy ecosystem in the Grand Canyon**. The results of this nonuse value study are summarized in Attachment 3 of the ROD. (Record of Decision, Operation of Glen Canyon Dam Final EIS, October 1996. Signed by Bruce Babbitt, Secretary of the Interior [emphasis added])

Twenty years have now passed since the original Welsh et al. (1995) Glen Canyon Dam passive use study informed the 1996 Record of Decision on operation of Glen Canyon Dam. The current Glen Canyon passive use study, funded by the NPS, has as its primary purposes to inform the current LTEMP EIS on Glen Canyon operations, and additionally, to explore issues of temporal stability of passive use values.

1.2 Timeline of Current Study

The current study has been developed over a period of nearly eight years (Table 2). In 2008, the NPS funded initial stages of study on estimating values associated with NPS resources along the Colorado River. These investigations included development of a preliminary attribute study and draft sampling plan for replicating the Welsh et al. (1995) Glen Canyon Dam passive use value study (APPENDIX D). This preliminary document was completed in 2009, and in 2012 NPS provided funding for the current study.

Contingent Valuation

[4] 59 Federal Register 14262.

Initially, the current study was not specifically tied to the LTEMP EIS process. Rather, it was envisioned as an academic study which would test issues of passive use value stability over time and across valuation question formats. When it became clear that the current study could help inform the ongoing LTEMP process, the authors coordinated with LTEMP managers and scientists to ensure the information gathered in this study was consistent with the needs of the EIS. Specifically, ecosystem attributes used in the current survey instrument (APPENDIX A) along with their attribute levels were chosen to coincide with anticipated primary attributes and levels of interest studied in the EIS.

In the summer of 2013 the draft survey instruments were tested using five individuals recruited in Missoula, MT from an advertisement on Craigslist. These individuals were administered the survey individually, and then were interviewed about their understanding of the survey, areas needing more clarity, and their suggestions for improving the overall survey. Participants received $50 compensation each for their time and cooperation. As a result of these cognitive interviews, minor wording changes were made to the draft survey instruments.

In August of 2013 the information collection review package was submitted to the Office of Management and Budget (OMB) for approval. At the same time, two peer reviewers were engaged to review the survey instruments and the study plan as outlined in the OMB submission. These peer reviews were completed in October 2013. After multiple levels of Agency (Department of Interior) and OMB review, the authors received OMB approval to conduct a limited pretest of the survey instrument in September 2014. The pretest was completed in early December 2014, and a report on the pretest was submitted for agency and OMB review in early January 2015 (APPENDIX B). On November 24, 2015 OMB gave final approval to conduct the primary survey data collection.

The data collection and survey administration began in early January 2016 and the final non-response phone survey was completed in mid-June 2016.

Table 2. Timeline of the Glen Canyon Passive Use Study

Task-Benchmark	Date
Original Welsh et al. (1995) Study published	1995
NPS-funded passive use study design and sampling plan completed	January 2009
Current study funded by NPS	August 2012
Delay waiting for development of LTEMP alternatives to link to survey	August 2012-June 2013
Draft survey instruments and limited cognitive interviews to test surveys	Summer 2013
Submission of OMB package	August 2013
Peer reviews of study design and sampling plan completed	October 2013
Department of Interior review	Nov 2013-Feb 2014
Resubmitted revised OMB package	March 2014
OMB approval of limited pretest of survey instrument	September 18 2014
Pretest completed	December 10, 2014
Pretest report submitted to DOI	January 5, 2015
Full OMB approval	November 24, 2015
Start survey administration	January 5, 2016
Draft study report	July 2016

1.3 Statement of Problem

As noted, the primary objectives of this study are to: 1) update the work and estimates of Welsh et al. (1995) and provide a discussion of the comparability and stability of passive use values over time, and 2) inform the current LTEMP EIS process in providing information on the estimated U.S. passive use values associated with different action alternatives presented and analyzed in the DEIS.

1.4 Report Organization

This report is organized in several major sections:

- Section 2 details the study design and data collection;
- Section 3 presents survey results exclusive of Willingness to Pay (WTP) modeling;
- Section 4 presents WTP modeling results;
- Appendices include all supporting and developmental materials associated with the study.

2.0 STUDY DESIGN AND DATA

As discussed above, the development of the current study began with a preliminary attribute study and sampling plan in 2009 (APPENDIX D). Since that original document, the focus, content, and scope of the study has evolved to focus more on informing the LTEMP EIS process, and less on providing a purely academic examination of theoretical issues related to passive use valuation methods. This section outlines the final attributes, attribute levels, experimental design, and sampling strategy used.

2.1 Survey Design

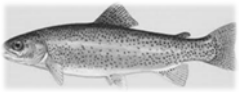
The choice of the structure of the discrete choice (DC) question and survey format used in this study was informed by previous successful, and similar, studies. The current study utilized a survey which presented respondents with two DC questions (choice tasks) each offering a choice between current management of the dam and its implication for long term changes in attribute levels, and alternatively "proposed plans" which offer different resulting changes in attribute outcomes.

2.1.1 Attribute Selection

The three primary ecosystem attributes included in the DC questions were changes in river sediment, and more specifically the buildup or erosion of beaches (or sandbars) along the river, changes in native fish (humpback chub) populations, and changes in the populations of large trout. An additional attribute was the cost of the proposed plans. This cost attribute was explained as being a result of higher electric bills in the 6-state Colorado River Basin and increased federal taxes for all U.S. residents needed to pay for the costs associated with the proposed plans. The survey text describing the primary ecological attributes examined in the survey is show in in Figure 2.

SEDIMENT Deposits of sand and mud called **beaches or sandbars**, are scattered along the river. Most of the rest of the river bank consists of cliffs and steep slopes covered with rocks, boulders, wind-blown sand and desert vegetation. Beaches with vegetation provide habitat for birds and other small animals. Beaches also are used by river floaters for camping

FIVE NATIVE FISH species, including the humpback chub shown, live in the Study area. Only one of these native species is found outside the Colorado River and its tributaries.



NON-NATIVE FISH also live in the river. Rainbow trout are not native to the Colorado River. They were introduced to this section of the Colorado River for recreational fishing following the construction of Glen Canyon Dam. People fish for rainbow trout primarily in the first 15 miles downstream from Glen Canyon Dam. **Several other non-native fish species,** including brown trout, common carp, channel catfish, and fathead minnow, also live in the study area.

Figure 2. Survey Description of Primary Attributes Used in Discrete Choice Questions

2.1.2 Attribute Levels

Just as the primary ecological attributes utilized in the DC survey questions were chosen to inform impact from and differences between the action alternatives developed for the Glen Canyon LTEMP DEIS, attribute level choices went through several layers of review by LTEMP scientists to ensure that the changes in levels tested in the choice questions were generally consistent with the anticipated alternative-specific changes in these same attributes from yet to be completed EIS analysis modeling. Figure 3 shows the attribute levels both for the "Current Management Plan" and for the "Proposed Plans."

Attribute Levels for Current Management Plan (fixed across all questions)

Erosion of sandbars

- 20% deterioration of sandbars

Populations of Native Fish within the Grand Canyon Corridor, including the endangered humpback chub

- Remain at present levels of native fish populations

Large Trout populations in the river

- Remain at present levels of large trout

Cost to your household

- $0

Attribute levels for Proposed Plans

Erosion of sandbars

- 20% deterioration number of sandbars
- Rate of change in the number of sandbars remains at present levels
- Potential for 20% increase in the number of sandbars

Populations of Native Fish within the Grand Canyon Corridor, including the endangered humpback chub

- 25% decrease in native fish populations
- Remain at present levels of native fish populations
- 25% increase in native fish populations
- 50% increase in native fish populations

Trout populations in the river

- 25% decrease in large trout populations
- Remain at present levels of large trout populations
- 25% increase in large trout populations
- 50% increase in large trout populations

Cost to your household

- $12
- $40
- $110
- $280

Figure 3. Glen Canyon Survey Attribute Levels

2.1.3 Experimental Design

Given the final design of the DC questions used 4 attributes with as many as 4 attribute levels (implying a full factorial design of 192 question versions), a set of SAS Macros was used in order to identify an efficient allocation of attribute levels across a manageable number of survey/question versions. A macro was employed to identify sizes of the experimental design that were efficient yet less than a full factorial design while optimizing D-efficiency (sometimes known as D-optimality), which is a standard measure of the goodness of the experimental design. As D-efficiency increases, the standard error of the parameter estimates in the linear model decrease. Next, a different macro was used to find and evaluate an efficient experimental design in which the variances of the parameter estimates are minimized, given an assumed parameter vector. Finally, we used a third macro to efficiently group the choice sets into 12 blocks (survey versions) of 2 choice questions each with 2 alternatives (including a current management alternative). An example of the DC questions posed includes four attributes: changes in sandbars along the river; changes in endangered species (chub) population levels; changes in populations of large trout; and increased household costs (increased taxes and possible power costs) varying from $12 to $280.

2.2 Sample Design and Data Collection

2.2.1 Pretest Survey Administration and Results

On September 18, 2014 the NPS received a Notice of Action (NOA) from the Office of Management and Budget approving a pilot survey to collect information concerning the total economic value of National Park System resources along the Colorado River Corridor (which includes the Glen Canyon Dam and Grand Canyon National Park). Following this approval, the pretest was conducted in November and December 2014. The primary goal of the pretest was to determine if the survey instrument and the sampling methods performed as anticipated. The results of the pretest suggested that the survey and sampling methods would provide the level of detail and data that will be one piece of information that the Secretary of the Interior will use to evaluate future dam operation plans associated with the current ongoing LTEMP DEIS.

The responses from the pretest version of the survey were used to predict a possible response rate for the final version, to test the questions in general and specifically to determine if the levels for the conjoint questions worked as expected. Below is a summary of the findings from the pretest (See APPENDIX C for full pretest report):

- A total of 225 U.S. household addresses were selected for the pretest sample. Of the 225 surveys mailed, 23 were retuned as undeliverable and 49 completed surveys were returned for an overall response rate of 24%.
- The results from the pretest suggest that most respondents understood the questions, followed instructions, and had adequate information to answer the stated-preference DC questions.
- Overall 39.7% of the respondents voted in favor of the action plans presented, but as expected this percentage was lower when the cost of the plan (bid amount) was higher.
- While the pretest sample size was too small to estimate any meaningful DC model parameters, respondents reacted to key choice attributes (cost) as predicted by theory (downward sloping demand curve).
- The range of high and low bids presented suggested that no change in overall bid range was needed in the final survey instrument in order to capture the essential bid response distribution.

2.2.2 Sample Frames

Two independent strata were selected for the administration of the Glen Canyon household survey: all U.S. households, and households located in the eight counties including or contiguous with Glen Canyon and the Grand Canyon (Table 3 and Figure 4). In order to acquire the most up-to-date address list of U.S. households, we utilized addressed-based sampling (ABS) and selecting the survey samples from the USPS's Delivery Sequence File (DSF). The DSF contains all postal mailing addresses in the United States. Using mail as the primary contact method avoids under-coverage problems found with other methods by including residential addresses, but also other types, such as post office boxes and general delivery. Unlike other sampling frames, this also provides the ability to accurately stratify the sample geographically.

ABS samples were purchased from Survey Sampling International (SSI) in late December 2015 for the two primary strata. In order to ensure that the local area (8 county) sample was not entirely dominated by Clark County, NV (Las Vegas and surrounding communities) we stratified the local area sample to include 50% addresses from Clark County, NV and 50% from the remaining seven (much more rural) counties in the area.

Table 3. Glen Canyon Survey Sample Frames.

Sample Frames	Total Number of Households	Number of Sampled Households
Glen Canyon Dam Local Sample **UTAH:** Washington, Kane and San Juan Counties **NEVADA:** Clark County **ARIZONA:** Mojave, Coconino, Navaho and Apache Counties	**939,900***	**1,132**
National Sample	**115,226,000***	**3,473**
Total		**4,605**

* U.S. Census Quickfacts (2014)

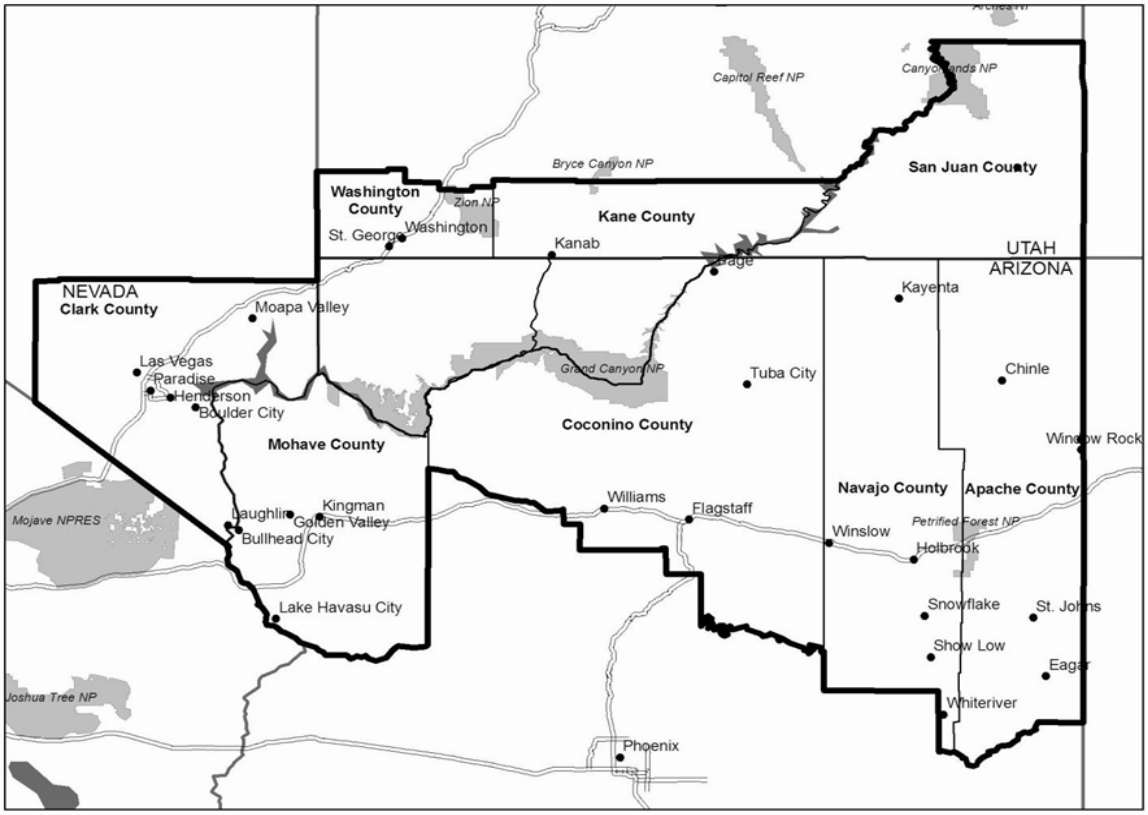


Figure 4. Map of 8-county Local Area Sample Frame

2.2.3 Survey Administration

The current study utilized a repeat contact mail-back survey method to gather survey responses. We used a modified Dillman (2007) method to maximize the response rate. As noted, in Nov.-Dec. of 2014 a pretest of the survey instrument was sent to a random sample (n=225) of U.S. households. The pretest was designed to help assess the upper end of the bid range for the DC questions as well as identify any understandability issues with the survey, and had a response rate of 24%. We began the main survey process in 2016 by sending an initial postcard to notify respondents that they should expect a copy of the survey in the mail within the next week or so. All potential respondents were then mailed a survey packet that included a cover letter, questionnaire, and a self-addressed stamped envelope. Ten days following the mailing of the survey packet, we sent a reminder postcard; two weeks after that, a packet including a replacement survey, cover letter, and a postage paid return envelope was mailed to all non-respondents. Table 4 below details the progression of the mailing protocol.

Table 4. Glen Canyon Survey Mailing Protocol

Mailing	Date
Pretest mailings	Nov.-Dec. 2014
Initial contact postcard	January 11, 2016
First survey mailing	January 19
Reminder postcard	January 25
Final survey mailing	February 19
Phone non-response survey	June 4 – 14

2.3 Statistical Analysis Methods

Once the data collection was completed, the data was cleaned and coded. All data was analyzed using SAS statistical software. The software was also used to perform statistical tests on responses to key survey measures among the two primary subpopulations (national and local).

We generated statistics to summarize and compare responses, response rates, and individual characteristics across groups defined in the sampling plan. A weighting adjustment was also generated to correct any detected non-response bias.

Estimating Household's Total Willingness-to-Pay (WTP)

To analyze the data from the DC experiment questions, we applied a random utility modeling (RUM) framework, which assumes that survey respondents implicitly assign utility to each choice option presented to them. This utility can be expressed as

$$U_{ij} = V(X_{ij}, Z_i; \beta^i) + e_{ij},$$

- U_{ij} is individual *i*'s utility for a choice option (i.e., restoration option) *j*
- $V(\cdot)$ is the nonstochastic part of utility, a function of X_{ij}
- X_{ij} represents a vector of attribute levels for the option *j* (including its cost) presented to the respondent
- Z_i, a vector of personal characteristics
- β^i, a vector of attribute-specific preference parameters
- e_{ij} is a stochastic term, which captures elements of the choice option that affect individuals' utility but are not observable to the analyst. On each choice occasion, respondents are assumed to select the option that provides the highest level of utility. By presenting respondents with a series of choice tasks and options with different values of X_{ij}, the resulting choices reveal information about the preference parameter vector.

Conditional Logit Estimation

To estimate the parameters of the DC model, we used a standard conditional logit (CL) model, which assumes the disturbance term follows a Type I extreme-value error structure and uses maximum-likelihood methods to estimate the attribute parameters. The conditional logit is a computationally straightforward estimation approach that can provide useful insights into the general pattern of respondents' preferences, trade-offs, and values.

The parameter estimates from the CL model was then used to estimate the average marginal value of each non-cost attribute. They were also used to estimate the average WTP for acquiring the combination of attributes associated with one management scenario (X_1) compared to the attributes of another scenario (e.g., the no action alternative)) ($X_{No\ Action}$):

$$WTP_i = (\hat{\beta}_j / \hat{\beta}_{Cost})(X_{i,j} - X_{NoAction,j})$$

- β_j represents a vector of attribute *i* preference parameters
- $X_{i,j}$ represents a vector of attribute *i* levels for the management scenario *j*
- WTP_i represents a vector of average WTP for acquiring the combination of attributes associated with management scenario *j*

The standard errors and confidence intervals for these value estimates were estimated using the Krinsky and Robb (1986) simulation method.

3.0 RESULTS

Results of the study analyses are presented in two primary groupings: results from willingness to pay (WTP) modeling, and non-WTP results. This section discusses survey results not tied directly to WTP modeling. The section includes discussions of survey response rates, non-response bias analysis, and respondent experience and preference analysis.

3.1 Survey Response Rates

The response rate for the current study was 18% for the local area sample and 12% for the national sample. These responses are comparable to a recent national mail household survey on National Parks by Harvard-Colorado State University (Haefele et al. 2016) which used a very similar survey protocol and achieved a 17-18% response rate. One difference between the Haefele et al. (2016) protocol and the current study was that the Harvard-CSU study was privately funded and offered some respondents a financial incentive to complete the survey. The current study was funded by NPS, was required to be reviewed by OMB, and was not budgeted to include financial incentives.

Recently, the Pew Research Center reported their rates of response to telephone surveys had dropped from 36% in 1997 to 9% (Pew Research Center for the People and the Press 2012). Although in that case the method of data collection (phone calls) was different from that employed by this study (mail-back surveys), it is indicative of a wider trend; the American Association for Public Opinion Research notes that "[l]argely due to increasing refusals, response rates across all modes of survey administration have declined, in some cases precipitously" (AAPOR 2016). The somewhat lower than anticipated response rate in this study is representative of these trends. However, the resulting sample size provides adequate data to conduct a robust analysis.

For a given survey, response rate is dependent on a wide range of interrelated factors, the relative importance of which change from individual to individual. The leverage-saliency theory of survey participation proposes that no single method has been shown to universally increase response rates because no single influencing factor holds constant in the magnitude of its influence across survey populations, and further that "the effect of one factor may be altered in the presence of another" (Groves 2000). As such, there is no magic bullet for declining response rates, but there are methods which have been consistently, if not universally, shown to be effective in increasing participation. One such method is the Dillman protocol employed by this study and described above (Chidlow 2015).

The most substantial threat posed by lower rates of participation is the possibility of non-response bias, which occurs when the data collected is not representative of the population surveyed due to a higher rate of non-response among segments of the population whose answers would have

differed non-trivially from those collected. For example, a common type of non-response bias is that of age—older individuals are generally more likely to respond to a survey, so younger people can be underrepresented in the data. In the past, high response rates were considered the most important safeguard against non-response bias, and surveys with low rates of participation were thought to be necessarily unreliable. Recent studies, however, have shown that lower response rates are not inherently correlated with a higher incidence of non-response bias (AAPOR 2016; Keeter 2000). Furthermore, bias that is known to exist in a study can be corrected for through monitoring and weighting of key factors among the respondents. This goes to show the decline in survey participation has not undermined the reliability of surveys as a method of statistical prediction, but rather demonstrated the effectiveness of statistical research's best practices (Keeter 2000). In accordance with those best practices, the design of this study aims to address the major sources of survey error not only by maximizing our response rate through use of the Dillman protocol, but also by identifying and correcting for non-response bias post-data collection.

Table 5. Glen Canyon Survey Response Rate

Survey Status/Statistic	Local Sample	National Sample	Total Response Rate
Surveys Mailed	1132	3473	4605
Non-Deliverable	186	377	563
Returned	166	363	529
Response Rate	17.55%	11.72%	13.23%

Table 5 shows the response data used to calculate this study's response rate. The surveys that came back as non-deliverable were subtracted from the number of surveys mailed, and the number of returns was then divided by that total. The overall response rates were 11.7% for the national sample and 17.6% for the local area sample. As discussed above, the local sample was stratified into two strata: Clark County, NV (Las Vegas area), and the other seven more rural counties that border or include Glen Canyon and the Grand Canyon. The stratification was designed to target the rural counties more heavily (in a 4:1 ratio) than the more urban (Clark County) respondents.

