Non-Market Values for Alternative Operations of the Glen Canyon Dam: Explorations in Choice and Valuation

Phase II Project Research and Findings

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1. Introduction and Overview of the Study

Understanding non-market values affected by proposed operational changes for the Glen Canyon Dam (GCD) has been the topic of considerable prior investigation, for both recreational use and environmental non-use values (e.g., Bishop et al., 1987; and Welsh et al., 1995). In addition to their role as investigations of market impacts (Douglass & Harpman, 1995), these studies were completed as part of prior federally-mandated environmental assessments on GCD operations (Lovich & Melis, 2007). They were important in bringing non-market values into the environmental and economic analysis of managing large coupled human and natural systems, such as the Colorado River Basin (Harpman et al., 1995; Loomis et al., 2005). But as with other components of evaluating this complex system (e.g., ecological effects), these *a priori* studies leave many unresolved issues, and merit re-visiting (see Lovich & Melis, 2007).

In 2014, as part of required updates of environmental assessments, the evaluation of potential changes in the operation of the GCD has raised important theoretical and practical questions about the range of societal values that may be affected, and how they can be measured for purposes of informing public policy. Such questions can be seen as part of a longer trend in expanding the perspective of socio-economic analyses in water resources management and policy (e.g., Castle, 2000). This report describes a pilot study designed to test for the sensitivity of members of the U.S. public to alternative non-market and non-use values that may be affected by dam operations. The study also develops and evaluates a methodology for future estimations of public willingness to pay for alternative dam operations that makes possible the incorporation of a wider array of value dimensions than have been considered in prior studies.

Changing the way the GCD is operated, in the interest of "repurposing" the way the Colorado River is used, will have a range of potential effects that may have diverse value implications for U.S. residents. Some of these value changes can be observed in market prices (e.g., the change in value of the electricity produced at the GCD) and others in changes in the value and quantity of non-priced goods that consumers of resources use (such as recreation on

the Colorado River or Lake Powell). Our interest is chiefly in those values that are neither included in market prices paid for goods and services nor related directly to an individual's use of the resource – termed *non-market, non-use* values (Loomis, 2014). Our primary focus is on how residents of the U.S. will evaluate the potential *bundles* of changes in conditions affecting non-market, non-use values that are affected when operational decisions may affect multiple kinds (or dimensions) of value. The conceptual and methodological challenge is that changes affecting multiple dimensions of value may, from the perspective of residents of the U.S., result in expressed values that range from negative to positive. A valid approach for measurement of non-use values for changing operations of the GCD must therefore evaluate relevant dimensions of value and provide for a range of values – from negative to positive – associated with those changes.

Using the survey-based contingent valuation (CV) method, the pilot study described here was designed to ascertain whether a cross-section of residents in the U.S. hold non-use values for a range of possible changes that could occur as a result of operational changes in hydropower production at the GCD. Prior CV research (Welsh et al., 1995) has focused on a subset of non-use values for the preservation of river-related resources – including riverside beaches, downstream habitat, and cultural sites – that might be affected by dam operations.[1] This study broadens the assessment of potential dimensions of non-use values in a number of ways. The first is to address the potential for non-use values held by U.S. residents related to prospective changes affecting rural communities that have adapted to the resources and economic opportunities afforded by the operation of the dam. The potential non-use values of interest in this case are not jobs or economic activity *per se*; rather we are considering the value placed on changes in the sustenance for what the public may perceive to be important or unique rural cultures and ways of life (e.g., see Berrens et al., 1998). This CV study also evaluates non-use value concerning a purely hypothetical question: if the change in dam operations were to increase reliance on electricity from power plants utilizing fossil fuels, what non-use value might U.S. residents place on avoidance of that increase? For both of these lines of inquiry, we have built upon the theoretical framework for non-use value that may be affected by changes in hydropower operations as developed by Loomis (2014).

[1] Focusing on the subset of value dimensions, Welsh et al. (1995: 5-17) concluded that U.S. residents would be willing to pay over $2.2 billion annually to modify GCD operations to achieve a "moderate fluctuating flow" regime (also see Lovich & Melis, 2007).