3.2 Analysis of Potential Non-Response Bias

Due to the increasing difficulty in achieving high response rates in national household surveys in recent years and the overall 13.2% response rate for the Glen Canyon Survey, a random phone survey of non-respondents was undertaken by Responsive Management of Harrisonburg, VA, a professional survey research firm. From previous NPS survey research (Haefele et al. 2016) we

identified a number of survey questions which were likely to identify non-response bias in the survey. These questions largely concerned the respondent's familiarity with and use of National Parks in general, and Glen Canyon and Grand Canyon National Park in particular. A comparison of responses from the mail and non-response phone survey showed some general stability between the samples, but statistically significant differences between respondents and non-respondents were evident for the national sample (in particular) for whether the respondents had ever visited a National Park. Inclusion of an indicator variable for this question in preliminary willingness to pay modeling runs showed it to be statistically significant in explaining WTP. Therefore, in order to control for this non-response bias, weights were constructed to more closely align the respondent sample with the estimated total population with regard to the percentage of the sample who had visited a National Park. Table 6 shows a comparison of the respondent and non-respondent samples for the key survey questions included in the non-response survey.

Table 6. Comparison of Survey and Nonresponse Survey Results

	Local Survey Sample (Sample Size)	Local Nonresponse Sample (Sample Size)	National Survey Sample (Sample Size)	National Nonresponse Sample (Sample Size)
Percent who have been to Glen Canyon Dam	57.53% (146)	47.50% (39)	11.49% (322)	17.16% (166)
P-value	0.2642		0.0820	
Percent who have visited a national park	98.08% (156)	92.50% (39)	90.09% (333)	59.76% (168)
P-value	0.0700		<0.0001**	
Percent who have visited Grand Canyon National Park	94.27% (157)	85.00% (39)	49.55% (337)	34.32% (169)
P-value	0.0508		0.0012**	
Asterisks indicate proportions are significantly different at the *95% or **99% level of confidence				

Comparisons were also made between selected key demographic characteristics of the U.S. sample and recent U.S. Census statistics (Table 7 through

Table 10). As can be seen in the tables, the U.S. sample respondents to the current survey were less likely to be female than the national populations (38% vs. 51%), more likely to classify themselves as "white", more likely to be college educated and less likely to report income below $25,000 per year.

In order to test the potential impact of these differences on responses to the key DC questions, the demographic variables were included as explanatory variables in logistic regressions modeling responses to the DC questions. None of the demographic characteristics were found to be statistically significant (95% level of confidence) predictors of DC questions choices. Therefore, no additional weighting based on census differences was applied in addition to the previously discussed non-response weighting.

Table 7. Comparison of Gender Distribution: Survey Sample vs. 2010 Census

Gender	National Sample	2010 Census
Male	62.04%	49.2%
Female	37.96%	50.8%

Table 8. Comparison of Race and Ethnicity Distribution: Survey Sample vs. 2010 Census

Race and Ethnicity	National Sample	2010 Census
Hispanic or Latino	3.93%	16%
White	93.88%	74.8%
Black or African American	3.67%	13.6%
American Indian or Alaska Native	2.45%	1.7%
Asian	1.53%	5.6%
Native Hawaiian or Other Pacific Islander	0.92%	.04%
Multiracial		2.9%

Table 9. Comparison of Educational Attainment: Survey Sample vs. 2010 Census

Educational Attainment	National Sample	2010 Census
Percent high school graduates	96.96%	86.3%
Percent bachelor's degree or higher	53.04%	29.3%
Percent graduate or professional degree	31.98%	11.0%

Table 10. Comparison of Income Distribution: Survey Sample vs. 2010 Census

Household Income	National Sample	2010 Census
Under $25,000	13.10%	23.2%
$25,000 to $34,999	10.48%	10.2%
$35,000 to $49,999	13.10%	13.5%
$50,000 to $74,999	18.12%	17.8%
$75,000 to $99,999	17.90%	12.2%
$100,000 to $199,999	20.74%	18.0%
$200,000 or more	6.55%	5.0%

3.3 Respondent Experience and Preference Results

To help establish a base of knowledge and provide an indication of how closely the respondents read the survey, the survey instrument began with a few pages of information about the history of the management of Glen Canyon Dam and then presented respondents with a series of true or false questions. Results are visualized in Figure 5 below. Overall, those surveyed had a good grasp on the material, with eight of the ten questions answered correctly more than 80% of the time.[5] There was little variation between the local and non-local sample.

[5] The two statements that respondents stumbled on were: 1) "native fish populations in the Colorado River **have declined continuously** since the dam was built," to which the correct answer is **false**, because although they declined during the 1990's, they have increased over the past ten years; and 2) "reducing daily fluctuations in the amount of water released from the dam will **reduce** the total amount of hydroelectricity provided," to which the correct answer is **false**, because the amount of power produced depends on the amount of water released, rather than the fluctuations in that amount.

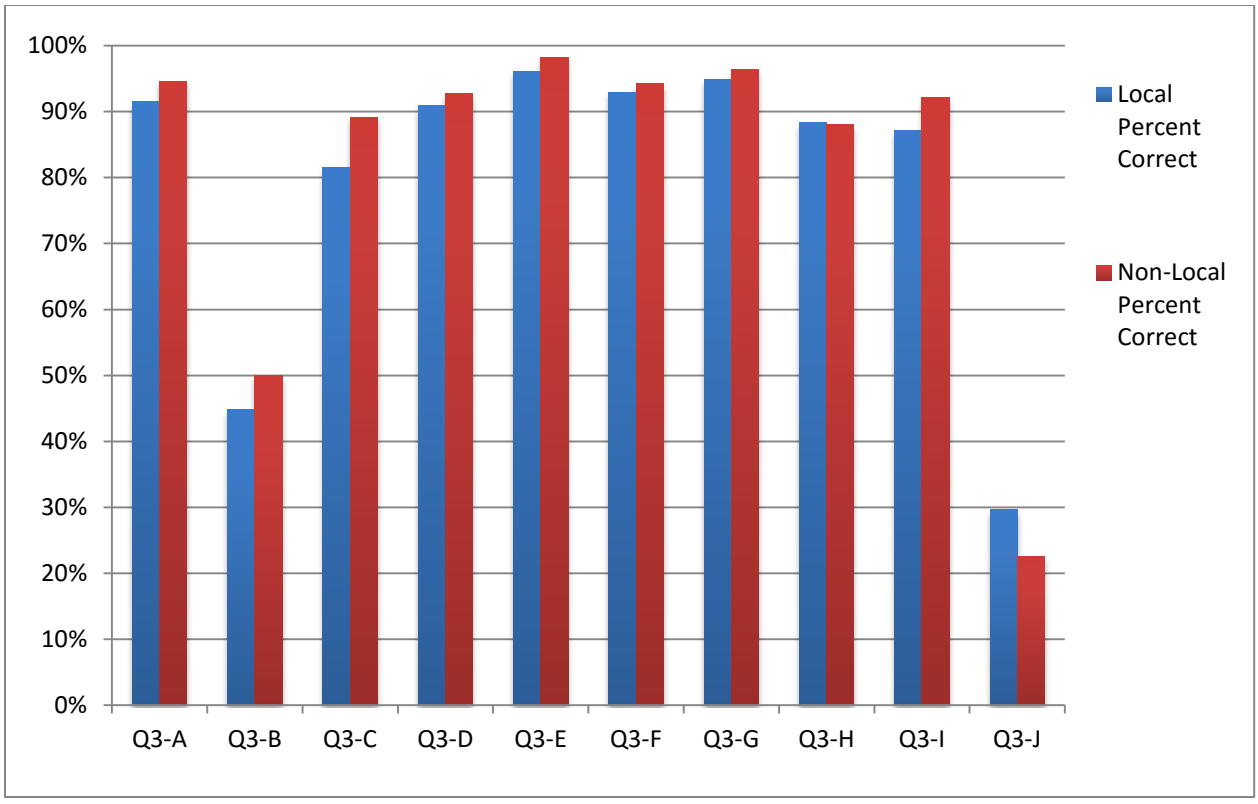


Figure 5. Respondent Understanding of Background Material, as Measured by Percentage of Correct Answers to Comprehension Questions

For the information provided to respondents and the exact questions used to measure reading comprehension, please see Appendix A, which contains the survey instrument.

The survey also asked a few questions to determine respondents' personal experience with Glen Canyon and the Grand Canyon area. Figure 6 shows the average percentage of those surveyed who have visited the Grand Canyon, seen the Colorado River, and gone down to the river itself.[6]

Unsurprisingly, on this question there was a large degree of variation between the local and non-local sample—while 50% of the non-local respondents had visited the Grand Canyon, that number shot up to 94% among locals.

[6] In this set of questions, respondents were instructed only to move on to the next if they had answered "yes" to the previous. Thus, each percentage is a function of the percentage before it—i.e. the number of respondents who have seen the Colorado River is not 89% of the total, but rather 89% of the 64% who had visited the Grand Canyon.

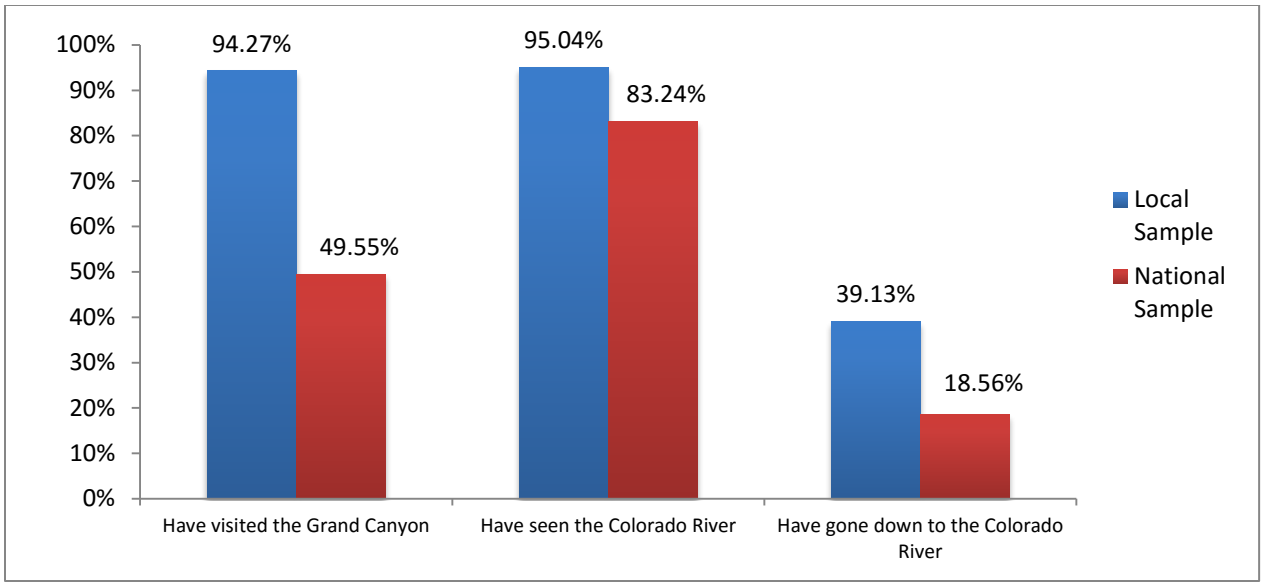


Figure 6. Respondent Experience with the Grand Canyon and the Colorado River, Separated into Local and Non-Local Samples

That division was also present in the respondents' awareness of Glen Canyon specifically. When broken out by area of residence, some stark (if expected) differences become apparent. As Figure 7 shows, 82% of local respondents had heard of Glen Canyon, and a 58% had visited it, as compared to 42% and 11% of non-local respondents, respectively.

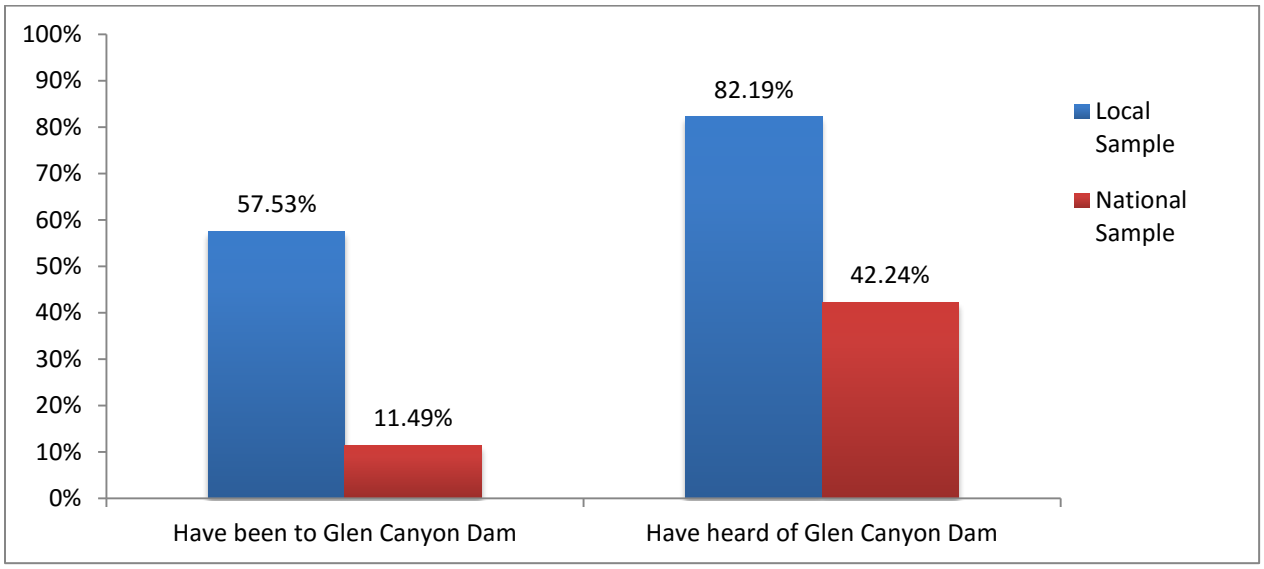


Figure 7. Respondent Awareness of Glen Canyon, Separated into Local and Non-Local Sample

Finally, to help gauge investment among those who had not visited the Grand Canyon, the survey asked how likely a future trip is. Most respondents answered either "very" (38%) or "somewhat" (33%) likely. Results are shown in Figure 8.

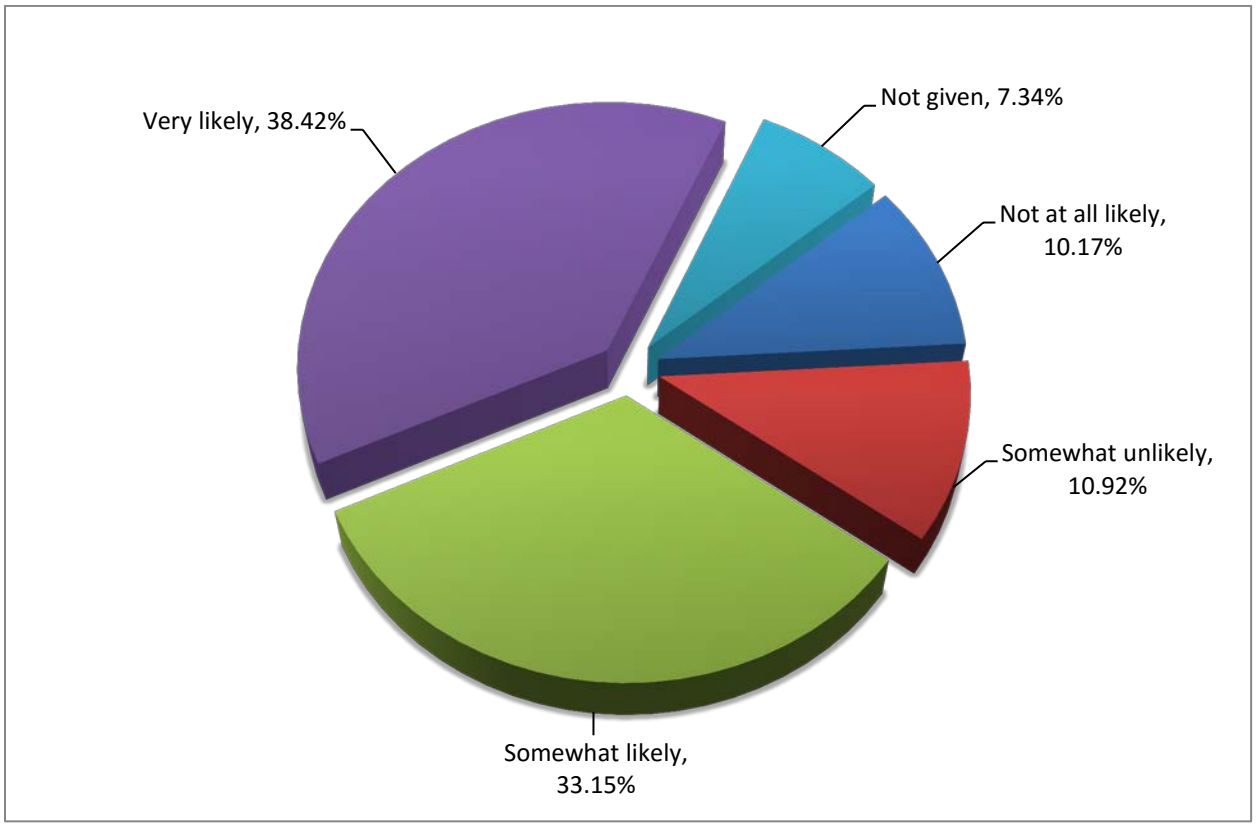


Figure 8. Likeliness of Future Grand Canyon Visit

The bulk of the survey was comprised of Likert-scaled questions that asked respondents to rate statements on a scale from 1 to 5, with 1 being "strongly agree" and 5 being "strongly disagree." These statements were arranged into sections that shared a similar theme, and the graphs on the following pages each show one of those blocks, with the responses grouped into two bars per question: one for the "agree" responses (1 and 2) and one for "disagree" responses (4 and 5).[7] Graphs comparing the "agree" and "disagree" responses for the National Sample are shown in Figure 9 to Figure 13. Comparisons between the Local and National samples for these questions are shown in Table 11. The first block of Likert-scaled questions dealt primarily with the effectiveness of

[7] A 3 on the scale was labeled "neither agree nor disagree," and has not been included in the graphs.

the survey and potential economic concerns of those surveyed (Figure 9). Most respondents (67%) felt the survey provided enough information and the majority (63%) also disagreed with the statement that the questions were hard to understand. 64% thought that their taxes would increase if one of the proposed plans were to pass. The fact that nearly two-thirds of respondents thought their taxes would increase with the proposed plans demonstrates consequentiality. In particular, as Carson and Groves (2007) note, the respondent needs to believe the if the agency implements a particular alternative that the specific quantity will be provided and the stated price will be assessed. The payment vehicle must be such that you cannot opt out of it (e.g., taxes). Since 2/3 of respondents believe that their taxes will increase the study design has met the conditions for consequentiality, hence minimizing hypothetical bias. Further, since the question format is binary it is incentive compatible. Mitani and Flores (2014) also demonstrate that if respondents believe they will have to pay, this reduces hypothetical bias.

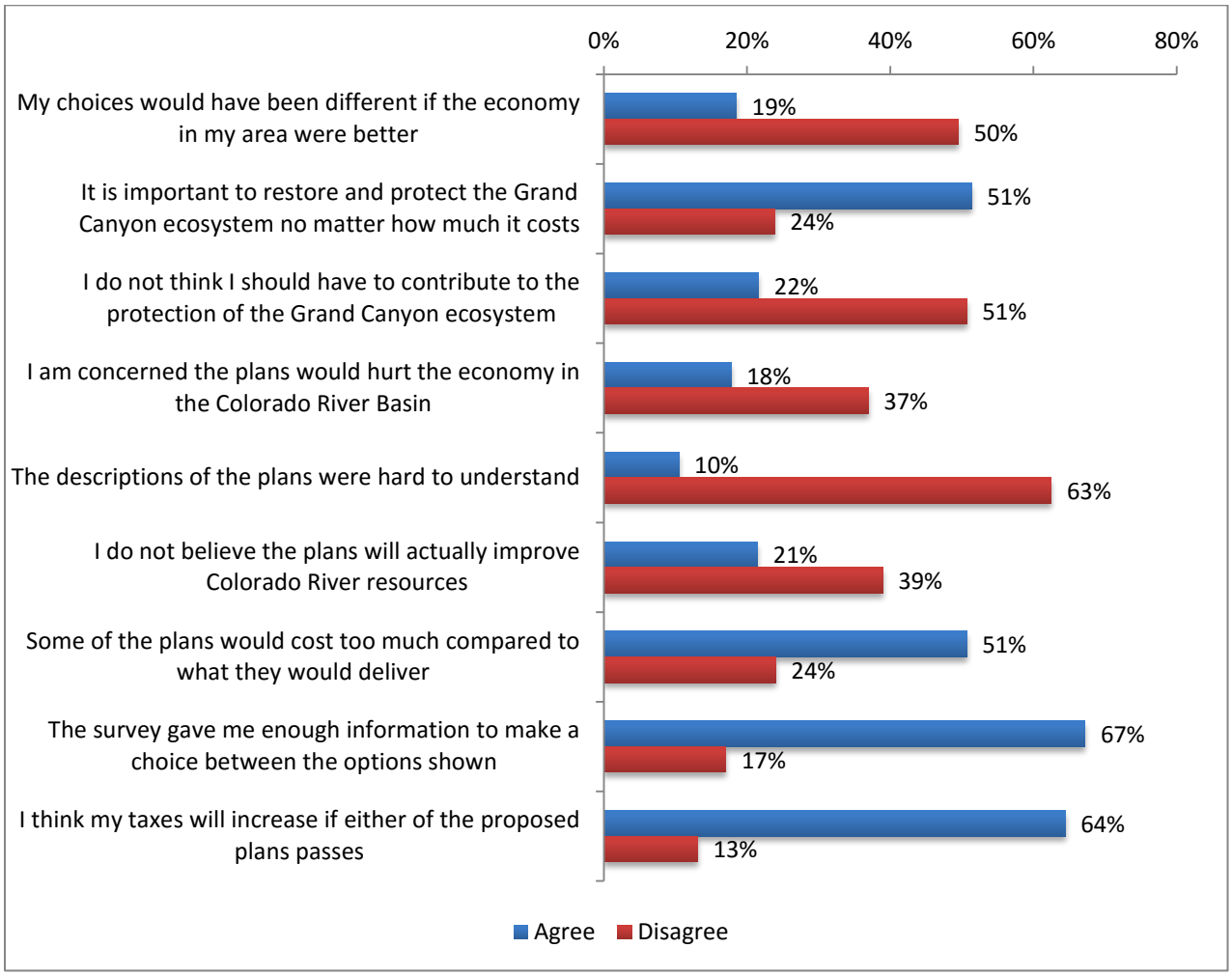


Figure 9. Levels of Respondent Agreement with Statements about Economic Concerns and Survey Effectiveness: National Sample

The next block of questions dealt with respondents' attitudes about the environment (Figure 10). Here, a clear pattern emerged—84% of those surveyed said they had a "great deal of concern" for habitat protection, and respondents also largely agreed that species should receive protection even if they aren't useful (75%) or despite the person surveyed never seeing or enjoying them (73%), that nature is delicately balanced (77%), and that protecting rare species is important (79%).