Our focus on the potential for complex changes associated with modifying hydropower operations required that we reconsider how to measure non-use values when the alteration results in a *bundle* of changes across multiple non-use attributes. When evaluating these bundles of non-use attributes, individuals may express positive or negative values for the change. A common approach used for measuring non-market values, contingent valuation of willingness to pay (WTP) responses, as often applied, does not readily incorporate negative values placed on what may be a non-rejectable "good"; however, a limited number of studies have attempted to address this concern (see, e.g., Bohara, Kerkvliet, and Berrens, 2001; Atkinson et al., 2004; Loureiro et al., 2004). Indeed, those who would not choose to support the good even if it costs them nothing are typically assumed to place no value (either positive or negative) on the good. This may be a reasonable assumption if the proposed change can be rejected or easily avoided by the individual (e.g., don't buy, don't use, don't participate, choose a readily available alternative, etc.). However, in the case of a non-rejectable good (Loureiro et al., 2004), such as in the case of a change in dam operations involving a complex bundle of attributes, this may not be a reasonable assumption. For that reason, this CV study required the development of a valuation approach that permits individuals to choose among options (e.g., change or no change), then provide a valuation response to that option, rather than valuing only one proposed course of action. This type of approach permits more flexible and comprehensive assessments of preferences and WTP for either changing dam operations or for keeping dam operations unchanged.

1.1 Study Limitations

As is described in detail in the next section, this pilot study focused on the differences in survey responses to a specific set of experimental treatments. However, the study was not intended to provide a means for estimating WTP or for making inference to the expressed values of U.S. population.

In order to focus on multiple experimental treatments encompassing variation in both the method of eliciting WTP and the inclusion of diverse value dimensions, we limited the range of expressed preferences to (a) preferred GCD operations at no cost and (b) preferences if the cost to the respondent was $25 per year for the foreseeable future in added taxes. In

this way, we were able to collect sufficient numbers of responses for each treatment to test for the magnitude and statistical significance of differences in expression of value across the different experimental treatments. However, because we were unable to include a sufficient range of dollar values representing costs to respondents for each option, our data do not permit us to estimate WTP under each of the experimental conditions.

In addition, the data were collected from a nationwide, online panel of willing Internet survey respondents – both to facilitate the experimental treatments and to reduce the cost and time required for data collection. Though the data closely match the national Census on an array of key demographic attributes, these data cannot be considered a random sample of the U.S. public, and therefore inference from our sample results to the U.S. population must be made with caution. See Section 2 and Appendix A for further discussion of the sample, its representativeness of the U.S. public, and the weighting process used for the analyses in subsequent sections of this report.

In sum, the pilot study described in this report is intended to provide guidance for future efforts that would evaluate a more limited number of scenarios using a methodologically appropriate range of dollar costs. The results described in this report should be understood in that light.

1.2 Outline of Report

This report details the pilot study and findings. Sections 2 through 6 are primarily methodological in nature. Section 2 describes the theoretical and practical puzzle that underlies this study – how do people formulate preferences for policies involving change in complex coupled human and natural systems? How is it that, when hydropower is generally seen as a benign and valuable resource, other studies (e.g., Welsh et al., 1995) have found that the public is willing to pay billions of dollars to constrain the use and lower the value of hydropower produced at the GCD? These are the kinds of questions that motivate this study.

Section 3 describes the research design, data collection process, and the set of experiments fielded in the study. Section 4 focuses on the results of our replication of earlier work undertaken to measure WTP for downstream ecological and cultural resources. The purpose of this section is to evaluate data that were collected using a survey design that

closely mirrors work done in prior studies. If the results of the replication match prior studies, they can provide a baseline for comparison with alternative approaches for presenting information and eliciting choices regarding GCD operations. Section 5 briefly describes results from a comparison survey design that randomizes the ordering in which the information about the study background and expected effects of changing dam operations is presented to respondents. Validation that randomization provides consistent results is necessary for the experiments described subsequently, in which additional dimensions of potential changes are introduced to supplement the ecosystem and cultural resource effects described in earlier studies. Section 6 describes an experiment in which the elicitation of respondent preferences and WTP are asked for two discrete options – change in dam operations or continuation of current operations – rather than asking only for valuation of a specified change. As described in Section 6, the validation of this innovation is necessary for measurement of preferences when it is possible that some respondents will not only prefer *not* to change dam operations, but may be willing to pay to *avoid* change.