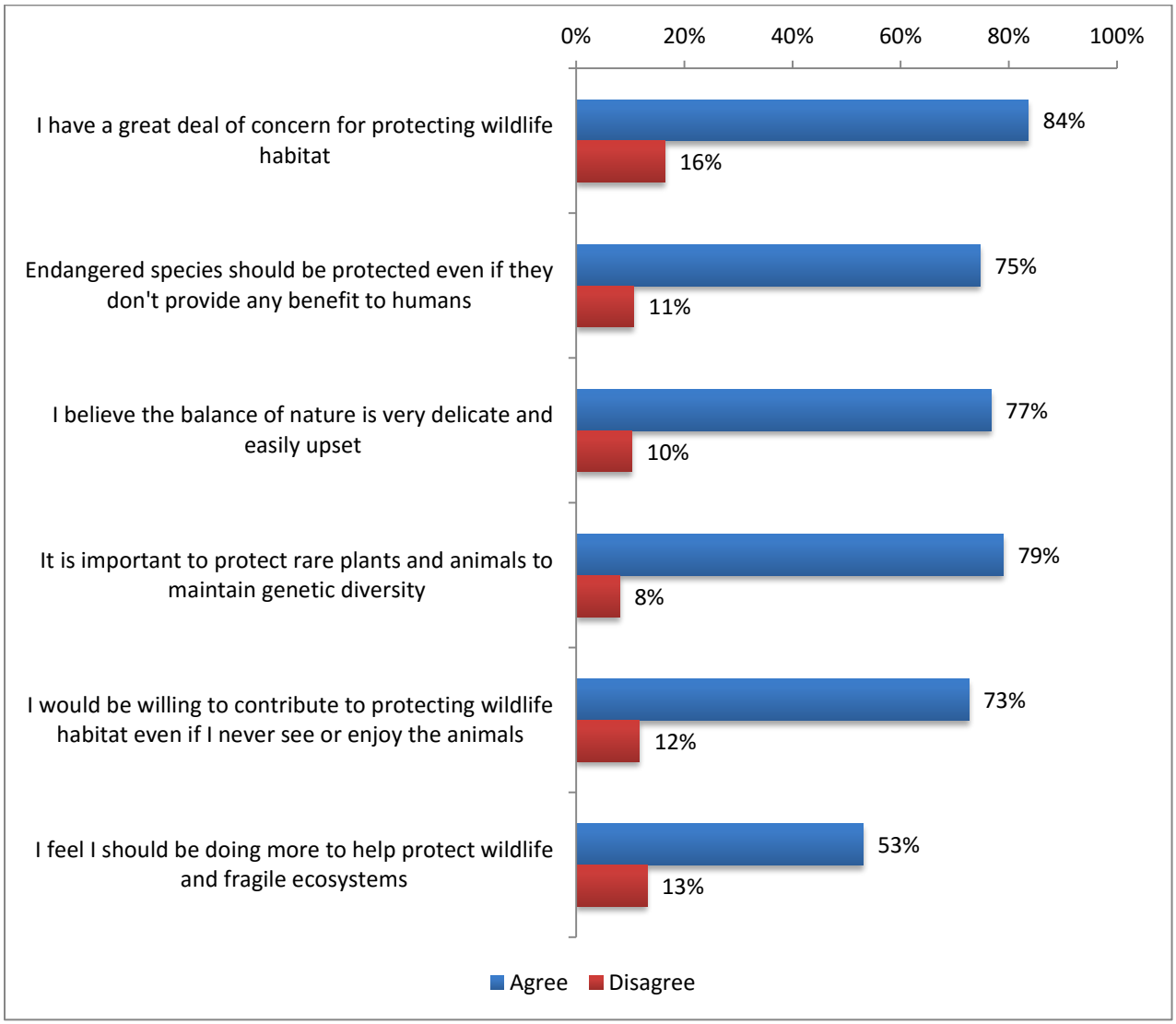


Figure 10. Levels of Respondent Agreement with Statements about Environmental Concerns: National Sample

There was less agreement in the next set of questions, which concerned business and the economy. Interestingly, although only 42% of respondents disagreed with the assertion that economic security should be considered before environmental problems, 65% disagreed with the statement that decisions to develop resources should be made "mostly on economic grounds" (Figure 11).

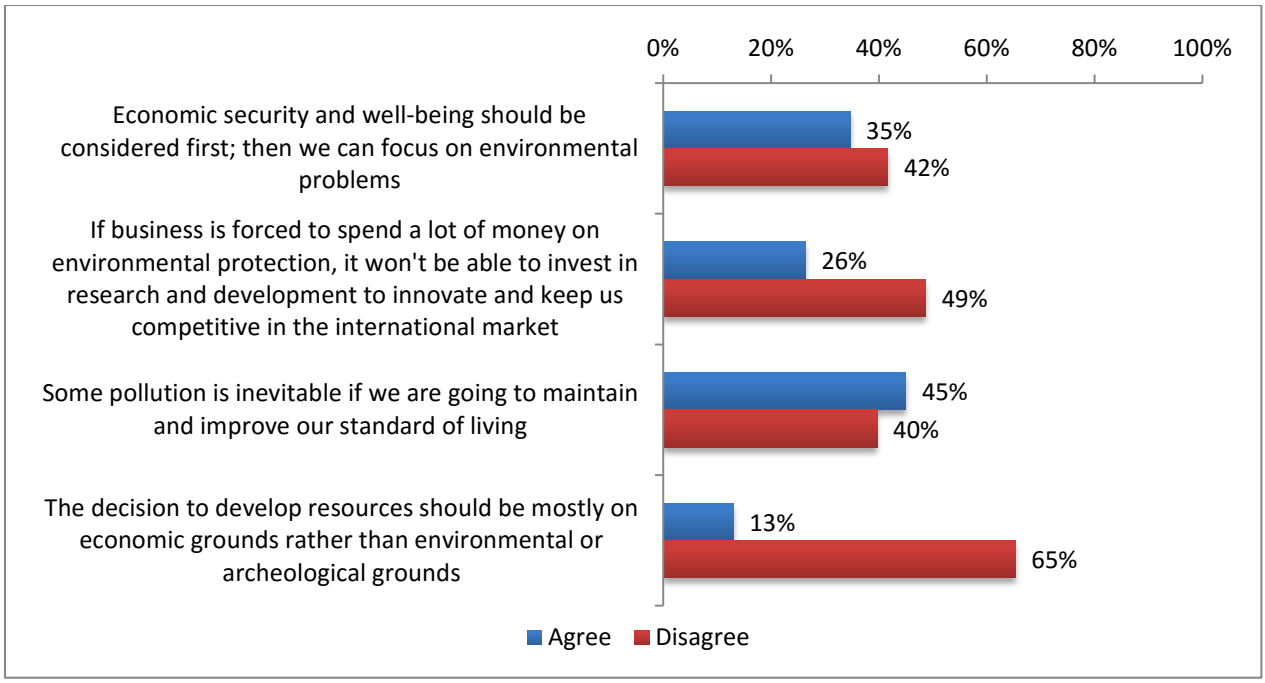


Figure 11. Levels of Respondent Agreement with Statements about Business and the Economy: National Sample

Respondents were also quite divided on the topic of hydroelectric dams, as shown in Figure 12. Although 80% agreed that dams can have "serious impacts" on the ecosystem, they were evenly split on whether dams should be built in national parks (37% in favor, 31% undecided, 32% against). 46% disagreed with the statement that the benefits of dams on the Colorado River outweigh the environmental impacts, and 53% disagreed that their development should be guided purely by economic considerations.

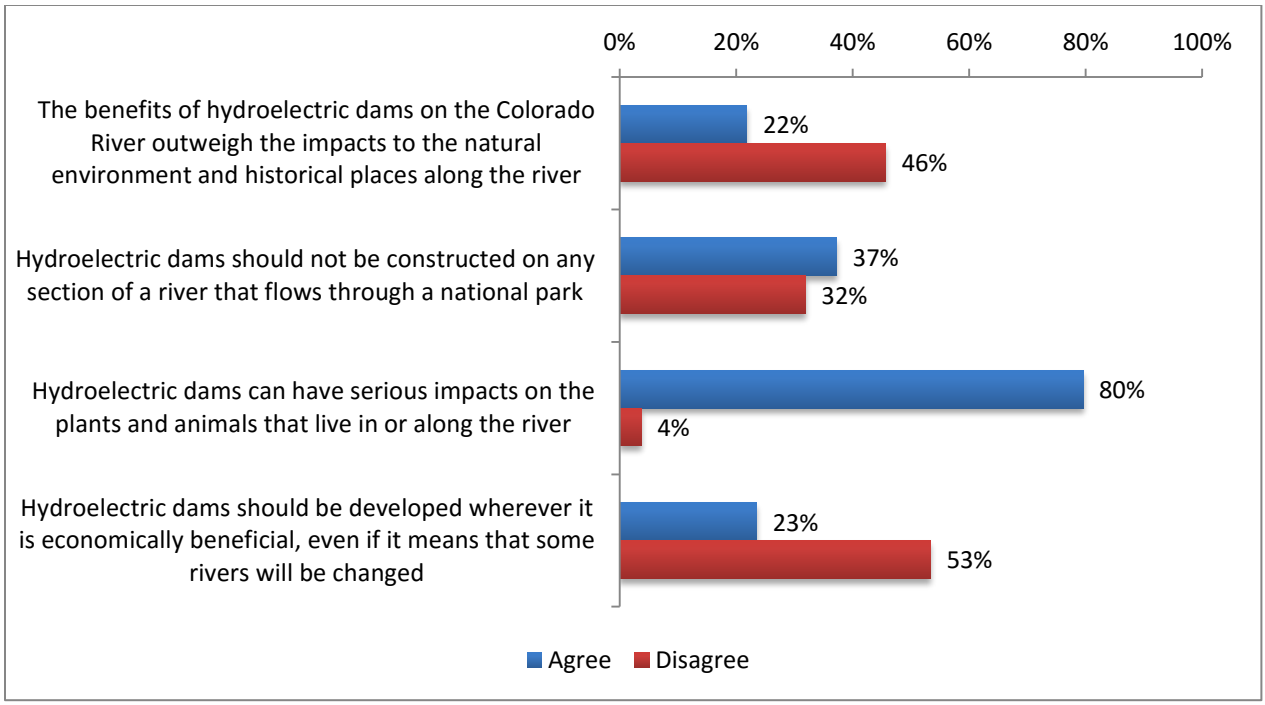


Figure 12. Levels of Respondent Agreement with Statements about Hydroelectric Dams: National Sample

The next, longer block of questions, shown in Figure 13, illustrates just how strongly respondents feel about national parks. Survey participants overwhelmingly indicated they find national parks valuable (whether they visit them or not) and believe in their mission of preservation. The questions that split opinion more substantially were whether Americans should financially support parks more (57% said yes), whether oil and gas finds in parks should be developed (43% no, 34% yes), and whether the NPS should institute more gift shops and commercial ventures to raise money (40% no, 37% undecided, and 23% yes). It seems fair to say from the responses that those surveyed are by and large very supportive of national parks as an idea, but differ more on what policies would be helpful in maintaining the system.

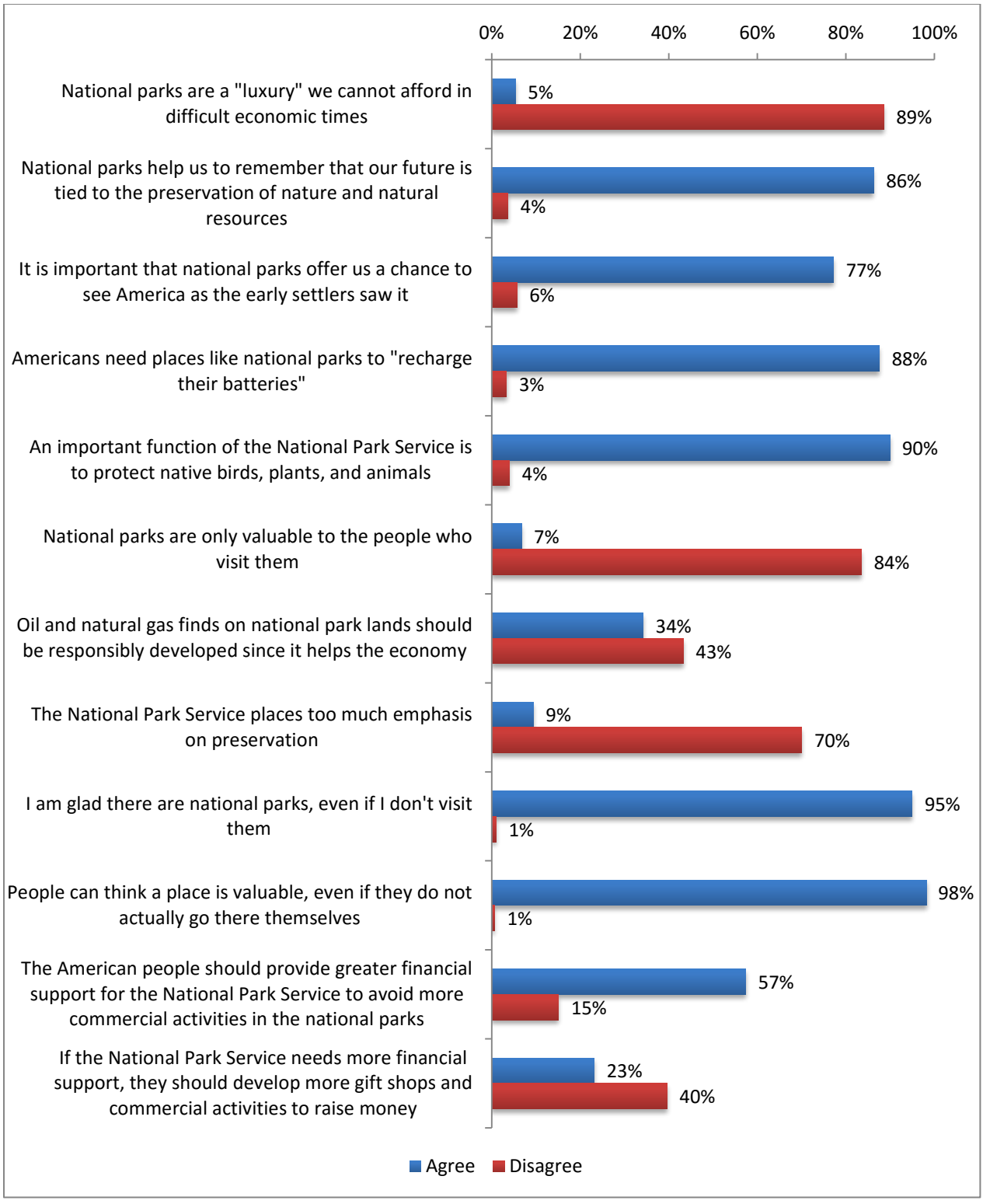


Figure 13. Levels of Respondent Agreement with Statements about National Parks: National Sample

Table 11. Comparison of Local and National Sample Likert-Scaled Responses to Statements

	Agree		Disagree	
Statement	**Local Sample**	**National Sample**	**Local Sample**	**National Sample**
My choices would have been different if the economy in my area were better	29%	19%	44%	50%
It is important to restore and protect the Grand Canyon ecosystem no matter how much it costs	40%	51%	37%	24%
I do not think I should have to contribute to the protection of the Grand Canyon ecosystem	20%	22%	49%	51%
I am concerned the plans would hurt the economy in the Colorado River Basin	23%	18%	35%	37%
The descriptions of the plans were hard to understand	16%	10%	54%	63%
I do not believe the plans will actually improve Colorado River resources	31%	22%	37%	39%
Some of the plans would cost too much compared to what they would deliver	57%	51%	19%	24%
The survey gave me enough information to make a choice between the options shown	64%	67%	12%	17%
I think my taxes will increase if either of the proposed plans passes	72%	64%	6%	13%
I have a great deal of concern for protecting wildlife habitat	88%	84%	12%	16%
Endangered species should be protected even if they don't provide any benefit to humans	66%	75%	14%	11%
I believe the balance of nature is very delicate and easily upset	76%	77%	10%	10%
It is important to protect rare plants and animals to maintain genetic diversity	73%	79%	7%	8%
I would be willing to contribute to protecting wildlife habitat even if I never see or enjoy the animals	61%	73%	12%	12%
I feel I should be doing more to help protect wildlife and fragile ecosystems	49%	53%	18%	13%
Economic security and well-being should be considered first; then we can focus on environmental problems	34%	35%	33%	42%
If business is forced to spend a lot of money on environmental protection, it won't be able to invest in research and development to innovate and keep us competitive in the international market	30%	26%	40%	49%
Some pollution is inevitable if we are going to maintain and improve our standard of living	49%	45%	35%	40%
The decision to develop resources should be mostly on economic grounds rather than environmental or archeological grounds	16%	13%	54%	65%

	Agree		Disagree	
Statement	**Local Sample**	**National Sample**	**Local Sample**	**National Sample**
The benefits of hydroelectric dams on the Colorado River outweigh the impacts to the natural environment and historical places along the river	39%	22%	30%	46%
Hydroelectric dams should not be constructed on any section of a river that flows through a national park	28%	37%	36%	32%
Hydroelectric dams can have serious impacts on the plants and animals that live in or along the river	76%	80%	7%	4%
Hydroelectric dams should be developed wherever it is economically beneficial, even if it means that some rivers will be changed	29%	23%	43%	53%
National parks are a "luxury" we cannot afford in difficult economic times	8%	5%	81%	89%
National parks help us to remember that our future is tied to the preservation of nature and natural resources	84%	86%	7%	4%
It is important that national parks offer us a chance to see America as the early settlers saw it	77%	77%	5%	6%
Americans need places like national parks to "recharge their batteries"	79%	88%	5%	3%
An important function of the National Park Service is to protect native birds, plants, and animals	88%	90%	3%	4%
National parks are only valuable to the people who visit them	11%	7%	76%	84%
Oil and natural gas finds on national park lands should be responsibly developed since it helps the economy	38%	34%	39%	43%
The National Park Service places too much emphasis on preservation	12%	9%	62%	70%
I am glad there are national parks, even if I don't visit them	90%	95%	10%	1%
People can think a place is valuable, even if they do not actually go there themselves	94%	98%	1%	1%
The American people should provide greater financial support for the National Park Service to avoid more commercial activities in the national parks	49%	57%	19%	15%
If the National Park Service needs more financial support, they should develop more gift shops and commercial activities to raise money	28%	23%	38%	40%

3.4 Demographics

So as to help determine the representativeness of the group sampled, questions 20 through 28 gathered some basic demographic information about the respondents. Section 3.2 (above) discusses comparisons between the U.S. sample respondents and benchmark U.S. Census statistics for the same population. As Figure 14 shows, respondents were very evenly distributed among income brackets.

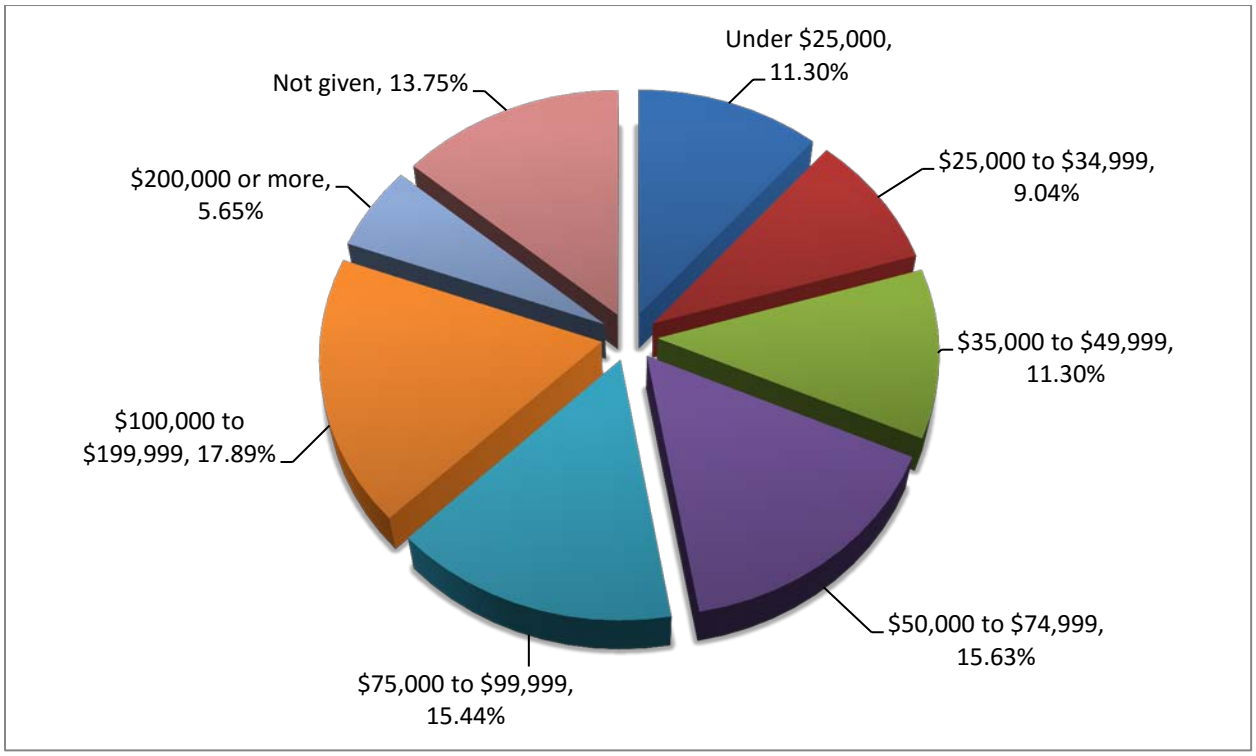


Figure 14. Distribution of Respondent Household Income: National Sample

Race and ethnicity were less evenly distributed. 83% of respondents were white, with the next largest single group being American Indians and Alaska Natives, at 4.5%. Of those who identified as native, 36% were Navajo and 41% were affiliated with a tribe not listed in the survey (mostly Cherokee). 3.8% of respondents were Hispanic or Latino.

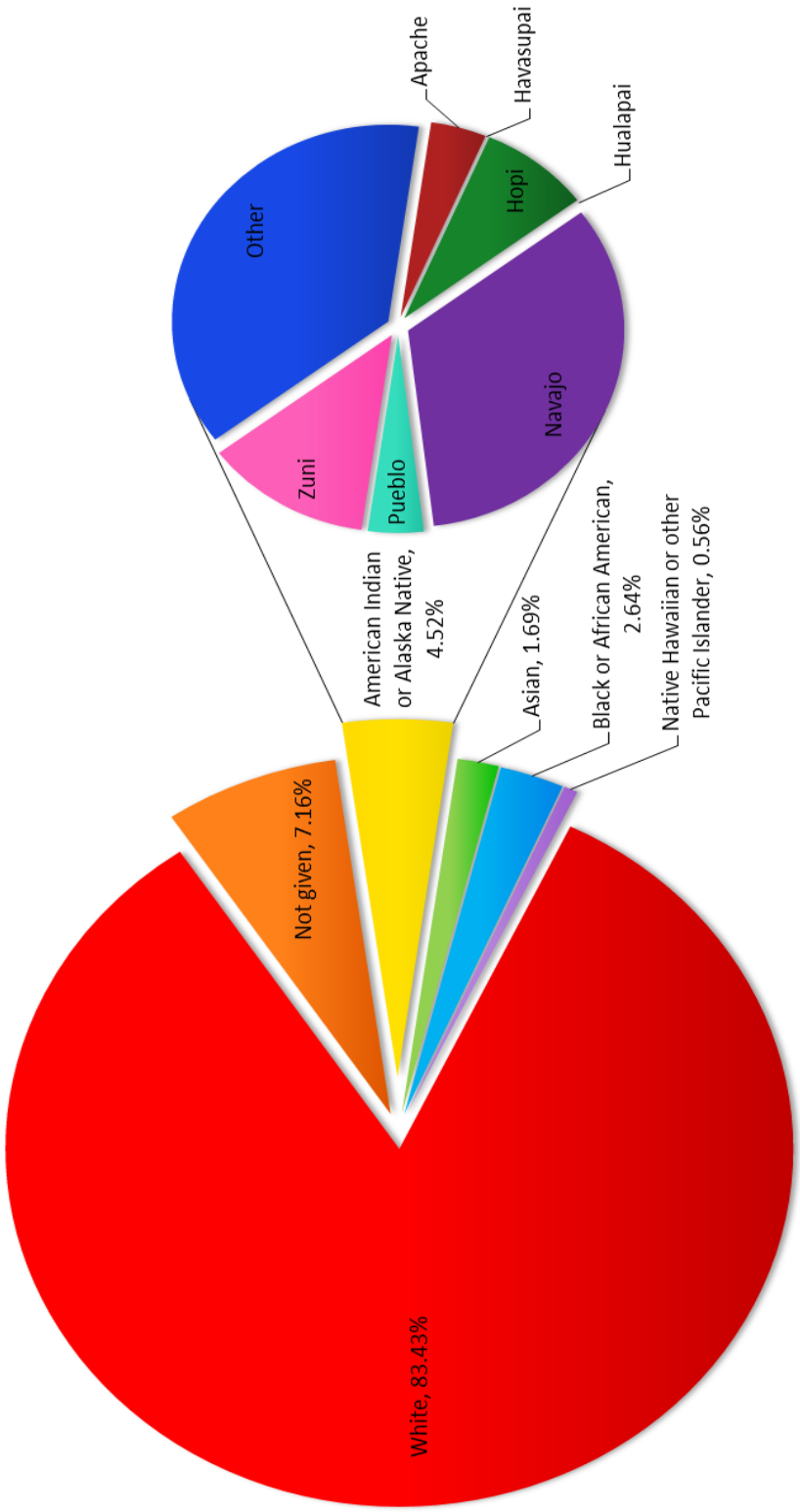


Figure 15. Racial Makeup of Respondents (Including Tribal Affiliation): Samples Combined

4.0 STATED PREFERENCE RESULTS AND WILLINGNESS TO PAY (WTP) MODELING

The primary objective of the Glen Canyon Survey was to provide information needed to estimate per household WTP values associated with different outcomes from dam-flow management related to endangered species (humpback chub populations), sandbars in the Grand Canyon (river beaches), and populations of large (over 16 inches) trout in the Glen Canyon. Respondents to the survey were faced with two discrete choice questions with different levels of these key river attributes included in the choices presented. Additionally, the effect of the changes in related hydropower operations were (along with increased taxes) included in the survey as the payment vehicle to represent the tradeoff of improved resource conditions with costs. In addition to the physical attributes in the canyons, respondents were asked to choose between current management at no cost and a changed outcome management plan that would cost between $12 and $280 per year per household over a 20-year period. The levels of the cost parameter and the river outcome attributes were varied among 12 versions of the survey to provide an efficient sampling design.

4.1 WTP Question Format

Figure 16 shows an example of one of two versions of the discrete choice questions presented to respondents. As noted, each respondent was presented with two such comparison questions (Proposed Plan A and B). Each of the two choice questions was followed with a questions exploring how certain the respondent felt about their answer to the choice questions. In the final estimation of WTP models and associated attribute marginal values, only responses where the respondent indicated that they were either “very certain” or “somewhat certain” of their response were included. Champ, et al. (1997) and Champ and Bishop (2001) found that if respondents are certain about their responses there is in general a good match between respondent stated WTP and actual cash WTP. As such screening for higher levels of certainty in DC responses reduces hypothetical bias associated with stated WTP.

Q1. Ask yourself whether you believe the improvements offered under <u>Proposed Plan A</u> are worth $280 each year to your household for the next 20 years. Voting for <u>Proposed Plan A</u> would mean you would have $280 less each year to spend on other things. You would be making a commitment to pay this additional amount each year for the next 20 years. Please check ONE box at the bottom of the table to indicate whether you prefer <u>Proposed Plan A</u>, or the <u>Existing Management Plan</u>

Resources impacted by policies	Existing Management Plan—conditions over the next 20 years	Proposed Plan A—conditions over the next 20 years
River Beaches  **(Size and number)**	20% decrease in size and number	Remain at present levels
 **Native fish (humpback chub) populations**	Remain at present levels	Remain at present levels
 **Trout populations**	Remain at present condition	50% <u>increase</u> in large trout
$ **Cost to your Household**	$ 0	<u>$280 per year</u> for 20 years
I would vote for (check only one ✓)	❑	❑

Q2. How certain do you feel about the choice you made above?

- ☐ Very certain
- ☐ Somewhat certain
- ☐ Not certain at all

Figure 16. Example of Glen Canyon Survey WTP Question Format

4.1.1 General Response Patterns to WTP Questions, and Certainty Follow-up

A key expectation in choice modeling which includes a cost parameter is that, everything else held constant, we expect the percentage of respondents willing to accept an alternative to decline as the price of that alternative increases. As can be seen from the raw cross-tabulation of the survey data (Table 12), this expected relationship holds true for both the local area and the national samples. This result of a negative price response is consistent with the economic law of demand.

Table 12. Percentage of Respondents Who Voted for Proposed Management Plans, by Cost Level

Sample	$12	$40	$110	$280
Local Sample	51.4%	39.4%	24.2%	19.5%
National Sample	56.4%	39.5%	32.0%	25.0%

Table 13 compares the percentage of respondents in each of the two sample frame who voted for the existing management plan (zero cost) and the proposed plan (positive cost between $12 and $280 per year). Overall, respondents from the local-area sample were more likely to vote for the zero cost existing plan than were respondents from the national sample (68% vs. 61%).

Table 13. Comparison of Percentages of Respondents Voting for the Existing Management and the Proposed Plans, by Sample Frame

	Local Sample	National Sample
Voted for existing management plan	67.93% (197)	61.26% (370)
Voted for proposed management plan	32.07% (93)	38.74% (234)
Sample size	290	604

The data in Table 14 and Table 15 show that within sample frames there was remarkable consistency in the levels of certainty respondents reported associated with their choice question "votes." Overall, very few respondents said they were "not certain at all" about their choices (1 to 2%). The largest share of responses reported being "very certain" of their choice (nearly 2/3 or more of responses in all cases).

Table 14. Comparison of Levels of Certainty by "Vote": Local Sample

	Sample Size	Very Certain	Somewhat Certain	Not Certain at All
Voted for existing management plan	195	66.7%	32.8%	0.5%
Voted for Proposed Plan A	93	64.5%	34.4%	1.1%
Voted for existing management plan	196	71.4%	28.1%	0.5%
Voted for Proposed Plan B	93	68.8%	29.0%	2.2%

Table 15. Comparison of Levels of Certainty by "Vote": National Sample

	Sample Size	Very Certain	Somewhat Certain	Not Certain at All
Voted for existing management plan	366	65.0%	33.6%	1.4%
Voted for Proposed Plan A	231	56.3%	42.4%	1.3%
Voted for existing management plan	370	67.3%	32.2%	0.5%
Voted for Proposed Plan B	232	54.3%	44.4%	1.3%

4.1.2 Motivations for voting both for and against the proposed management plans

Question blocks 9 and 10 in the Glen Canyon Survey (APPENDIX A) probed reasons respondents might have either opposed (Q9) or supported (Q10) the proposed management plans in the choice questions and their associated increased in costs. Table 16 shows that a large percentage of respondents who voted against one of the proposed plans (for the existing zero cost management) agreed or strongly agreed that they did so because they either were opposed to any more taxes or government spending, or because they felt their taxes were too high already. These responses (particularly the first) could be interpreted as "protest responses" in which the respondent was not evaluating the choices presented on their merits, but rather responded based on predetermined beliefs. While some WTP analyses have excluded protest responses from the data, inclusion (as was done in this case) provides a conservative bias to resulting estimated values.

Table 16. Likert-Scaled Responses to Reasons for Voting Against the "Proposed Plan" and Associated Increase in Costs

	I voted for the existing management plan because I am against any more taxes or government spending				
	Strongly Agree	**Agree**	**Neither Agree nor Disagree**	**Disagree**	**Strongly Disagree**
Local Sample	21.91%	26.69%	23.51%	17.93%	9.96%
National Sample	20.55%	22.88%	14.62%	25.85%	16.10%
	I voted for the existing management plan because I feel my taxes are already too high				
	Strongly Agree	**Agree**	**Neither Agree nor Disagree**	**Disagree**	**Strongly Disagree**
Local Sample	24.50%	26.10%	22.89%	17.27%	9.24%
National Sample	21.56%	24.31%	16.49%	25.79%	11.84%

Table 17 shows responses to the Q10 questions asked of those who voted for one or more of the proposed management plans with their associated costs. The table shows that between 20 and 24% of respondents voting for a proposed management plan felt that doing so would increase the chances that the government would do the same type of thing in a river basin near them. The low percentage of responses agreeing with this first question in Table 17 indicates that respondents are just valuing the Colorado River through the Grand Canyon NP. Thus this would indicate the survey has face validity in that the respondent is valuing what the researcher intended and not something larger. The responses to the second statement showing that 70 to 75% of respondents who voted for a proposed management plan did so more for future generations than for themselves provides strong evidence of a significant “bequest motive” in votes to preserve and protect resources below Glen Canyon Dam.

Table 17. Likert-Scaled Responses to Reasons for Voting for the "Proposed Plan" and Associated Increase in Costs

	I voted for the proposed plan because I thought it would increase the chances that the government would do the same thing in river basins closer to my home				
	Strongly Agree	**Agree**	**Neither Agree nor Disagree**	**Disagree**	**Strongly Disagree**
Local Sample	5.92%	14.20%	43.79%	25.44%	10.65%
National Sample	8.58%	15.55%	31.90%	29.76%	14.21%
	I voted for the proposed plan more for future generations than for myself				
	Strongly Agree	**Agree**	**Neither Agree nor Disagree**	**Disagree**	**Strongly Disagree**
Local Sample	27.12%	43.50%	25.42%	0.56%	3.39%
National Sample	30.13%	45.71%	16.10%	6.49%	1.56%

4.1.3 Sensitivity of Choice Question Responses to Respondent Characteristics and Beliefs

Prior to estimation of attribute-based models of respondent willingness to pay, responses to the DC questions were modeled as a function of a wide range of respondent characteristics and stated beliefs (Table 18). The results of these predictive models provide information on whether the stated DC selections are consistent with what might be expected for respondents with a range of characteristics. Within the Local area sample, the odds of choosing a proposed management plan with associated increased costs was lower for those "very certain" of their choice, as well as for those who did not believe that any of the plans would actually improve the Colorado River resources. While there is no *a priori* expectation regarding the effect of certainty on plan choices, the lower odds for those not believing the plans would work is consistent with expectations. Also among the Local-area sample, the odds of choosing a proposed plan was higher for those "willing to contribute to protect wildlife", those who expressed "great concern for protecting wildlife habitat" and for female respondents.

Table 18. Sensitivity of Discrete Choice Responses to respondent Characteristics and Beliefs.

	Question Number	Local Sample	National Sample
Been to Glen Canyon Dam	Q1	NS[a]	NS
Heard of Glen Canyon Dam	Q2	NS	Higher[b]
Very certain of choice	Q5, Q7	Lower[c]	Lower
Somewhat certain of choice	Q5, Q7	NS	NS
Strongly agreed that none of the plans will actually improve Colorado River resources	Q8F	Lower	NS
Strongly agreed survey provided enough information to make a decision	Q8H	NS	NS
Agree economic security should be considered before environment	Q12	NS	NS
Agree willing to contribute to protect wildlife	Q11	Higher	Higher
Agree have great concern for protecting wildlife habitat	Q11	Higher	Higher
Agree Hydro dams can have serious impacts on plants and animals	Q13	NS	Higher
BA or greater education	Q23	NS	NS
Female	Q20	Higher	NS
Age	Q21	NS	NS
Household income > $50,000 per year	Q28	NS	NS

[a] Not Significant: indicated the coefficient was not significant at a 90% level of confidence.
[b] Indicates the interaction term was significant at the 90% level of confidence and predicted a higher probability of selection a proposed management plan.
[c] Indicates the interaction term was significant at the 90% level of confidence and predicted a lower probability of selection a proposed management plan.

Among the National Sample respondents, odds of choosing a proposed plan were higher among those who had heard of Glen Canyon Dam, for those "willing to contribute to protect wildlife", those who expressed "great concern for protecting wildlife habitat" and for those who agreed that "hydroelectric dams can have serious impacts on plants and animals."

While many of the included covariates in the DC models were not statistically significant, those that were (where there was an *a priori* expectation) consistent with expectations in direction of their signs.

4.2 Conditional Logit Willingness to Pay Models

Several alternatives were explored for the specification of models of WTP using the Glen Canyon Survey responses. One model was explored using discrete attribute levels as the model covariates, while another used a continuous covariate specification. These estimates are discussed below, beginning with the discrete attribute level model.

4.2.1 WTP Modeling Using Discrete Attribute-Level Covariates

The discrete choice data from the Glen Canyon Survey was initially modeled by inclusion of each alternative attribute level as a covariate in the model along with the cost variable (Table 19). The limitation of the discrete change model is that it provides a limited amount of information on WTP, with values being directly estimable for only the specific attribute levels modeled (e.g. 25% decrease in chub, no change in chub, 25% increase in chub, or 50% increase in chub). Figure 17 and Figure 18 show plots of the WTP per household estimates associated with the calculated marginal changes models in the discrete covariate model.

The modeled impacts on sandbars, chub, and large trout below Glen Canyon Dam are presented in the LTEMP DEIS as continuous change levels, rather than the few discrete points modeled in Table 19. Therefore, the models using attribute-level discrete covariates were limited in their use for estimating alternative-specific WTP values unless *ad hoc* interpolation between the discrete points was employed.

The discrete attribute-level covariate approach provided a solid empirical model with highly significant parameters for many covariates and generally theoretically expected signs. For example, the successive estimates for a 20% increase in beaches, or sandbars, and the parameters on a 40% increase (from a 20% decrease to a 20% increase) shows the impact is approximately linear with WTP also doubling. The exception with regards to statistically significant covariates was for positive changes in large trout populations. Respondents in both samples seemed to value the status quo

for trout populations most highly, and the discrete-level models provide no solid trend for interpreting increasing trout populations.

Table 19. Estimated Attribute-level Discrete Choice Willingness to Pay Model

Attribute	Parameter Estimate	Standard Error	P-Statistic
National (Sample Size: 594)			
COST	-0.00564	0.000933	<.0001
BEACHES0	0.3956	0.2072	0.0562
BEACHES20	0.8276	0.2095	<.0001
CHUBNEG25	-0.6982	0.2580	0.0068
CHUB25	0.4996	0.2626	0.0571
CHUB50	0.6213	0.2161	0.0040
TROUTNEG25	-0.8631	0.2363	0.0003
TROUT25	-0.9089	0.2370	0.0001
TROUT50	-0.0597	0.2479	0.8098
Local (Sample Size: 284)			
COST	-0.00939	0.00177	<.0001
BEACHES0	0.3628	0.3375	0.2824
BEACHES20	0.9778	0.3319	0.0032
CHUBNEG25	-0.6201	0.4183	0.1382
CHUB25	0.4271	0.4201	0.3094
CHUB50	0.9277	0.3292	0.0048
TROUTNEG25	-1.0619	0.3847	0.0058
TROUT25	-0.4740	0.3370	0.1596
TROUT50	-0.0856	0.3876	0.8253

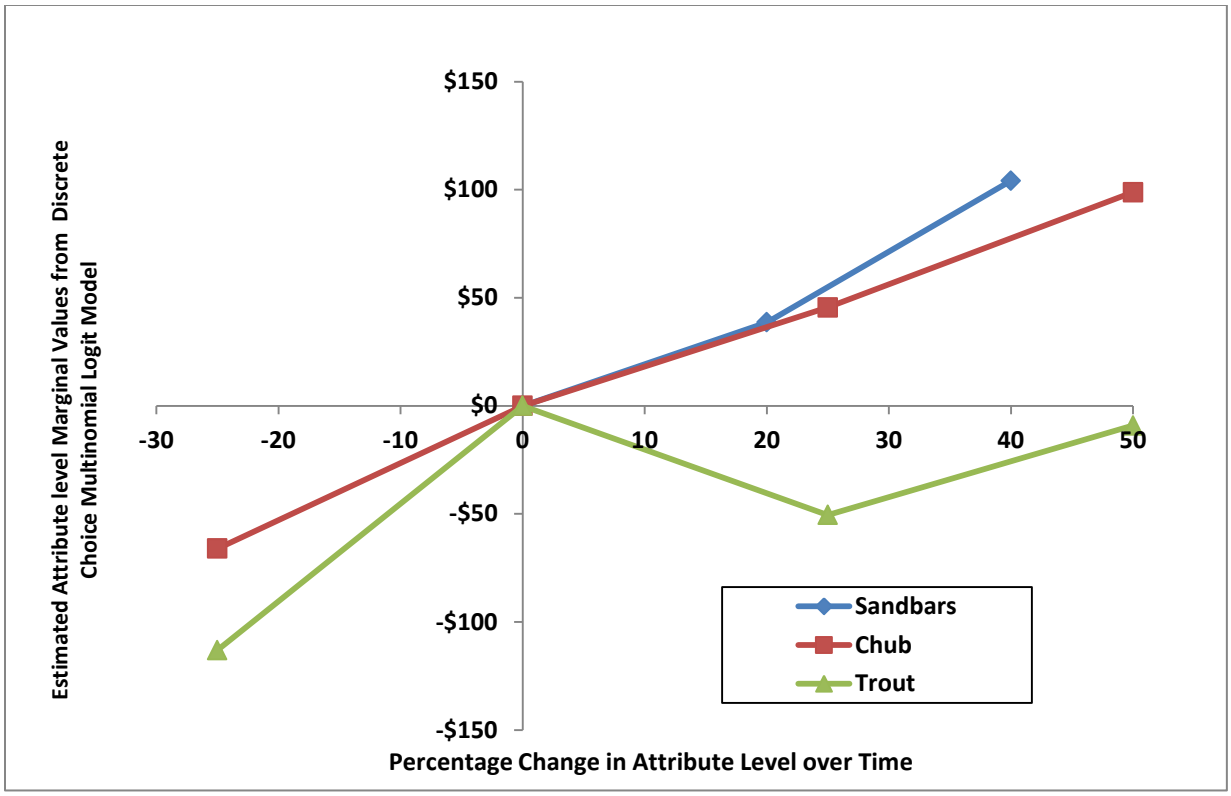


Figure 17. Estimated Attribute Level Marginal Values from Discrete Level Modeling: Local Area Sample

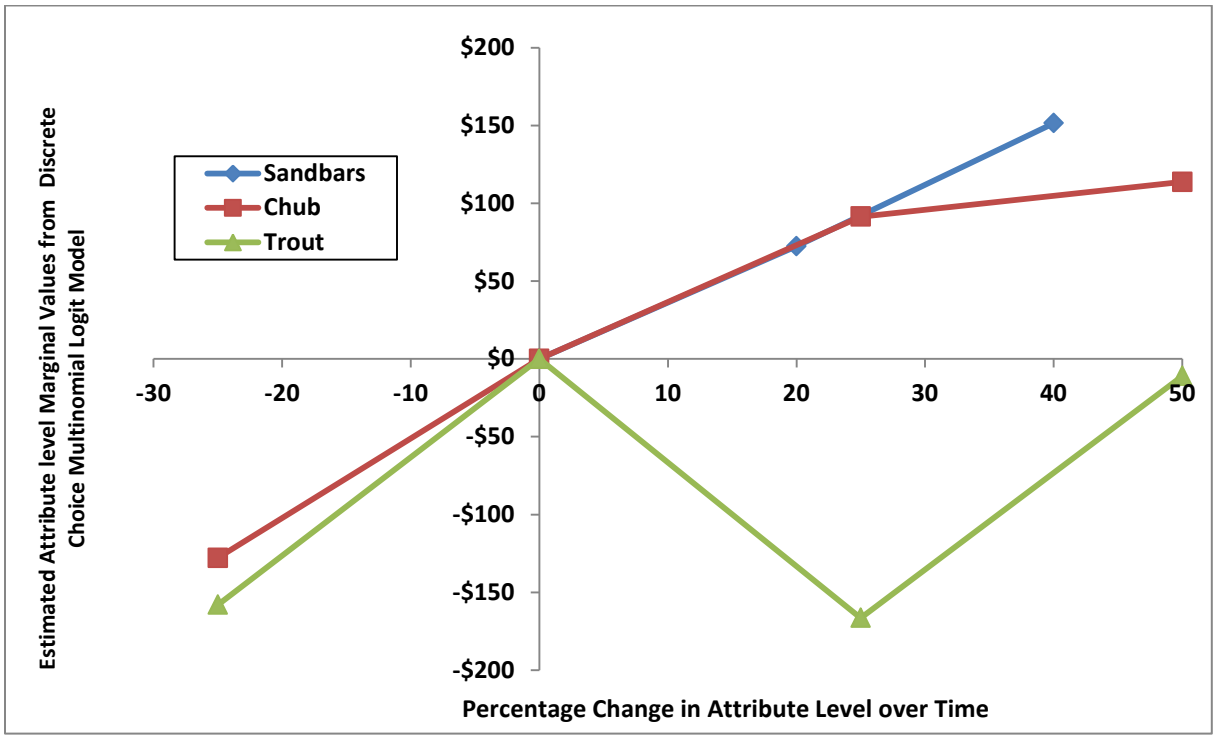


Figure 18. Estimated Attribute Level Marginal Values from Discrete Level Modeling: National Sample

4.2.2 WTP Modeling Continuous Attribute Covariates

While the attribute-level discrete covariate models were problematic in terms of estimated LTEMP EIS alternative-specific welfare levels, they did (in the cases of sandbars and chub populations) inform the functional forms of the covariates that might be used to estimate the attributes as continuous functions of WTP. The suggested functional forms for sandbars and chub are both roughly linear. Lacking statistically significant information on respondent preferences for changes in trout populations, a continuous covariate model of WTP was estimated using information from three of the four attributes (sandbars, chub populations and costs). Table 20 shows the estimated discrete choice model using continuous attributes for sandbars and chub as covariates. The continuous attribute model has all covariates with the expected signs and all but one statistically significant at the 95% level of confidence or greater.