Sections 7 and 8 focus on the primary substantive experiments fielded in this pilot study. In Section 7 we describe the results of three experiments in which additional value dimensions are provided to respondents. One experiment describes potential effects of changing dam operations on rural farming and ranching communities (also see Jacobs, 2011) and another focuses on possible effects on Native American tribes that currently receive benefits from electricity produced at GCD. A third experiment combines the description of effects on both groups. These tests are intended to determine whether inclusion of these local community dimensions of value will substantively change the expression of preferences and value by the survey respondents. Section 8 shifts the focus from the results of analysis of responses to a purely hypothetical scenario, in which changes in dam operations are described as resulting in reductions in overall production of hydropower, with the deficit being replaced with power from conventional fossil fuel plants (consideration of effects on local communities, as described in Section 7, are omitted from this experiment). Evidence of non-market and non-use values associated with such a change would be of relevance for cases in which changes in hydropower capacity are being considered, such as the removal or addition of generators.

Section 9 turns to the question of why the survey respondents chose to support changing or maintaining the current operations of the GCD. Using a set of models that relate individual characteristics (income, education, rural residence), beliefs (environmental views, perceptions of hydropower), and intended behaviors (expectations of visiting the Glen Canyon in the future), along with the variations in experimental treatments, to preferences for GCD dam operations, we show that differences in preferences are systematically and reasonably related to respondents' values and characteristics, as well as the variation in experimental treatments.

Section 10 concludes with a summary of our study results. Appendices A and B provide a description of the data collection and representativeness of the sample, and the survey wording and response frequencies, respectively. Appendix C shows the specific wording and formatting of the experimental treatments in visual form, as fielded for this study.

2. Background—The Research Puzzle

For members of the U.S. public, hydropower is broadly understood to be a stable, secure, and renewable form of energy. A 2012 nationwide survey found that, when apprised of the distribution of current energy sources, U.S. residents would prefer to see reliance on hydropower rise from 3% to 20% of the overall mix of energy sources (Herron, Jenkins-Smith, & Silva, 2012). Why would Americans prefer to see such an increase? In large part it appears to be because of the perceived attributes of hydropower. In nationwide surveys taken in 2008 and 2014, large respondent majorities consistently characterized hydropower as clean, safe, and renewable. Put simply, Americans appear to prefer hydropower because it – like solar and wind power – is viewed as beneficial to society and the environment (Jenkins-Smith & Herron, 2008).

Considering the positive views of hydropower held by a large majority of the public, it is notable that studies of social preferences seem to indicate a substantial willingness to pay (WTP) to constrain the production of hydropower at the GCD (Welsh et al., 1995). Why is that? In WTP studies, public valuation for hydropower is likely to be highly responsive to the value dimensions of which the members of the public are apprised, and the resulting tradeoffs among values that are implied. If so, the decision to include or exclude potentially relevant value dimensions from the choice scenario is of central importance in interpreting the study results. In this research we systematically analyze several factors that may help explain the finding that, in spite of the strikingly positive public perceptions of hydropower, the public would be willing to pay to constrain production of hydropower at the GCD. Specifically, we explore how the presentation of information, the approach used to structure choices, and the omission of potentially relevant dimensions of value in previous work may have contributed to the puzzle described above. But, some background context is necessary to explain why the kinds of information and structure of choices would matter for how the public can express non-use values for complex policy decisions of the kind represented by the operation of the GCD.

The GCD represents an important component of a much larger coupled human and natural system on the Colorado River (Jacobs, 2011). Completed in 1966, the GCD provides a

renewable supply of (non-fossil fuel based) hydroelectricity, and regulates flows between the upper and lower basins of the Colorado River. Over time, local communities and ecosystems interact with, and are affected by, the regular pattern of operations in these large coupled systems. These become the working landscapes of the river, and an increasingly important part of conservation debates (Kareiva, Marvier, & Lalaz, 2012).