Table 20. Estimated Discrete Choice Willingness to Pay Model using Continuous Attribute Covariates

Attribute	Parameter Estimate	Standard Error	P-Statistic
National (Sample Size: 594)			
Cost	-0.00665	0.000857	<.0001
Sandbars	0.0105	0.00436	0.0160
Chub Population	0.0130	0.00309	<.0001
-2 Log Likelihood	722.16		
Local (Sample Size: 284)			
Cost	-0.0097	0.00159	<.0001
Sandbars	0.0118	0.00686	0.0867
Chub Population	0.0170	0.00459	0.0002
-2 Log Likelihood	316.75		

4.3 Estimated WTP per Household Values for Alternative Attribute Levels

As noted previously, to estimate the parameters of the discrete choice models, we used a standard conditional logit (CL) model (McFadden 1986[8]), which assumes the disturbance term follows a Type I extreme-value error structure and uses maximum-likelihood methods to estimate β_1 and β_2. The

8 McFadden, D. (1986). The Choice Theory Approach to Market Research. Marketing Science 5(4):275 - 97.

conditional logit is a computationally straightforward estimation approach that can provide useful insights into the general pattern of respondents' preference, trade-offs, and values.

The parameter estimates from the CL model were then used to estimate the average marginal value of each non-cost attribute:

$$MWTP_i = (\hat{\beta}_j / \hat{\beta}_{Cost})$$

- β_j represents a vector of attribute *i* preference parameters

.

Table 21 shows the estimated marginal values for all attribute-level coefficients estimated using the discrete attribute level functional form of the conditional logit model. Overall, marginal values for specific attribute level changes are lower for the local area sample than for the national sample.

Table 21. Estimated Marginal WTP Values from Attribute-Level Model

		National Sample		Local Sample	
Attribute	**Change Relative to Baseline**	**Estimated Coefficient**	**Marginal Household WTP**	**Estimated Coefficient**	**Marginal Household WTP**
COST	--	-0.0055		-0.0094	
BEACHES0	20% increase	0.3956	$72.45	0.3628	$38.64
BEACHES20	40% increase	0.8276	$151.58	0.9778	$104.13
CHUBNEG25	25% decrease	-0.6982	-$127.88	-0.6201	-$66.04
CHUB25	25% increase	0.4996	$91.50	0.4271	$45.48
CHUB50	50% increase	0.6213	$113.79	0.9277	$98.80
TROUTNEG25	25% decrease	-0.8631	-$158.08	-1.0619	-$113.09
TROUT25	25% increase	-0.9089	-$166.47	-0.4740	-$50.48
TROUT50	50% increase	-0.0597	-$10.93	-0.0856	-$9.12

Just as marginal change values can be calculated for the discrete attribute level model (Table 21), marginal values can also be calculated based on the results of the continuous attribute model coefficients (Table 20). The estimated marginal value of a one-percent change in the attribute levels for BEACHDIFF (sandbars) and CHUB (native humpback chub populations) are shown in Table 22. These marginal values are consistently more conservative than those estimated using the discrete attribute level model results. It is not surprising that the marginal values of the discrete and continuous model specifications differ. The continuous specification imposes a more restrictive

functional form than the discrete model in that marginal values are the same across all levels of the attribute for the continuous model. The discrete form is more like a piecewise regression that allows the slope to change across different levels of the attributes.

Table 22. Estimated Marginal WTP Values from Continuous Variable Models.

National Sample		
Attribute	**Parameter Estimate**	**Marginal value per household of 1% increase in attribute level**
COST	-0.00665	
BEACHDIFF	0.0105	$1.58
CHUB	0.013	$1.95
Local Sample		
Attribute	**Parameter Estimate**	**Marginal value per household of 1% increase in attribute level**
COST	-0.0097	
BEACHDIFF	0.0118	$1.22
CHUB	0.017	$1.75

4.4 Aggregate Annual Value Analysis

While estimating the marginal values of changes in individual attribute levels, provides some insight into how respondents value resources along the Colorado River, the LTEMP DEIS presents and discusses alternative dam management proposals as having different impacts on all the key attributes modeled in this analysis. The LTEMP DEIS presents a No Action alternative (Alternative A) in addition to six action alternatives (B through G). The key objectives of the action alternatives are described in the DEIS as follows:

- The objective of Alternative B is to increase hydropower generation while limiting impacts on other resources and relying on flow and non-flow actions to the extent possible to mitigate impacts of higher fluctuations.
- The objective of Alternative C is to adaptively operate Glen Canyon Dam to achieve a balance of resource objectives with priorities placed on humpback chub, sediment, and minimizing impacts on hydropower.
- The objective of Alternative D (the preferred alternative) is to adaptively operate Glen Canyon Dam to best meet the resource goals of the LTEMP (Section 1.4). Like Alternative C,

Alternative D features condition-dependent flow and non-flow actions that would be triggered by resource conditions.

- The objective of Alternative E is to provide for recovery of the humpback chub while protecting other important resources including sediment, the rainbow trout fishery at Lee's Ferry, aquatic food base, and hydropower resources. Alternative E features a number of condition-dependent flow and non-flow actions that would be triggered by resource conditions.
- The objective of Alternative F is to a provide flows that follow a more natural pattern while limiting sediment transport and providing for warming in summer months.
- The objective of Alternative G is to maximize the conservation of sediment, in order to maintain and increase sandbar size.

The LTEMP DEIS presents modeled estimates of changes in 20-year sand load index values and percentage changes in humpback chub populations relative to the no-action alternative (Alternative A) for each of the action alternatives B-G (Table 23). These statistics are based on the primary modeling metrics used in the LTEMP EIS for these resource areas. As noted, for sediment, the metric used was the sand load index. For humpback chub, the metric used was from the coupled rainbow trout–humpback chub model. However it should be noted that there were limitations to these models and there were additional quantitative and qualitative analyses considered for these resources that are fully discussed in the LTEMP EIS sections 4.3 and 4.5.

Table 23. Long Term Changes from Alternative A, by Alternative and Attribute

Attribute	A (No Action)	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F	Alternative G
Sandbars	0	2	31.4	30.4	23.8	33.4	35.2
Chub Population	0	8	0	4	6	-12	-6

The continuous attribute models of respondent WTP were also used to estimate the average WTP for acquiring the combination of attributes associated with one management scenario (X_1) compared to the attributes of another scenario (e.g., the no action alternative) ($X_{No\ Action}$):

$$WTP_i = (\hat{\beta}_j / \hat{\beta}_{Cost})(X_{i,j} - X_{NoAction,j})$$

- β_j represents a vector of attribute *i* preference parameters
- $X_{i,j}$ represents a vector of attribute *i* levels for the management scenario *j*
- WTP_i represents a vector of average WTP for acquiring the combination of attributes associated with management scenario *j*

The standard errors and confidence intervals for these value estimates were estimated using the Krinsky and Robb (1986)[9] simulation method.

4.4.1 EIS Alternative-Specific WTP Results

Household and aggregate WTP estimates were modeled with two approaches:

1. Direct application of the estimated continuous attribute WTP coefficients to the long term percentage changes in attribute levels by alternative. This approach assumes that the non-response weighting corrected for all potential differences in WTP between respondents and non-respondents.
2. Direct application of the estimated continuous attribute WTP coefficients as above, and identification of the potential share of the population with zero WTP (rather than a WTP value imputed from the model), and adjustment of estimated WTP to account for the potential impact of these individuals on the estimates.

4.4.2 Estimated WTP by Direct Application of Model Coefficients with No Adjustment for Potential "Zero Value" Non-Respondents

Direct application of the attribute change levels (Table 23) to the coefficients shown in Table 20 result in the per household annual WTP values detailed in Table 24, and the aggregate annual population WTP by alternative shown in Table 25.

This calculation shows Alternative D (the preferred alternative) as the highest valued, with Alternative B being the lowest. Standard errors of the estimated WTP values were simulated (Krinsky and Robb 1986) though performing 10,000 random draws from a multivariate distribution defined by the model parameters and their variance-covariance matrix.

Table 24. Per Household Net Economic Value of Alternatives (Standard Errors in Parentheses)

Sample	A (No Action)	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F	Alternative G
National Sample	0	$18.80 (3.64)	$49.58 (18.23)	**$55.82 (17.10)**	$49.31 (13.13)	$29.28 (22.01)	$43.85 (21.57)
Local Sample	0	$16.45 (3.74)	$38.20 (20.25)	**$43.99 (18.93)**	$39.47 (14.46)	$19.60 (24.52)	$32.31 (24.03)

9 Krinsky, I., and Robb, A.L. (1986). On approximating the statistical properties of elasticities. The Review of Economics and Statistics 68(4):715-719.

Multiplying the annual per-household WTP values in Table 24 by the relevant household base for the sample areas yields the estimated aggregate WTP (Table 25) for the sample areas based on direct application of the continuous model results.

Table 25. Aggregate Net Economic Value of Alternatives (in Millions of 2015 Dollars)[10]

Sample	A (No Action)	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F	Alternative G
National Sample	0	2,167	5,715	6,434	5,684	3,375	5,055
Local Sample	0	15	36	41	37	18	30

4.4.3 Estimated WTP by Direct Application of Model Coefficients with Adjustment for Assumed "Zero Value" Non-Respondents

As noted, the previous estimation of household and aggregate WTP by alternative was based on the assumption that the weighting for non-response bias discussed previously compensated for all non-response bias in WTP estimation. In their 1995 study of Glen Canyon total value, Welsh et al. (1995) examined the same resource using a different WTP question format. They followed up all "no" responses to their WTP questions with asking respondents if they would support the proposed dam operation change of the cost was "zero." Welsh et al. (1995) then weighted their WTP values by imputing a value of zero to the share of their respondents who said they would not support the changed scenario even at a zero cost.

While the current survey did not present the follow up question in the same way, we did ask those who chose the "status quo" plan at zero cost over the "proposed plan" at a positive cost questions related to why they chose this way. Overall, there were 38.8% of the Local sample and 30.3% of the National sample who agreed that they voted against the proposed plan because "I am against any more taxes or government spending." These results were used to scale the WTP results presented above downward to adjust for potential "hard zero" WTP in 38.8% of the Local and 30.3% of the National populations. This approach provides a conservative estimate of value that is similar in method for aggregation to Welsh et al. (1995). Table 26 and Table 27 show the per household and aggregate annual WTP values based on this adjustment.

[10] Reweighting of the sample by National Park visitation adjusted for possible non-response bias, therefore we applied the resulting marginal values per household in Tables 24 and 26, to the entire number of U.S. households.

Table 26. Conservative per Household Net Economic Value of Alternatives (Standard Errors in Parentheses)

Sample	A (No Action)	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F	Alternative G
National Sample	0	$ 13.11 (2.54)	$ 34.57 (12.73)	$ 38.92 (11.91)	$ 34.38 (9.12)	$ 20.41 (15.48)	$ 30.57 (15.13)
Local Sample	0	$ 10.07 (2.25)	$ 23.38 (12.44)	$ 26.93 (11.64)	$ 24.16 (8.91)	$ 12.00 (14.99)	$ 19.77 (14.73)

Table 27. Conservative Aggregate Net Economic Value of Alternatives (in Millions of 2015 Dollars)

Sample	A (No Action)	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F	Alternative G
National Sample (aggregate WTP/year)	0	1,511	3,985	4,486	3,963	2,353	3,524
95% C.I.		950 to 2,100	1,062 to 6,816	1,760 to 7,141	1,880 to 6,002	-1,219 to 5,777	43 to 6,878
Ranking	**7**	**6**	**2**	**1**	**3**	**5**	**4**
Local Sample (aggregate WTP/year)	0	9	22	25	23	11	19
95% C.I.		5 to 14	-2 to 44	3 to 46	6 to 39	-17 to 38	-10 to 45
Ranking	**7**	**6**	**3**	**1**	**2**	**5**	**4**

4.4.4 Ranking of WTP Estimates across Alternatives

The LTEMP DEIS selected Alternative D as the preferred alternative. Both the modeling from the national and the local samples also show D as the most highly valued of the alternatives presented (Table ES10). Further, the ranking of alternatives in terms of WTP is generally consistent between the local and the national sample models. The alternative rankings are emphasized in Table ES11 since from a "decision analysis perspective" the policy question within the overall EIS process is which alternative to pick as the Preferred Alternative. This process fundamentally involves ranking of alternatives as the primary method of comparison.

Alternative D is an adaptive management alternative to further the goals for four key resources: sediment, chub, trout, and hydropower. These goals are included as outcomes (attributes) in our discrete choice models, where hydropower costs and taxes are the cost or payment variable. The next highest rated alternatives are "C" and "E" which were in part the basis for developing the preferred alternative "D". Alternatives "F" and "G" returned estimated WTP values per household (and aggregate) that were lower than "C" "D" and "E" and that are not statistically different from

zero. These alternatives differ from the primary outcome-based alternatives in specifying flow scenarios, such as variations of natural flows and steady flows. Alternative "B" is relatively precisely estimated and is the lowest valued action alternative. This alternative was designed to maximize the value of hydropower subject to the constraint of meeting goals for other resources. Compared to alternatives primarily based on natural flows or steady flows, these results provide some support for the idea that adaptive management can most efficiently achieve the most highly valued LTEMP DEIS outcomes.

The primary finding, as summarized in Table ES11, is that the agency Preferred Alternative (D) is most highly valued by both the national and local respondents. The national aggregate annual value is $4,486 million (95% confidence interval 1,760-7,141) and the local aggregate annual value is $25 million (95% C.I. 3 million-46 million). The values for alternative D are higher than the next two most highly ranked alternatives (C and E). The latter are quite similar to D which was actually developed relatively late in the EIS process in part by drawing on the best features of both C and E alternatives. While the point estimates for both household and aggregate WTP associated with Alternatives C, D, and E show preferences, considering their 95% confidence intervals, these three estimates are not statistically different from one another.

4.5 Comparing WTP Results from the Current Study to those from Welsh et al. 1995

A major impetus for the National Park service to commission the current study of total values associated with operational impacts of Glen Canyon Dam was to update the groundbreaking study of the same resource by Welsh et al. (1995) 20 years previously. The current study differed from the earlier Welsh study in many ways, including value elicitation method and descriptions of the impacts of alternative flow scenarios. While the Welsh study used a dichotomous choice question format for the key valuation questions, the current study used a DC model framework. The Welsh study described alternative flow release scenarios in terms of both how the flows would be released and how that release pattern corresponded to natural pre-dam flows, and in terms of what impact those release patterns would have on downstream resources.

The current study did not describe flow release patterns to respondents but rather focused only on "outcomes," or impacts to the resources which were used as attributes in the choice questions. In both studies, choices were made to exclude respondents who had a relatively low level of certainty in their responses to the valuation questions from the WTP analysis. In any case, while there are differences between the alternatives analyzed by the Welsh study and the current LTEMP DEIS, some alternatives are similar to moving to some variant of natural river flows or steady flow. Despite many differences between the two studies and the fact that over 20 years have passed since the original survey, the range of per household WTP estimates from the two studies are

relatively consistent. Adjusting the preferred estimates from the Welsh study report using a simple CPI adjustment for price changes between the times of the two studies (1.60) results in estimates from the 1995 Welsh study in 2016 dollars ranging from $22 to $46 per household per year, depending on the sample frame and the scenario modeled. These estimates are similar to the estimates from our calculation of WTP with no "zero value" adjustment, and generally higher than our conservative estimates with a "zero value" adjustment for a share of respondents assumed to have zero WTP.

4.6 Model Validation

1. The estimated WTP models shown in Table 19 and Table 20 show a number of characteristics that provide validation for the models and associated WTP estimates.
2. There is a strong price response seen in both the local and the national samples. As predicted by theory, increasing levels of the cost parameter leads to a decreased probability of the respondent choosing the scenario.
3. The models for two very different populations (the 8-county Colorado River region and the U.S. as a whole) showed strong consistency in parameter estimates and significance.
4. Covariates showed generally expected signs in all models and strong statistical significance.
5. The attribute level model contained a built in scope test which showed distinct differences in preferences for different levels of change in attributes.
6. The binary WTP question format used was a referendum format that used taxes as payment vehicle, as recommended by the Arrow et al. (1993) blue ribbon commission on contingent valuation.
7. Estimated WTP values were in the same general range as the earlier Welsh et al. (1995) estimates for values computed with generally parallel assumptions and adjusted for inflation.

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APPENDIX A: GLEN CANYON TOTAL VALUE SURVEY MATERIALS

Initial and Reminder Postcards and Survey Letters

Greetings,

I am writing to ask you to participate in a National Park Service survey about an important issue affecting the **Colorado River in Grand Canyon National Park**. In a week or so, you will receive a survey in the mail. The survey is part of a national study of issues concerning the operation of Glen Canyon Dam. Glen Canyon Dam creates Lake Powell and controls the discharge of water into the Colorado River through the Grand Canyon and affects the resources in and along the river.

Even if you have never heard of the Glen Canyon Dam, your answers are valuable to this study. You are one of a small number of people selected to give your opinions on this matter, and your household represents many other households similar to yours. What U.S. households think about these issues is important to future management decisions regarding Glen Canyon Dam.

Researchers from the University of Montana are conducting this study. A postage paid envelope will be supplied to return the survey. If you have any questions about the study, **you can call Chris Neher, the survey manager at (406)721-2265.**

Thank you, in advance, for your participation!

Bruce Peacock
National Parks Service

OMB Control Number: 1024-0270
Expiration Date: 11-30-2018

Greetings,

Here is the survey I told you about in my previous postcard. This study is about the Glen Canyon Dam, which controls the water level in the **Colorado River as it flows through Grand Canyon National Park** and part of Glen Canyon National Recreation Area. Government officials will soon be making decisions about how to operate the dam. Your participation in the study will help them understand how people in households like yours feel about trade-offs between cultural and natural resources, such as fish, vegetation, and beaches, at the bottom of the Grand Canyon and part of Glen Canyon and the production of electricity from Glen Canyon Dam. Answers to this survey will affect future decisions about how the dam is operated.

Your response to this survey is very important. We could not send this survey to every household in the nation. Your household is part of a relatively small group of households who have been randomly selected to participate in this survey. Your answers will represent the views of many other households similar to yours and will ensure that all households are represented in decisions about the operation of the Glen Canyon Dam. To ensure a random selection of respondents within a household, we are asking that the survey be filled out by the adult member of your household with the **most recent birthday**.

As you complete the survey please take the time to read all the background information presented within it. This background information describes Glen Canyon Dam, the resources below the dam, and how the operation of the dam affects these resources. I realize you may not have heard about Glen Canyon Dam before you received this survey. The background information was designed by scientists studying the dam and the Grand Canyon resources downstream to help you understand the issues. The survey does not require any technical knowledge about hydroelectricity or dam operations. The survey takes approximately 30 minutes to complete. Previous participants told us that they found the survey to be interesting and informative.

Your name will never be associated with your survey answers. Information from the survey will only be reported in statistical terms. There is an identification number on the back of the survey so researchers from the University of Montana, Missoula will know who has already returned the survey and whom to send reminders to.