As institutional arrangements and specific operating patterns for the dam are periodically reviewed and re-evaluated, an important management consideration or step was the attempt to account for the non-market environmental values that might be affected, including both use values and non-use values (Loomis et al., 2005). For example, prominent CV studies on the GCD in the 1990's estimated non-market monetary values for posited changes in both downstream and reservoir recreational uses (Bishop et al., 1987). Further, as a component of environmental assessments in the 1990's, Welsh et al. (1995) provided an important early CV study on non-market, non-use values associated with downstream environmental and ecosystem effects from proposed changes on GCD operations.

In the intervening decades, our understanding of the complex regional linkages in large coupled human and natural systems, as well as connections to broader global impacts from our choices about the energy production mix, has only increased (Liu et al., 2007). To wit, in roughly the last decade the term "Anthropocene" has emerged as a buzzword in geologic chronology (as distinguished from the Holocene) to better recognize our current human impacts and interactions with earth systems (Crutzen, 2002). As scientists debate the merits of epochal change, it is clear that human welfare is increasingly connected to both regional and global change. Choices about, for example, old growth forest protection in one region might affect the market for hardwoods on another continent (e.g., Chimeli et al., 2012), or choices about our regional energy mix might affect global climate change, or operational changes in one section of a large regulated river system may affect communities and working landscapes both up- and downstream. As such, this connects to broader debates about what conservation in the Anthropocene actually means (Gillings & Hagan-Lawson, 2014; Kareiva et al., 2012). Or in our context, it connects to questions about the multiple dimensions that attempts at "valuation in the Anthropocene" might need to consider.

We are not arguing that every standard valuation exercise needs to consider broader regional or global connections. But operational changes in large coupled human and natural systems, which involve much more than a select set or type of sites, are likely to confront such questions. Further, such questions are consistent with an adaptive management perspective, as previously adopted for the GCD operations (Lovich & Melis, 2007).

Understanding large coupled human and natural systems requires understanding the ways that communities and working landscapes (Kareiva et al., 2012) become inextricably linked with particular operational patterns. Thus, any significant proposed change in operational patterns must both expect and account for the social disruption likely to be brought about with the operational change. As noted by Bromley (2000), with respect to evolving river system management in the U.S.:

> "Is this transition in water policy fair to those whose lives and livelihood are inextricably bound up with the shifting purpose of the rivers? There is no easy answer to that. A civilized nation cushions the inevitable transitions for those caught in the vise of shifting priorities and purposes."

Communities have adapted to (optimized to) the prior human interventions. The question is whether the public at large holds any positive or negative non-market value for these arrangements, in the form of paternalistic altruism (Loomis, 2014).

In addition, the possibility exists that other policy decisions (unlike the GCD case) may result in changes in capacity at existing dams, and such change in turn might result in net changes in air emissions as hydropower is replaced with electrical generation using fossil fuels. Are there non-market values attached to the implications of emissions resulting from such a hypothetical change?

Below, we lay out our strategy for investigating these exploratory questions.

3. Research Design and Experiments

We undertook this pilot study using data from a national Internet-based survey fielded by the University of Oklahoma's Center for Energy, Security & Society (hereafter referred to as the Center),[2] in which survey respondents were randomly assigned to receive one of seven experimental treatments.[3] The survey data were obtained from 2,465 respondents who were recruited by Survey Sampling International (Fairfield, CT) to take the survey in an online format. The respondent recruitment was designed to achieve approximate national representativeness on key demographic attributes such as gender, region of residence, and the respondents' race/ethnicity. For purposes of analysis, the data were weighted to match the 2013 U.S. Census estimates. The survey instrument was designed and tested by the Center, using as a replication base (see Section 4) the information and elicitation questions employed in the survey reported in Welsh et al. (1995). The instrument includes sections that ascertain locational and demographic attributes; provide background information on the Glen Canyon Dam and the potential effects of changes in GCD operations; elicit preferences for dam operations and willingness to pay $25 in additional annual taxes for their preferred option; and measure an array of attitudinal attributes and behaviors relevant to valuation choices. A more detailed description of the data collection method is provided in Appendix A, and a listing of question wording and response frequencies for questions relevant to this report are provided in Appendix B.