When the survey is completed, simply return it in the enclosed postage-paid envelope. If you have any questions about the study, we would like to hear from you. You can call Chris Neher, the survey project manager, at (406) 721-2265.

I appreciate your help in this study and know that your time is valuable.

Thank you,

Bruce Peacock

Social Science Division, National Park Service

Hello,

A few days ago your household received a questionnaire about the tradeoffs between the production of electricity at Glen Canyon Dam and the natural and cultural resources along the Colorado River in the Grand Canyon and part of Glen Canyon. If the survey has been completed and returned, please consider this a "thank you." Otherwise, I hope you will be able to fill it out and return it soon.

Your household's responses to this survey are very important. We can only survey a small number of households, so your responses will represent many other households like yours, who are not able to participate in this study.

Thank you for your participation.

Sincerely,

Bruce Peacock OMB Control Number: 1024-0270

National Parks Service Expiration Date: 11-30-2018

Greetings,

About a month ago, we sent a questionnaire to your household. The survey asked about your opinions on how the Glen Canyon Dam on the Colorado River should be operated. Hearing from your household is very important. If you have already completed and returned the questionnaire, please accept our sincere thanks. If you have not done so, we would still very much like to hear from your household.

Even if you have never heard about Glen Canyon Dam prior to receiving this survey, your opinions are very important for this study. You don't need to have any special knowledge about hydroelectricity, dam operations, or environmental issues to fill out the survey. Answers to this survey will affect future decisions about how the Glen Canyon Dam is operated.

Your household is part of a relatively small group of households who have been randomly selected to participate in this survey. Your answers will represent the views of many other households similar to yours and will ensure that the opinions of all households are represented in decisions about the operation of the Glen Canyon Dam. Your name will not be associated with your survey answers.

I have enclosed another copy of the survey in case the first one was lost or misplaced. There is an identification number on the back of the survey so that researchers from the University of Montana, Missoula will know who has already returned the survey and who to send reminders to.

When the survey is completed, simply return it in the enclosed postage-paid envelope. We hope that you find the survey interesting and enjoyable to fill out. If you have any questions or concerns about this survey or the study, please feel free to call Chris Neher, the survey project manager, at (406) 721-2265.

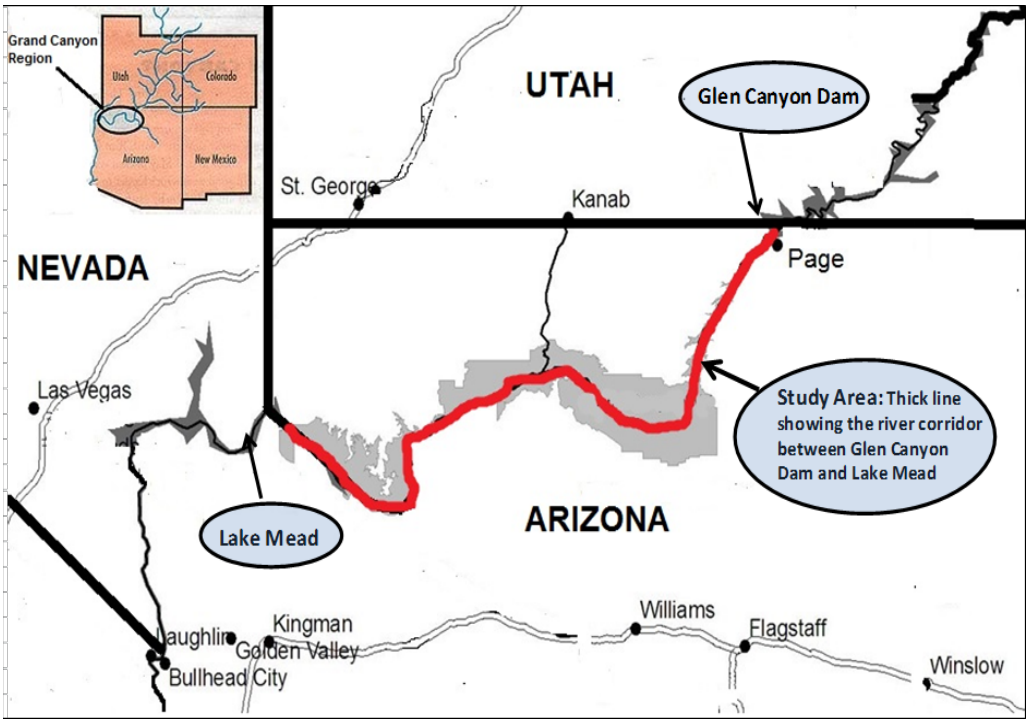
I appreciate your help in this study.

Sincerely,

Bruce Peacock
Social Science Division, National Parks Service

Survey Instrument

National Park Service
Glen Canyon Survey



Paperwork Reduction and Privacy Act Statement: The National Park Service is authorized by 16 U.S.C. 1a-7 to collect this information. This information collection will provide data for the economic analysis of the alternative management and operation protocols that will be one piece of information that the Secretary of the Interior will use to evaluate future dam operation plans associated with the current ongoing Glen Canyon DEIS. Response to this request is voluntary. No action may be taken against you for refusing to supply the information requested. The permanent data will be anonymous. An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. OMB Control Number: 1024-0270 Expiration Date: 11-30-2018

BURDEN ESTIMATE Public reporting burden for this collection is estimated to average 30 minutes per response. Direct comments regarding the burden estimate or any other aspect of this form to: Chris Neher at (406) 721-2265; or Phadrea Ponds, NPS Information Collection Coordinator, Fort Collins, CO; pponds@nps.gov (email).

BACKGROUND INFORMATION ABOUT THIS STUDY

Please read these pages before you complete the survey.

This study deals with the ways Glen Canyon Dam could be operated to benefit natural resources in the Study area. A map showing the location of the Dam and the Study area appears on the cover. A description of the resources in the Study area is contained on the following pages.

GLEN CANYON DAM AND THE STUDY AREA

Glen Canyon Dam

- Glen Canyon Dam is located on the Colorado River in Arizona.
  - It is just upstream from the Grand Canyon within Glen Canyon.
  - It was built to provide water supplies and hydroelectricity.
  - It was completed in 1963.
  - It controls the water flow through the Grand Canyon and a lower portion of Glen Canyon.
  - Revenues from the sale of hydroelectricity are used to repay costs of building and operating the dam.

The Study area

- The Study area consists only of the area in and along the Colorado River at the bottom of the Grand Canyon and part of Glen Canyon.
- The Study area begins at Glen Canyon Dam.
- The Study area continues for nearly 300 miles downstream from the dam.
- The Study area ends at Lake Mead near Las Vegas, Nevada.
- Part of the Study area is within the Grand Canyon National Park and part of Glen Canyon National Recreation Area.
- Part of the Study area is bordered by American Indian reservations.

Q1. Have you ever been to Glen Canyon Dam in Arizona?

❑ No ❑ Yes

Q2. Before receiving this survey had you heard of Glen Canyon Dam?

❑ No ❑ Yes

HOW GLEN CANYON DAM AFFECTS THE COLORADO RIVER IN THE STUDY AREA

- The amount of electricity produced by Glen Canyon Dam depends on the amount of water released from the dam: the more water released, the more electricity produced.
- More water is released during periods of high demand for electricity and less water is released during periods of low demand for electricity.
  - On a seasonal basis, more water is released during the hottest summer months and the coldest winter months.

- On a daily basis, more water is released during the day than at night.

NATURAL RESOURCES IN THE STUDY AREA

The natural resources in the Study area are located in and along the Colorado River below Glen Canyon Dam.

SEDIMENT Deposits of sand and mud called **beaches or sandbars**, are scattered along the river. Most of the rest of the river bank consists of cliffs and steep slopes covered with rocks, boulders, wind-blown sand and desert vegetation. Beaches with vegetation provide habitat for birds and other small animals. Beaches also are used by river floaters for camping.

FIVE NATIVE FISH species, including the humpback chub shown, live in the Study area. Only one of these native species is found outside the Colorado River and its tributaries.

NON-NATIVE FISH also live in the river. Rainbow trout are not native to the Colorado River. They were introduced to this section of the Colorado River for recreational fishing following the construction of Glen Canyon Dam. People fish for rainbow trout primarily in the first 15 miles downstream from Glen Canyon Dam. **Several other non-native fish species,** including brown trout, common carp, channel catfish, and fathead minnow, also live in the study area.

- Only a small percentage of visitors to the Grand Canyon National Park or part of Glen Canyon National Recreation Area actually see or directly use the natural resources in the study area.
    - The only people who directly interact with the resources in the study area are visitors who float the river, backpack or recreationally fish, American Indians using resources in the study area, scientists studying the river and National Park Service personnel.

SOME PEOPLE ARE CONCERNED ABOUT THESE RESOURCES

Because of a reduction in sediment supply below Glen Canyon Dam, erosion has decreased the number and size of **beaches along the river**.

- In the first 30 years following construction of Glen Canyon Dam the total size of Grand Canyon beaches decreased substantially. For example, during this period the total acreage of beaches **decreased by more than 25%**. In the past 20 years, controlled floods released from Glen Canyon Dam have resulted in periodic rebuilding of beaches, slowing the decline in size.
- The loss of beaches is most severe along the narrow sections of the Colorado River.

Populations of native fish in the Study area declined during the 1990s, but have increased over the last ten years.

- Eight species of native fish evolved in the Colorado River when the water was warmer in the summer, colder in the winter, and much more turbid year round than it is today.
- Three of the eight native fish species are no longer found in the Study area.
- Two of five remaining native species, the humpback chub and razorback sucker, are in danger of becoming extinct.
- Consistently cold water released year-round from Glen Canyon Dam may be the most important cause of the decline of native fish populations.
- Predation and competition from non-native fish (trout, carp, catfish, and minnow species) may have contributed to the decline of native species.

Conditions for **trout are affected by daily fluctuations in water level**.

- Trout eggs can warm-up or dry out and die if they are laid at high water levels and then the water level drops.
- The diversity of aquatic invertebrates, many of which feed on trout eggs, may be reduced because of exposure of eggs during low-water periods. This may reduce food options for juvenile and adult trout to a very small number of invertebrate species.

WHAT CAN BE DONE TO BETTER PROTECT THE RESOURCES?

There are a number of tools available for improving natural resource conditions below Glen Canyon Dam. The tools available are:

River flow controls --Dam managers can modify the water releases from the dam to make changes to the timing, fluctuations and average river levels. These modifications may affect sandbar erosion, hydropower revenue, and native and non-native fish. The frequency of short periods of high water releases may affect the rebuilding of sandbars in the Grand Canyon.

Fish management tools -- Resource managers use various tools to increase or decrease native and non-native fish. These controls include direct removal of non-native species, flows designed to promote healthy trout populations (fewer numbers but larger trout), and flows designed to partially control the temperature of water through low summer flows to affect the growth and survival of native fish species.

Native fish and native vegetation restoration - All approaches for this project would include non-flow experimental actions for native re-vegetation/restoration and weed removal and restoration of native fish to certain tributary locations**.**

Cost of tools -- River managers are able to use these tools in combinations in order to benefit the river corridor resources. All of these tools have costs associated with them. These costs would be passed on to the public through a combination of:

- higher electric power bills for households in the six-state Colorado River Basin, and

- increased federal taxes from all U.S. Residents

Assume that the costs for using the management tools mentioned above for your household (and similar households in your area) would <u>begin in 2016</u> and would last for the <u>next 20 years</u>.

We presented a lot of material in the background information. We would like to ask a few questions about the background information to make sure it was clearly presented. Please feel free to refer to the first few pages of the survey when answering these questions.

Q3. For each statement below, please circle the letter "T" if you think the statement is true or the letter "F" if you think the statement is false. *(Only one answer for each statement)*

	TRUE	FALSE
There are now many **more** beaches along the Colorado River than there were before Glen Canyon Dam was built.	T	F
Native fish populations in the Colorado River **have declined continuously** since the dam was built**.**	T	F
The decrease in river beaches is most severe along **wide** sections of the river.	T	F
Trout are **not native** to the study area.	T	F
All native fish species have disappeared from the Grand Canyon.	T	F
Nearly all visitors to the Grand Canyon National Park use the beaches along the river.	T	F
Water levels below Glen Canyon Dam are **constant** throughout a 24 hour period.	T	F
The Study area consists **only** of the area in and along the Colorado River between Glen Canyon Dam and Lake Mead.	T	F
Two of the native fish species are in danger of extinction.	T	F
Reducing daily fluctuations in the amount of water released from the dam will **reduce** the total amount of hydroelectricity produced.	T	F

Ask yourself whether you believe the improvements offered under Proposed Plan A are worth $280 each year to your household for the next 20 years. Voting for Proposed Plan A would mean you would have $280 less each year to spend on other things. You would be making a commitment to pay this additional amount each year for the next 20 years. Please check ONE box at the bottom of the table to indicate whether you prefer Proposed Plan A, or the Existing Management Plan

Resources impacted by policies	Existing Management Plan—conditions over the next 20 years	Proposed Plan A—conditions over the next 20 years
River Beaches (Size and number)	20% decrease in size and number	20% increase in size and number
Native fish (humpback chub) populations	Remain at present levels	25% increase in humpback chub populations
Trout populations	Remain at present condition	25% increase in large trout
Cost to your Household	$ 0	$280 per year for 20 years
I would vote for (check only one)	❑	❑

Q4.How certain do you feel about the choice you made above?

- ☐ Very certain
- ☐ Somewhat certain
- ☐ Not certain at all

Now consider a different choice…

We would now like to know how you would vote if you were presented with a completely different Proposed Plan. For this next choice, please imagine that Proposed Plan A is NOT an option. Please consider how you would vote if you had to choose between the two plans below. When making this choice, please imagine that the ONLY two options are Proposed Plan B and the Existing Management Plan.

Q5. Ask yourself whether you believe the improvements offered under Proposed Plan B are worth $40 each year to your household. Voting for Proposed Plan B would mean you would have $40 less each year to spend on other things. You would be making a commitment to pay this additional amount each year for the next 20 years. Please check ONE box at the bottom of the table to indicate whether you prefer Proposed Plan B, or the Existing Management Plan.

Resources impacted by policies	Existing Management Plan—conditions over the next 20 years	Proposed Plan B—conditions over the next 20 years
River Beaches (Size and number)	20% decrease in size and number	Remain at present levels
Native fish (humpback chub) populations	Remain at present levels	50% increase in humpback chub populations
Trout populations	Remain at present condition	Remain at present levels
Cost to your Household	$ 0	$40 per year for 20 years
I would vote for (check only one)	❑	❑

Q6. How certain do you feel about the choice you made above?

- ☐ Very certain
- ☐ Somewhat certain
- ☐ Not certain at all

Q7. Thinking about the choices you just made, please rate how much you agree or disagree with each of the following statements. *(Circle one number for each statement)*

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
My choices would have been different if the economy in my area were better.	1	2	3	4	5
It is important to restore and protect the Grand Canyon ecosystem no matter how much it costs.	1	2	3	4	5
I do not think I should have to contribute to the protection of the Grand Canyon ecosystem.	1	2	3	4	5
I am concerned that the plans would hurt the economy in the Colorado River Basin.	1	2	3	4	5
The descriptions of the plans were hard to understand.	1	2	3	4	5
I do not believe the plans will actually improve the Colorado River resources.	1	2	3	4	5
Some of the plans would cost too much compared to what they would deliver.	1	2	3	4	5
The survey gave me enough information to make a choice between the options shown.	1	2	3	4	5
I think my taxes will increase if either of the proposed plans passes.	1	2	3	4	5

Q8. If you voted for the <u>EXISTING MANAGEMENT PLAN</u> in either of the choices, please rate how much you agree or disagree with each of the following statements. If not, skip to Q10.

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
I voted for the CURRENT MANAGEMENT PLAN because I am against any more taxes or government spending.	1	2	3	4	5
I voted for the CURRENT MANAGEMENT PLAN because I believe my taxes are already too high.	1	2	3	4	5

Q9. If you voted for <u>PROPOSED PLAN A or PROPOSED PLAN B</u>, please rate how much you agree or disagree with each of the following statements. If not, skip this question.

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
I voted for the Proposed Plan because I thought it would increase the chances that the government would do the same thing in river basins closer to my home.	1	2	3	4	5
I voted for the Proposed Plan more for future generations than for myself.	1	2	3	4	5

Q10. People often have different views about environmental issues. On a scale of 1 to 5, with 1 being strongly agree and 5 being strongly disagree, please indicate how you feel about each

statement written below. *(Circle one number for each statement)*

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
I have a great deal of concern for protecting wildlife habitat.	**1**	**2**	**3**	**4**	**5**
Endangered species should be protected even if they don't provide any benefit to humans.	**1**	**2**	**3**	**4**	**5**
I believe the balance of nature is very delicate and easily upset.	**1**	**2**	**3**	**4**	**5**
It is important to protect rare plants and animals to maintain genetic diversity.	**1**	**2**	**3**	**4**	**5**
I would be willing to contribute to protecting wildlife habitat even if I never see or enjoy the animals.	**1**	**2**	**3**	**4**	**5**
I feel I should be doing more to help protect wildlife and fragile ecosystems.	**1**	**2**	**3**	**4**	**5**

Q11. The following statements discuss economic and environmental issues. We would like to understand how you feel about these issues. On a scale of 1 to 5, with 1 being strongly agree and 5 being strongly disagree, please indicate how you feel about each statement written below. *(Circle one number for each statement)*

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
Economic security and well-being should be considered first; then we can focus on environmental problems.	**1**	**2**	**3**	**4**	**5**
If business is forced to spend a lot of money on environmental protection, it won't be able to invest in research and development to innovate and keep us competitive in the international market.	**1**	**2**	**3**	**4**	**5**
Some pollution is inevitable if we are going to maintain and improve our standard of living.	**1**	**2**	**3**	**4**	**5**
The decision to develop resources should be based mostly on economic grounds rather than environmental or archeological grounds.	**1**	**2**	**3**	**4**	**5**

Q13. The following statements discuss hydroelectricity. We would like to understand how you feel about these issues. On a scale of 1 to 5, with 1 being strongly agree and 5 being strongly disagree, please indicate how you feel about each statement written below. *(One number for each statement)*

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
The benefits of hydroelectric dams on the Colorado River outweigh the impacts to the natural environment and historical places along the river.	**1**	**2**	**3**	**4**	**5**
Hydroelectric dams should not be constructed on any section of a river that flows through a national park.	**1**	**2**	**3**	**4**	**5**
Hydroelectric dams can have serious impacts on the plants and animals that live in or along the river.	**1**	**2**	**3**	**4**	**5**
Hydroelectric dams should be developed wherever it is economically beneficial, even if it means that some rivers will be changed.	**1**	**2**	**3**	**4**	**5**

Q14. **Have you ever visited any national parks in the United States?**

❑ No ❑ Yes ❑ Don't Know

Q15. **We are interested in learning how you feel about national parks in general. On a scale of 1 to 5, with 1 being "strongly agree" and 5 being "strongly disagree," please indicate how you feel about each statement written below.** *(One number for each statement)*

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
National parks are a "luxury" we cannot afford in difficult economic times.	1	2	3	4	5
National parks help us to remember that our future is tied to the preservation of nature and natural resources.	1	2	3	4	5
It is important that national parks offer us a chance to see America as the early settlers saw it.	1	2	3	4	5
Americans need places like national parks to "recharge their batteries."	1	2	3	4	5
An important function of the National Park Service is to protect native birds, plants, and animals.	1	2	3	4	5
National parks are only valuable to the people who visit them.	1	2	3	4	5
Oil and natural gas finds on national park lands should be responsibly developed since it helps the economy.	1	2	3	4	5
The National Park Service places too much emphasis on preservation.	1	2	3	4	5
I am glad there are national parks, even if I don't visit them.	1	2	3	4	5
People can think a place is valuable, even if they do not actually go there themselves.	1	2	3	4	5
The American people should provide greater financial support for the National Park Service to avoid more commercial activities in the national parks.	1	2	3	4	5
If the National Park Service needs more financial support, they should develop more gift shops and commercial activities to raise money.	1	2	3	4	5

Q16. **Have you ever visited Grand Canyon National Park?**

- ☐ No → *Skip to Question 19*
- ☐ Yes

Q17. **Did you see the Colorado River while you were in Grand Canyon National Park?**

- ☐ No → *Skip to Question 19*
- ☐ Yes

Q18. **Did you go down to the Colorado River while you were at the Grand Canyon National Park?**

- ☐ No
- ☐ Yes

Q19. **How likely do you think it is that you will visit the Grand Canyon National Park in the future?**

- ☐ Not at all likely
- ☐ Somewhat unlikely
- ☐ Somewhat likely
- ☐ Very likely

Q20. **Are you male or female?**

- ☐ Male
- ☐ Female

Q21. **What is your age?**

_____ years old

Q22. **How many people live in your household?**

_____ people 18 years old or older
_____ people under the age of 18
_____ total number of people in the household

Q23. **What is the highest degree or level of school you have completed?**

- ☐ No high school diploma
- ☐ High school diploma or GED
- ☐ Some college credit but no degree
- ☐ Associate's degree (for example: AA or AS)
- ☐ Bachelor's degree (for example: BA or BS)
- ☐ Some graduate school or professional school credit or a graduate or professional degree

Q24. **Which of the following categories best describes your household employment status?** *(Check all that apply)*

- ☐ Employed full time
- ☐ Employed part time
- ☐ Retired
- ☐ Student
- ☐ Work in the household (for example, raise children)
- ☐ Unemployed
- ☐ Other *(please describe)* _____

Q25. **Are you Hispanic or Latino?**

- ☐ No
- ☐ Yes

Q26. **Please select the racial category or categories with which you most closely identify by placing an "X" in the appropriate box.** *(Check one or more)*

- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or other Pacific Islander
- ☐ White

Q27. **Do you or either of your parents belong to any of the following tribes?** *(Check all that apply or leave blank if not applicable)*

- ☐ Apache
- ☐ Havasupai
- ☐ Hopi
- ☐ Hualapai
- ☐ Navajo
- ☐ Pueblo
- ☐ Zuni
- ☐ Other *(please specify)*:_____

Q28. **What was your total pre-tax household income, including all earners in your household, in 2015?**

- ☐ Under $25,000
- ☐ $25,000 to $34,999
- ☐ $35,000 to $49,999
- ☐ $50,000 to $74,999
- ☐ $75,000 to $99,999
- ☐ $100,000 to $199,999
- ☐ $200,000 or more

Is there anything else you would like to tell us about managing Glen Canyon Dam?

COMMENT:

_____

_____

_____

THANK YOU FOR YOUR HELP!

Please return only this survey booklet in the enclosed, postage-paid envelope

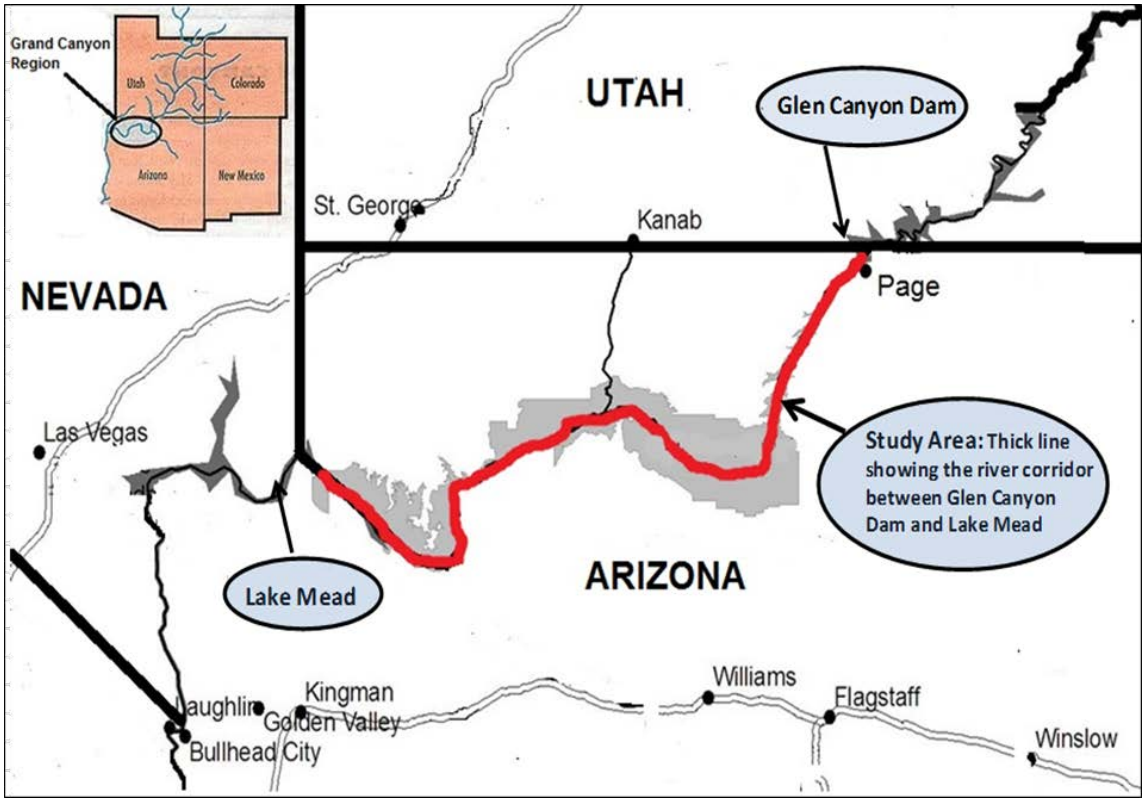
For questions, contact:
Chris Neher (406) 721-2265

V3

Non-response Survey Script

National Park Service

Glen Canyon Survey
Non-response Phone Script



1. **Hello, my name is _____ and I'm calling from Responsive Management a professional survey research firm. A couple of months ago, we mailed you a survey about the operation of Glen Canyon Dam on the Colorado River. This survey is sponsored by the National Park Service. In order to interpret the results of our survey, we need to understand a little bit about those people who did not return the survey as well as those who did. We are not selling anything or asking for any donations, and this will only take 3 or 4 minutes. Do you have time to answer a few short questions?**

☐ No

☐ Yes

2. **First, to your knowledge, have you ever been to Glen Canyon Dam in Arizona?**

❑ No ❑ Yes

3. **Have you ever visited any national parks in the United States?**

☐ No

☐ Yes

☐ Don't Know

4. **Have you ever visited Grand Canyon National Park?**

☐ No

☐ Yes

5. **RECORD GENDER**

☐ Male

☐ Female

6. **Do you or either of your parents belong to a Native American Tribe?**

☐ No

☐ Yes

THANK YOU FOR YOUR HELP

APPENDIX B: GLEN CANYON PRETEST REPORT

Pretest Report—Glen Canyon Total Value Survey

Summary of Glen Canyon Survey Pretest Results

DOI submitted an Information Collection Request (ICR) to the Office of Management and Budget (OMB) to conduct a pretest of the National Park Service Glen Canyon Survey. Following approval of the ICR in August 2014, the pretest was conducted in November and December 2014. The primary goal of the pretest was to assess whether the survey instrument and data collection process worked as expected. This report summarizes the results from the pretest.

Overall, the data from the pretest suggest that the survey instrument works well. Several small typographical (layout or punctuation) changes have been made to the survey instrument based on the pretest responses, and on close review of the survey materials. These edits, none of which impact the core survey valuation questions, are noted below.

1. **Response rates**

    a. **The response rate was marginally lower than expected, but well within similar results from the literature.**

The pretest followed the data collection plan described in the ICR and supporting statements. The households in the sample were mailed a pre-notification letter informing them that their household had been selected to be part of the survey. Following the letter, households received a packet containing a cover letter on NPS/University of Montana letterhead introducing the survey, a copy of the survey instrument, and a postage-paid return envelope. A reminder postcard was sent one week later. Finally, a second packet was sent that included a letter asking the respondent to complete the survey and a second copy of the survey instrument. The following table shows the mailing schedule for the pretest.

Pretest Survey Mailing Schedule

Contact	Date Mailed
Pre-notification letter mailing	November 7, 2014
First mailing of survey Instrument	November 14, 2014
Reminder postcard including Web address	November 21, 2014
Second mailing of survey instrument	December 9, 2014

A total of 225 U.S. household addresses were selected for the pretest sample (the ICR package specified 200, but 225 were mailed to allow for bad address returns). Of the 225 survey mailed, 23 were retuned as undeliverable and 49 completed surveys were returned for an overall **response rate of 24%.** This response is somewhat lower than the anticipated 30% response for the U.S. household sample population (the surveys were mailed to a U.S. household sample only). Responses may have suffered marginally from timing. The mailing of the survey was held until after the November general election date in order to not be lost in the volume of mailed election materials. This timing however, pushed the administration of the survey into the holiday season. It is hoped that response rates for the final survey instrument will benefit from better timing.

2. Was the survey instrument understandable to the public?

a. The results from the pretest suggest that most respondents could understand the questions, followed instructions and had adequate information to answer the stated-preference conjoint questions.

Following the presentation of background information on Glen Canyon Dam and Natural Resources in the Study Area, respondents were asked a series of True/False questions in order to gauge how well they understood the information presented. The following table shows the statements presented, the correct answer, and the percent of respondents who chose the correct answer. For all statements, 85% or more of respondents understood the information correctly, indicating a high degree of understanding of the material presented.

Statement	Correct Answer	Percent Correct
There are now many **more** beaches along the Colorado River than there were before Glen Canyon Dam was built.	F	95%
Native fish populations in the Colorado River **have fluctuated dramatically** since the dam was built**.**	F	88%
The decrease in river beaches is most severe along **wide** sections of the river.	F	85%
Trout are **not native** to the study area.	T	95%
All native fish species have disappeared from the Grand Canyon.	F	98%
Nearly all visitors to the Grand Canyon National Park use the beaches along the river.	F	88%
Water levels below Glen Canyon Dam are **constant** throughout a 24 hour period.	F	90%
The Study area consists **only** of the area in and along the Colorado River between Glen Canyon Dam and Lake Mead.	T	90%
Two of the native fish species are in danger of extinction.	T	88%
Reducing daily fluctuations in the amount of water released from the dam will **reduce** the total amount of hydroelectricity produced.	F	85%

PROPOSED SURVEY CHANGE

The second statement "Native fish populations in the Colorado River **have fluctuated dramatically** since the dam was built**"** is somewhat ambiguous given the information presented, and will be changed in the final survey to a more definitive,

> "Native fish populations in the Colorado River **have declined continuously** since the dam was built."

The correct answer to this new formulation will be "False," in recognition that native fish populations have fluctuated somewhat since the dam was built.

As part of the survey, respondents were asked their level of agreement with a series of statements related to the choices they made in the conjoint questions. There were two statements that dealt directly with comprehension, presented below. Looking first at the statement "The descriptions of the plans were hard to understand", only 18% of respondents agreed with the statement (only 2.6% strongly agreed). For the statement "The survey provided me with enough information to make a choice between the options shown", only about 10% of respondents disagreed (again, only 2.6% strongly disagreed).

Responses to Comprehension Questions

Statement	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
The descriptions of the plans were hard to understand.	2.6%	15.8%	26.3%	36.8%	18..4%
The survey gave me enough information to make a choice between the options shown.	18.0%	51.2%	20.5%	7.7%	2.6%

We also looked at the written comments provided at the end of the survey for evidence that the survey was hard to understand or was biased. A total of 21 or 48 possible respondents wrote additional comments at the end of the survey. As expected, there are comments expressing both "conservation" viewpoints as well as more "limited taxation/pro-resource development" viewpoints. None of the comments included any charge of bias in the survey. A number of respondents expressed appreciation for the opportunity to complete a survey on the topic.

3. Did the levels for the conjoint questions work?

a. Overall 39.7% of the sample voted in favor of the action plans presented, but as expected this percentage was lower when the cost of the plan (bid amount) was higher.

The tables below show the percent of respondents voting for the action plans and the no action plan. Overall, without accounting for differences in attribute levels across the plans, 39.7% of the respondents selected an Action Plan (with associated increased costs) and 69.3% selected no action (zero additional cost).

The table also breaks down the percent voting for an Action Plan by the cost of the plan for the sample, and for each of the two conjoint questions. For all question responses combined, the percent voting for an Action Plan (A or B) was highest at the $40 bid level (54%), declined at the $110 bid level (39%), and was lowest at the $280 bid level (15%). This pattern is consistent with expectations, and indicates the upped bid level is sufficiently high to capture not only the median of the distribution but much of the tail as well. Based on these pretest results, no changes in the range of bid levels are proposed for the final survey.

Reponses to Conjoint Questions by Question

	First Conjoint Question	Second Conjoint Question	All Responses
Voted for no action	49%	61.5%	60.3%
Voted for plan	41%	38.5%	39.7%

Vote by Cost of Plan

	$40	$110	$280
Voted for Action Plan, Total Sample	53.8%	38.5%	15.4%

Conclusions:

Overall, the pretest of the Glen Canyon Total Value survey provided valuable feedback and support for moving on to full survey implementation with only one minor question wording change (noted above).

While the pretest response rate was marginally lower than expected based on similar recent surveys, the PIs feel this can be attributed to survey timing of administering the pretest between a national election and the holiday season. We fully expect response rates for the final survey to match our a priori expectations.

A key focus of the pretest was on the understandability and effectiveness of the conjoint question survey section in conveying information, and eliciting consistent, meaningful responses. While the pretest sample size is too small to estimate any meaningful discrete choice model parameters, respondents reacted to key choice attributes (cost) as predicted by theory (downward sloping demand curve). Additionally, the range of high and low bids presented suggests that no change in overall bid range is needed in the final survey instrument in order to capture the essential bid response distribution.

APPENDIC C: DISCRETE CHOICE ATTRIBUTE LEVELS FOR SURVEY VERSIONS

Survey Version	Proposed Plan Questions	Sandbar Attribute Level	Chub Population Attribute Level	Large Trout Population Attribute Level	Cost per year per household
1	1	20% INCREASE	25% INCREASE	50% INCREASE	$12
	2	NO CHANGE	25% INCREASE	25% DECREASE	$40
2	1	NO CHANGE	NO CHANGE	50% INCREASE	$280
	2	NO CHANGE	25% INCREASE	50% INCREASE	$12
3	1	20% INCREASE	25% INCREASE	25% INCREASE	$280
	2	NO CHANGE	50% INCREASE	NO CHANGE	$40
4	1	20% INCREASE	50% INCREASE	25% INCREASE	$40
	2	20% DECREASE	25% INCREASE	NO CHANGE	$110
5	1	20% INCREASE	50% INCREASE	NO CHANGE	$280
	2	20% INCREASE	NO CHANGE	NO CHANGE	$110
6	1	20% INCREASE	25% DECREASE	50% INCREASE	$40
	2	20% DECREASE	NO CHANGE	25% INCREASE	$40
7	1	20% INCREASE	NO CHANGE	25% DECREASE	$12
	2	NO CHANGE	50% INCREASE	25% INCREASE	$110
8	1	20% DECREASE	25% INCREASE	25% DECREASE	$280
	2	NO CHANGE	25% DECREASE	NO CHANGE	$12
9	1	20% DECREASE	50% INCREASE	50% INCREASE	$110
	2	20% INCREASE	25% DECREASE	25% DECREASE	$110
10	1	NO CHANGE	25% DECREASE	25% DECREASE	$280
	2	20% DECREASE	25% DECREASE	50% INCREASE	$280
11	1	20% DECREASE	25% DECREASE	25% INCREASE	$12
	2	20% DECREASE	NO CHANGE	NO CHANGE	$40
12	1	20% DECREASE	50% INCREASE	25% DECREASE	$12
	2	NO CHANGE	NO CHANGE	25% INCREASE	$110

APPENDIX D: ORIGINAL PASSIVE USE ATTRIBUTE STUDY AND DRAFT SAMPLING PLAN (2009)

Note: The following Survey Sampling Plan was developed in 2008-09. The current study described in the preceding report used the 2009 plan as a starting point, and supplemented and modified that plan based on more recent data on ecological conditions below Glen Canyon Dam from the LTEMP EIS team, as well as changes in available funding for the study. Specifically a partial replication of the Welsh et al. 1995 study was not included in the final study design. The following sampling plan is shown for completeness and for its discussion of how the environmental attributes in Welsh et al. 1995 link to the specification of attributes and levels in the current study. This appendix also illustrates the full temporal scope of the economic research.

Colorado River Economics Study-Phase III

Survey Sampling Plan, and Draft Survey Instruments—Passive Use

June 2009

Dr. John Duffield, Dr. David Patterson and Chris Neher
The University of Montana
Department of Mathematical Sciences
Missoula, Montana 59812

1.0 Introduction

In addition to the need to quantify direct water-related recreational use values in the Colorado River Basin (likely to be dominated by use at Lake Powell and Lake Mead), there is a need to quantify total economic values associated with the Basin's most unique resource, the Grand Canyon of the Colorado. This section summarizes the survey plan for estimating total economic values for alternative conservation strategies for Grand Canyon riparian and aquatic resources.

This document describes the details of the proposed surveys for assessing the impact of varying water and flow levels in the Colorado River and its reservoirs on national and local passive use values.

In the context of the following sample plan, four specific sampling characteristics are discussed.

Sampling Frame: the population from which the sample is to be drawn,

Subsamples: any specific groups within the sample population who will be targeted for stratified sampling or identification within the sample,

Target Sample Size: The sample sizes desired for the pretest and pilot surveys, and the basis for that size

Survey Methods and Procedures: Physical procedures proposed for implementing the sampling plan.

The discussion of the sampling plan for the passive use survey includes descriptions of prior sampling of these groups, and how the current study will either replicate, or diverge from those prior methods.

2.0 Passive Use Values for the Grand Canyon Riparian Ecosystem

Previous research has established that there are significant passive use values associated with environmental services provided by the Grand Canyon. Contingent valuation methods have been applied to estimate willingness to pay to improve native vegetation, native fishes, game fish (such as trout), and cultural sites in Glen Canyon National Recreation Area downstream of Glen Canyon Dam and in Grand Canyon National Park (Welsh et al. 1995). The latter study utilized a population survey including households in the entire U.S to identify willingness to pay to reduce flow fluctuations from Glen Canyon Dam to protect wildlife, beaches, and cultural sites. Because these resources are of national significance, this research was reviewed by several National Research Council panels (National Research Council 1996; 1999). The panels concluded that the research was high quality, but needed to be updated.

A recent National Research Council publication (2005) examined methods for estimating total economic values for ecosystem services. The recommendation of this panel, and the direction of the recent economics literature, is to use stated choice methods (Kanninen 2007), also referred to as attribute-based stated preference methods (Holmes and Adamowicz 2003). However, the contingent valuation approach undertaken by Welsh et al. (1993) is well accepted, has been published, and has been thoroughly peer reviewed.

The current proposed study uses the lessons learned from the Welsh study's surveys as a starting point in designing the current application of contingent valuation and choice-based methods for Grand Canyon riparian zone passive use values.

The current study is being implemented in two phases as necessitated by the OMB ICR requirements and process: 1) cognitive interviews, pretests, and pilot studies, and 2) final studies. This sampling plan is specific to the first phase of this research through the pilot study.

The following table shows a comparison of sample parameters from the Welsh et al. study and for the pretest and pilot phases of the proposed follow-up validation study of two of the same recreational groups.

Comparison of Welsh (19xx) and Current Proposed Sampling Methods.

Sample Parameter	**Welsh et al.**	**Current Study (pretest and pilot phases)**
National Household Sample		
Sample Frame	National households	National households
Sample Contacts (#)	3,400	1,600
Final Sample Size (response rate)	1,728 / 66%	960 / 60%
Contact Method	Mail / telephone non-response	Mail / telephone non-response
Local/Regional Household Sample		
Sample Frame	Regional households	Localized households
Sample Contacts (#)	2,550	1,000
Final Sample Size (response rate)	1,423 / 75%	650 / 65%
Contact Method	Mail / telephone non-response	Mail / telephone non-response

3.0 Grand Canyon Water Flow Management Policy Context

Current water operations at Glen Canyon Dam are dictated by the 1995 Final EIS on Glen Canyon Dam (U. S. Bureau of Reclamation, 1996). The EIS and associated record of Decision (ROD) outlined generalized operating rules governing dam releases under the preferred alternative of modified low fluctuating flows (MLFF).

3.1 Colorado River EIS: Glen Canyon Operation Guidelines

The following table shows the general range of operating parameters for water releases from Glen Canyon Dam as outlined in the 1996 ROD. In comparison to earlier management practices , the MLFF scenario adopted in the ROD places limitations on daily fluctuations, minimum and maximum flow levels, and ramping rates during flow changes. The primary goals of the modified releases were to stabilize flows in order to reduce sediment loss within the riparian zone, protect native fish, and provide more predictability for river recreators.

Glen Canyon Dam Operating Limits as outlined in Final EIS.

Dam releases under operating rules, as well as constrained by annual hydrology	**General range of hydrologic conditions for Glen Canyon Dam**		
	Dry	Normal	Wet
Minimum releases 7 a.m. - 7 p.m. (cfs)	8,000	8,000	8,000
Minimum releases 7 p.m. - 7 a.m. (cfs)	5,000	5,000	5,000
Maximum peak under diurnal releases (cfs)	25,000	25,000	25,000
Daily fluctuations (cfs/24 hr)	5,000 to 8,000	5,000 to 8,000	5,000 to 8,000
Ramp rate (cfs/hr)	4,000 up, 1,500 down	4,000 up, 1,500 down	4,000 up, 1,500 down
Monthly volume (maf)	480,000-900,000	700,000-1,200,000	800,000-2,000,000

Source: (Grand Canyon Research and Monitoring Center, 2005)

4.0 Current Grand Canyon Flow Management Policy and Results

In 1996, the final Record of Decision (ROD) on the operation of Glen Canyon Dam was issued by the Secretary of the Interior (U.S. Department of the Interior, 1996). The ROD began a period of research, monitoring and adaptive management of the resource. The Final EIS associated with operation of Glen Canyon Dam included a number of estimates and predictions regarding the impacts of the preferred modified low fluctuating flows (MLFF) on resources within the riparian corridor.

4.1 EIS v. SCORE Report Findings

The 2005 SCORE report (Grand Canyon Research and Monitoring Center, 2005) included a chapter evaluating the results of ten years of adaptive management of the river and adherence to the MLFF release constraints.11 The table shows the entire prediction and outcome table from the SCORE report. Several key resources and attributes from the table are highlighted below.

Fish Habitat and Populations

The federally endangered humpback chub has continued to decline in population under the MLFF releases despite predictions of minor increases in native fish populations.

Populations of native bluehead and funnelmouth suckers has remained stable over the same period.

Populations of trout (particularly in the Lees Ferry reach) have increased substantially under MLFF exceeding predictions of modest increases in the Final EIS for Glen Canyon Dam.

Fine sediment has continued to decrease in the river despite IES predictions of modest improvement in sediment accumulation.

Archeological and Native American cultural sites continue to be exposed and eroded as sand export from the ecosystem continues to exceed the sand supply.

The EIS predicted that the MLFF release scenario would result in a modest increase in woody vegetation within the riparian corridor. This prediction had been largely proven correct with significant expansion of non-native tamarisk and arrowweed.

11 Jeffery Lovich and Theodore Melis, "Chapter 13: Lessons from 10 Years of Adaptive Management in Grand Canyon," in SCORE (2005), p. 207-220.

Predictions and Results: Grand Canyon Ecosystem Services (SCORE 2005).

Resource Area	Prediction	Actual	Comment
Fine sediment (sandbars and related physical habitats linked to native fishes (backwaters), terrestrial vegetation, marshes, campsites for recreation, and in situ preservation of archeological resources)	Modest improvement through implementation of constrained daily powerplant operations and periodic implementation of experimental high flows following accumulation of new tributary sand supplies in the main channel of the ecosystem. Sand accumulation was predicted to occur under average to-below-average hydrology and associated hydroelectric power operations	-	Sandbars continued to erode, and new sand inputs were not accumulated within the main channel. Experimental high flows were conducted, but the lack of flexibility in the timing and frequency of these controlled floods limited their effectiveness.
Coarse sediment (debris flow impacts from tributaries and their influence on the navigability of rapids and terrestrial sandbars)	Inputs of coarse-grained sediment from tributary debris flows will continue to accumulate in the main channel under constrained hydropower operations, causing rapids to worsen and burying sandbars under coarse deposits. High-flow releases may partially rework the new deposits and improve navigation within rapids.	+	The influence of ongoing, naturally occurring debris flows, in terms of aggradation of rapids and burial of sandbars, has been partially mitigated by occasional experimental high flows. The ability of high dam releases to rework new debris flow deposits is related more to peak discharge and timing after debris-flow events than it is to the duration of the high releases.
Aquatic food web	"Potential major increase"	+/-	Increases were apparent in Lees Ferry reach but not canyonwide. Fine-sediment inputs from tributaries below the Lees Ferry reach are most likely the limiting factor in primary productivity.
Native fish	"Potential minor increase"	+/-	Recruitment and population of adult humpback chub decreased; native suckers may be stable or slightly increasing.
Nonnative fish	"Potential minor increase"	+	Rainbow trout population increased substantially following the operational change in the Lees Ferry reach and within Marble Canyon.
Interactions between native and nonnative fish	"Potential minor increase in warm, stable microhabitats" An increase in warm, stable microhabitats would favor native fish and nonnative warm water fish.	-	Warmer dam releases because of drought-lowered Lake Powell levels may have increased warm microhabitats, but this situation is not directly related to dam operations.
Trout	"Increased growth potential, stocking-dependent"	-	Rainbow trout numbers have increased in the Lees Ferry reach, but condition factor has declined. Stocking is not required.
Woody plants	Modest increase Exotic species included (tamarisk, camel thorn (*Alhagi maurorum*)).	+	Woody vegetation has increased, especially arrowweed (*Pluchea sericea*) and nonnative tamarisk, in the riparian zone that was formerly inundated frequently under the no action period (1963–91) of hydropower operations.

Emergent marsh plants	"Same as or less than no action"	**+/-**	Wet marsh species decreased, and dry marsh species increased, likely because of the reductions of daily inundation and without periodic rejuvenation through floods.
Wintering waterfowl	Potential increase	**+/-**	Trends vary by species and are difficult to distinguish from background variation.
Native fish (humpback chub, razorback sucker, flannelmouth sucker)	"Potential minor increase"	**+/-**	Recruitment and population of adult humpback chub decreased; native suckers may be stable or slightly increasing.
Bald eagle	"Potential increase"	**?**	Numbers in Arizona have increased overall.
Peregrine falcon	No effect	**+**	Numbers have been stable in Grand Canyon since 1988.
Kanab ambersnail	"Some incidental take"	**+/-**	Snail habitat increased since 1998, but not snail numbers, which are relatively stable.
Southwestern willow flycatcher	"Undetermined increase"	**-**	No increase, but the flycatcher is uncommon in Grand Canyon.
Archaeological sites affected	"Moderate (less than 157)"	**?**	Subsequent analyses have not been conducted to fully assess.
Traditional cultural properties affected	"Moderate"	**?**	Subsequent analyses have not been conducted to fully assess.
Traditional cultural resources affected	"Increased protection"	**?**	Subsequent analyses have not been conducted to fully assess.
Effect of emissions on regional air quality	"Slight reduction"	**?**	Not Addressed by Glen Canyon Dam Adaptive Management Program (GCDAMP).
Angler safety	"Moderate improvement"	**?**	No long-term monitoring data.
Day rafting	"Major improvement"	**?**	Pre-EIS study suggests that net willingness-to-pay values were insensitive to flows. More studies are needed.
Whitewater boating safety	"Minor improvement"	**?**	NPS responsibility—not monitored as part of GCDAMP.
Whitewater boating camping beaches (average area at normal peak stage)	"Minor increase"	**-**	Camping areas have been diminished because of vegetation expansion and sandbar erosion, despite the fact that the new operating policy has limited daily peaking release to 25,000 cfs.
Whitewater boating wilderness values	"Moderate to potential to become major increase"	**?**	Potential decrease and decline in campable areas (see chapter 12).
Economic benefits (not related to hydropower revenue)	Positive	**+**	Increase to both locally and regionally.
Annual economic cost (foregone hydroelectric power revenue)	Acceptable costs relative to other alternatives	**?**	Subsequent studies are not available to fully assess.
Wholesale rate of power	Acceptable costs relative to other alternatives	**?**	Not monitored as part of GCDAMP. See Western Area Power Administration (WAPA) for data.
Retail rate of power (70% of end users)	"No change to slight decrease"	**?**	Not monitored as part of GCDAMP. See WAPA for data.
Retail rate of power (23% of end users)	"Slight decrease to moderate increase"	**?**	Not monitored as part of GCDAMP. See WAPA for data.

Retail rate of power (7% of end users)	Acceptable costs relative to other alternatives	**?**	Not monitored as part of GCDAMP. See WAPA for data.
Nonuse value	"No data"	**+**	Substantial nonuse value, $3–$4 billion, has been demonstrated as willingness to pay for flows to protect fish

Overall, it appears that the predictions included in the 1995 Glen Canyon Dam EIS were overly optimistic regarding the impacts of the MLFF scenario on native fish populations, and sediments, and generally underestimated the impacts of the modified flows on non-native trout populations and riparian, vegetation growth. Additionally, impacts to archeological and Native American cultural sites are tied to the sediment balance in the corridor, and thus have worsened over the 10 years since the EIS ROD was issued.

4.2 Valuation Attributes for Current Study

As noted, the current proposed pilot survey of national passive use values will utilize two basic formats of the valuation question: 1) a replication of the original Welsh format intended to replicate and calibrate his results **[This aspect of the final study was not funded or included in the current report]** , and 2) a choice question format. For the choice question, attention will be given to the primary attributes that had varying levels within the Welsh study (native and non-native fish populations and habitat, and power costs. Additionally, attributes associated with archeological and Native American cultural sites will be included in the pilot survey design. Appendices B and C show two formats of the survey instrument including the choice question format.

5.0 Passive Use Sampling Plan

5.1 Introduction

Paralleling the earlier work by Welsh et al. (1995), the focus of the current total economic valuation research is on conservation strategies for the riparian and aquatic ecosystem in the Grand Canyon. The current study will both undertake a replication **[not included in final study design]** and update of the Welsh et al. national study, as well as a stated choice approach. Separate samples will be collected to support estimates using the two different models. This approach will provide an opportunity to replicate and validate the earlier work by Welsh et al., as well as provide insights into benefit transfer over time for total valuation studies. An important feature of the Welsh et al. study, a comprehensive set of attitude measures, will facilitate and inform this comparison over time. By also implementing a choice model, this study can potentially provide an important contribution to the economics literature on valuing ecosystem services.

A significant economy for the current study, and a reduction in the potential burden on survey respondents, is that the Welsh et al. effort carefully identified and quantified key attributes of the Grand Canyon riparian and aquatic ecosystem. This is important both for a contingent valuation and a choice experiment study design. These attributes include status of endangered fish species, beach size, cultural sites, and native vegetation. Much of the qualitative research undertaken by Welsh et al. has direct relevance for the design of the choice experiment, not to mention the existence of final parametric estimates in the context of their contingent valuation models.

5.2 Cognitive Interviews, Focus Groups and Pretest

Data collection for total economic valuation. Up to 20 one-on-one cognitive interviews will be conducted as part of the survey design process. One pretest of each method's survey instrument will be conducted on 100 potential respondents. The sampling frame for the total economic value study will include two strata for each of the methods: local Colorado River Basin residents proximate to the Colorado River in the study area and national residents. The original Welsh et al. study national sample had 850 potential respondents for each of four river-management scenarios, for a total of 3,400 national sample. For the current study, two of the current most interesting and plausible river-management scenarios will be investigated for each method.

5.3 Pilot Survey

A pilot survey will be implemented with 300 potential respondents for each sample. Following Welsh et al. (and most of the economics literature) potential respondents will be recruited using telephone lists. Survey implementation will be through repeat mail survey contacts following the Dillman (2000) methods.

The following is a general outline of the major decision parameters associated with implementation of the survey of Grand Canyon floaters.

Sample Frame

The proposed passive use value survey will have a national household sample frame. The samples for the survey will be contracted from Survey Sampling Inc., who will draw the representative household sample, and augment it with information from other available public databases. This is the same procedure used by Welsh et al. in the original passive use survey.

Subsamples

It is anticipated that two primary subsamples will be drawn for the pilot survey: 1) a sample of all U.S. households, and 2) a local area subsample specific to the counties, and (more specifically) zip codes contiguous to the Grand Canyon Corridor.

The two subsamples will undergo "de-duping," or removal of any duplicate households present in both samples.

Target Sample Sizes

For the current study surveying will be completed in three surveys: 1) cognitive interviews, 2) a pretest survey, and 3) a pilot survey. The draft survey instrument will be administered to a small sample of respondents (up to 20) in one-on-one cognitive interviews. These cognitive interview responses will be used to determine if the questions posed by Welsh and those added for the current study are relevant and are understood. The pretest will be utilized primarily to assess question comprehension and to set CV question parameters that are relevant to current flow levels in the river, and current price levels.

It is anticipated that pilot survey sample sizes for the current study will be large enough to allow limited statistical analysis of responses in order to most accurately calibrate the bid levels on the key contingent valuation questions regarding alternative optimum flow levels, and to examine the feasibility and relative efficiency of the choice experiment.

Survey Method and Procedures

As was the case with the original Welsh et al. study, the proposed study will use a mail survey contact method with a modified Dillman follow-up protocol. A notification letter on NPS letterhead will be sent to sampled floaters, followed by an initial survey packet. The survey packet mailing will be followed by a postcard reminder, and, later, by a second survey packet for non-responders.

The Welsh et al. experimental design included seven versions of a mail questionnaire, two sample populations, and a follow-up telephone interview with non-respondents. Two separate random samples were identified within the National household sample frame: a national sample and a marketing area sample. The national sample consisted of residents of the United States. The marketing area sample was a subset of the national sample consisting of households receiving power from the Salt Lake City Area Integrated Projects (SLCA/IP). For the national sample, the payment vehicle consisted of an annual payment in increased taxes. For residents of the marketing area, increases in utility bills were used as a payment vehicle. Surveys administered to each sample also differed in the description of resources affected by the dam operation alternative. In the national sample, each survey contained a description of the environmental and power cost impacts associated with a particular dam operation alternative. In contrast, the marketing area surveys described only the environmental impacts of the dam operation alternative.

Welsh used separate survey versions in order to evaluate the three dam operation alternatives chosen for detailed study. This resulted in a total of six survey versions (three for the national sample and three for the marketing area sample).

Welsh developed one additional survey version for the national sample to examine in more detail the effects on the study of including the impacts of alternatives on power costs in the national sample versions.

Questionnaire Version	Water Release Alternative
National Sample	
Version 1	Moderate Fluctuating Flow
Version 2	Low Fluctuating Flow
Version 3	Seasonally Adjusted Steady Flow
Version 4	Seasonally Adjusted Steady Flow with Moderate Flow
Marketing Area Sample	
Version 5	Moderate Fluctuating Flow
Version 6	Low Fluctuating Flow
Version 7	Seasonally Adjusted Steady Flow

The original sample size for the Welsh survey was 850 contacts per survey version. Over the 7 survey versions a total of 5,950 households were surveyed.

5.3.1 Valuation Question Formats

The passive use valuation survey implemented by Welsh et al. utilized a dichotomous choice format of contingent valuation question. Essentially, respondents were asked whether they would pay for alternative bundles of attributes associated with different Grand Canyon flow regimes. **Error! Reference source not found.** outlines the combinations of attributes and attribute levels utilized on the Welsh survey versions. The current study proposes to (within the pilot survey) utilize two survey versions utilizing two different question formats: 1) a dichotomous choice replication of the Welsh et al. format, and 2) a choice question format. A USBOR technical memorandum (Harpman,

2008) provides a clear, introductory discussion of design and analysis of choice format valuation questions. The following discussion of design of choice model valuation questions is based on the USBR memorandum.

The following is excerpted from the (Harpman, 2008) outline of an eight step approach to design of choice models.

1) Characterize the Problem --identifying the problem and characterizing its salient features. For a traditional marketing study, this might include identifying the focus of the exercise in terms of product features, packaging or price and how that might affect market share or total product purchases. In the natural resource economics context, the analyst should identify the geographic scope and the range of economic values potentially affected by changes in amenity services.

2) Identify the Relevant Population --An important aspect of any primary survey exercise is the identification of the population which could be affected by the proposed management action.

3) Attributes and Levels -- The researcher will need to identify the most important attributes shaping consumer decisions about the good. For example, if a fishing experience is the good, the researcher will need to identify the attributes of that experience which affect consumer choice. These attributes may include access, cost, catch rate, species caught, crowding and a host of other characteristics.

Setting appropriate levels for each attribute requires experience and professional judgment. For discontinuous attributes such as color, the attribute levels might be blue, red, green and black. For continuous attributes such as price, the attribute levels should be specific points like $10, $100 and $500. There is balance between too few options and too many. The range of levels should encompass the bounds of realistic price levels and span the range of possible policy outcomes.

4) Experimental Design --Identification of an appropriate experimental design is critically important to survey development and model estimation. Three experimental designs are in common use today. These are the full factorial design, the fractional factorial design and the randomized design.

Full Factorial --A factorial experimental design combines every level of each attribute with every level of all other attributes. Depending on the author, full factorial designs may also be called, “full profile” designs. A practical problem with a full factorial design is that a large number of profiles are generated as the number of attributes and levels increases. In addition, some combinations of attributes and levels may not be logical or realistic.

There are a number of statistical and economic advantages of a full factorial experimental design. In a full factorial design, all of the attributes are orthogonal or independent of each other. This allows the econometric identification of all of the “main” and “interaction” effects. The “main” effect is the difference between the average (mean) response to each attribute level and the overall average (or “grand mean”). In multiple regression analysis, the main effects are represented by the estimated parameter for the attribute and the grand mean is represented by the intercept term (Holmes and Adamowicz 2003). An interaction effect occurs if the response to the level of one attribute is

affected by the level of another attribute. In a regression model, interaction effects are represented in the equation by the cross product of two (or more) variables. Interaction effects are important to economists because they identify the presence and strength of substitute and complementary relationships between/among attributes.

Fractional Factorial --The number of profiles necessary for a full factorial design can pose a significant burden on respondent patience and cognitive ability. Fractional designs reduce the number of profiles and reduce the burden on respondents. Typically, fractional designs also reduce the statistical efficiency of the experiment and may preclude identification of all substitutes and complements.

Randomized --In a randomized design, each respondent is presented with a limited number of profiles drawn at random from a full profile. In principle, drawing a random sample from a full factorial design will result in an orthogonal design. Naturally, this result is premised on the statistics of large samples. Nonetheless, this approach avoids the considerable complexities associated with constructing a fractional factorial design.

5) Survey Development --Like other examples of stated preference techniques, conjoint analyses are based on primary surveys. An impressive array of different survey approaches have evolved. Some of the more common approaches include mail surveys, in-person surveys, phone surveys, internet surveys and hybrid (mixed mode) combinations of all of these.

Perhaps the most important aspect of a survey is the clear, concise and efficient communication of the information pertinent to the attributes described. A large number of tools including maps, photos, text, graphics and drawings are often used to aid in this process. As with any survey, pre-testing of the instrument is essential to ensure the respondents understand the information being conveyed. An excellent exposition of survey design for nonmarket valuation is contained in Champ (2003).

Elicitation Formats --Although there are many variants, three major types of survey elicitation formats are commonly encountered in surveys designed for conjoint analysis. These are ranking, rating, and choice based formats.

In the choice-based elicitation format, respondents are presented with one or more profiles and asked to select the profile which is most preferred. The theoretical foundation for choice-based conjoint experiments is the random utility maximization (RUM) model.

The choice-based elicitation format is said to mimic the actual market choices faced by consumers on a daily basis. This includes choices such as selecting a brand of cereal or deciding whether or not to purchase a good with particular levels of attributes from a set including similar goods with differing levels of attributes. This format is thought to focus a consumer's attention on the tradeoffs between attributes that are necessary when making a decision.

6) Collect Data --Once the survey design is complete, the next step is data collection or survey implementation.

7) Estimate the Model --Using the data collected, a variety of econometric approaches are then used to estimate a conjoint model. The specific approach employed varies with the nature of the problem being addressed, the data collected, the response format (ranking, rating or choice), the skill of the researcher and other factors.

8) Interpret the Results --Finally, the estimated conjoint model is used for simulation purposes and to compute relevant economic welfare measures. These results are then interpreted for policy makers.

5.3.2 Grand Canyon Attribute Selection and Design

The Welsh et al. Grand Canyon passive use study presented respondents with a variety of valuation questions, each detailing a number of river ecosystem and economic attributes associated with a specified water flow scenario. The following table shows the different valuation scenarios presented by Welsh, and the alternative attributes and levels associated with each scenario. While a first blush look at the table suggests a large number of attributes for design of a full-factorial choice experiment, a closer look shows that a number of the attributes used by Welsh did not vary across any of the scenarios. The table rows shaded in grey show the river attributes that remained stable across all scenarios. Only variables associated with native fish, trout, and electricity prices varied across the scenarios. This much smaller set of attributes and associated levels suggests that design of a choice question format that is comparable to the Welsh dichotomous choice format would be fairly straightforward.

Comparison of Welsh et al. Attributes across Survey Scenarios.

Attribute	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Number & size of beaches	Remain at present levels	Remain at present levels	Remain at present levels	Remain at present levels	Remain at present levels	Remain at present levels	Remain at present levels
Sacred & archeological sites	Decrease substantially	Decrease substantially	Decrease substantially	Decrease substantially	Decrease substantially	Decrease substantially	Decrease substantially
Vegetation & wildlife	Increase by 10%	Increase by 10%	Increase by 10%	Increase by 10%	Increase by 10%	Increase by 10%	Increase by 10%
Native fish conditions	Small improvement	Moderate improvement	Major improvement	Major improvement	Small improvement	Moderate improvement	Major improvement
Native fish populations	Decline in numbers	Likely increase in numbers	Increase in numbers	Increase in numbers	Decline in numbers	Likely increase in numbers	Increase in numbers
Conditions for trout	Small improvement	Moderate improvement	Major improvement	Major improvement	Small improvement	Moderate improvement	Major improvement
Change in electric bill	$3 per month average increase	$3 per month average increase	$9 per month average increase	$3 per month average increase			
Change in farm income	No significant average change	No significant average change	No significant average change	No significant average change			

5.3.1 Pilot Test Sample Size Justification

As noted in the discussion above, this phase of the Colorado River Recreation Survey will include 3 steps: 1) one-on-one cognitive surveys to inform initial survey design, 2) survey pretest, and 3) pilot survey. The primary goals of each of these steps are outlined below. The three survey steps are intended to ensure that sufficient information is available at each survey step (including the final survey administration, not included in this package) to ensure appropriate question design and response choice and category scaling.

Sample Size Criteria.

Survey Step	**Purpose for Survey Step**	**Criteria for Sample Size**
Cognitive survey	Provide basic information to inform initial survey design	Consistent information received from cognitive survey respondents on important issues related to survey design
Pretest survey	Test survey questions for applicability and comprehension. Inform choice of CV parameters.	Large enough sample to identify clearly out-of-range question response classes, and to identify generally appropriate CV question bid ranges
Pilot Survey	Provide statistically significant initial results for key survey response statistics, and valuation estimates and comparison of valuation of alternative methods. Inform the design of a RUM model of lake boating based on a panel data set.	Provide estimates for binary responses in the range of +/- 5% to 10% at the 95% level of confidence. Provide estimates for mean WTP associated with CV questions in the range of +/- 10% to 20% at the 95% level of confidence.

The three primary categories of statistical results to be generated from the Colorado River and reservoir surveys are binomial response means, mean response values to open-ended questions, and mean willingness to pay estimates from CV questions. The relationship between the variability of binomial response proportions and sample size is analytically defined. A final sample size of 400 yields a binomial proportion estimate whose accuracy is estimated to be approximately +/- 5% at the 95% level of confidence and a sample of 100 yields precision in the range of +/- 10% at the 95% level. The

relationship between sample size and mean responses to open-ended survey questions, on the other hand, do not have a strict analytical relationship. Rather, the variability of such a mean estimate is a function of both sample size and the distribution and range of responses. Previous studies have shown sample sizes of 300-400 for open-ended expenditure questions produce mean estimates with variability in the range of 10% to 20% at the 95% level of confidence (Duffield, Neher, & Patterson, Wolves and People in Yellowstone: Impacts on the Regional Economy, 2006).

Mean willingness to pay estimates from dichotomous choice CV questions are complex statistics with no rigid analytic relationship to sample size. However, there is a clear inverse relationship between the coefficient of variation associated with estimated CV means and variances and sample size. Previous CV studies have estimated mean CV WTP estimates with estimated variability in the range of +/- 10% to 20% at the 95% level of confidence associated with sample sizes in the range of 300 to 400 responses.

The precision associated with NEV estimates from choice question formats is a function of number of attributes tested, the number of levels tested for each attribute, and the number of scenarios presented. Additionally, whether estimates of main effects or interactive effects are desired, impacts the final sample sizes necessary for a desired welfare estimate precision level. For the current study, and given the anticipated number of attributes, attribute levels, and scenarios, it is estimated that sample sizes in the range of 250 will yield sufficient sample to estimate main effects for the models.

5.3.2 Proposed Sample Size Distribution

The following table outlines proposed sample sizes for the two distinct populations to be sampled in the household survey of Colorado River Passive Use Values. The estimated response rates of 60-65% overall are based on results from other national household surveys. These sample sizes are designed to provide sufficient information in order to estimate parameters with a level of precision necessary to fully inform any further and expanded sampling of these populations on issues associated with recreational values and their relationship to lake and river levels.

Proposed Colorado Recreation Sample Sizes.

Population / Subsample	**Proposed Sample Size**			
	Cognitive Interviews	**Pre-test**	**Pilot Survey**	
			Contacts	**Anticipated Completes**
National household Survey	Up to 20	50	1600	960
Local household survey	Up to 20	50	1000	650

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