The heart of this study derives from the comparison of responses to the seven randomly assigned experimental treatments. The first of these treatments is designed to replicate the original Welsh et al. (1995) study that found a substantial WTP for proposed changes in operations at the GCD. This replication serves as the baseline against which we compare the results of our six additional experimental treatments. Treatment #2 randomly varies the

[2] The survey design and data collection were undertaken by the Center. The University of Oklahoma's Office of Vice President for Research provided the funding for the survey data collection.
[3] The survey was fielded from April 22-24, 2014 and took an average of 26 minutes to complete. Respondents were weighted to match 2013 U.S. Census estimates.

ordering of information presented in the replication treatment.[4] This is necessary to set the stage for the inclusion (in randomized order) of information relevant to the additional value dimensions considered in subsequent treatments.

Treatment #3 changes the structure in which respondents were asked express their preference for future dam operations. In the replication treatment, individuals were asked to vote "yes" or "no" on a single proposal for changing dam operations, whereas in this treatment respondents were asked to vote for one of two options for operating the dam. Such an approach is more useful when asking respondents to trade off important competing value considerations. In addition to being more conceptually appropriate, this approach allowed us to assess the extent to which respondents may hold a positive WTP[5] for maintaining dam operations; earlier studies were not designed in a manner that could capture such preferences (or dimensions of valuation).

The remaining four treatments were designed to permit assessment of the effects of including additional value dimensions in the consideration of dam operations. Three of these treatments provide information and summarize the potential effects of changed dam operations on: (Treatment #4) Native American tribes; (#5) Rural Western communities; and (#6) both Native American tribes and rural Western communities. Treatment #7 provided respondents with purely hypothetical information about potential effects of changed dam operations on air emissions and quality. Table 1 summarizes the seven experimental treatments and presents the sample size for each.[6]

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[4] In survey experiments, it is important to avoid unintended bias due to the ordering of the presentation of information to respondents. The use of a programmed survey instrument applied on an Internet platform, as was done for this pilot study, readily permits this kind of randomization.

[5] Eliciting individual preference responses for such positive values for maintaining current operations could either be framed as willingness to pay to avoid any perceived loss due to changes in current operations (technically, a Hicksian equivalent welfare change measure), or a willingness to accept compensation for perceived loss due to proposed changes in operations (technically, a Hicksian compensating welfare change measure). The measures differ in assumed property rights. However, if public funds are necessary to implement any option (including maintaining current operations), then ultimately a WTP perspective may be necessary.

[6] Note that, rather than vary each dimension of value independently (as could be implemented in a choice experiment), we evaluated specified bundles of attributes in a sequential set of plausible treatment options. We opted for this approach because (a) we sought to compare alternative bundles with the results of a specific bundle of value dimensions represented in prior research (Welsh et al., 1995), and (b) we sought to present respondents with logically consistent bundles of changes on value dimensions rather than groups of attributes that were randomly aggregated.

Table 1: Experimental Treatments

Treatment	Concept	Sample Size
1. Replication	Used Welsh et al. (1995) language and format, in Internet survey mode	341
2. Adds randomized presentation of information to #1	Replication of Welsh et al. (1995) with the exception of randomizing the order of information	345
3. Adds referendum choice options to #2	Permits respondent to vote for one of two options, rather than one "proposal"	352
4. Adds Native American effects to #3	Adds information and potential effects of changed operations on Tribes	343
5. Adds rural Western community effects to #3	Adds information and potential effects of changed operations on rural communities	397
6. Combines #4 and #5	Combines information and potential effects on Tribes and rural communities	345
7. Adds hypothetical air emission effects to #3	Includes hypothetical effects of increased air emissions (*not* combined with #4-6)	342

Table 2 summarizes the features of each of the seven treatments to which respondents are assigned. Specifically, it indicates whether each treatment has randomized information blocks, a vote on a proposal to change operations versus a choice between two options for dam operations, and the dimensions of information presented to respondents.

Table 2: Design Features of Experimental Treatments

Treatment	Replication of Information in Welsh et al. (1995)	Randomized Information Blocks	Vote on Proposal to Change Operations	Choose Between Two Options for Dam Operations	Description of Effects on Native American Tribes	Description of Effects on Rural Western Communities	Description of Effects on Air Emissions
1	X		X				
2	X	X	X				
3		X		X			
4		X		X	X		
5		X		X		X	
6		X		X	X	X	
7		X		X			X

Using data derived from these experimental treatments, we tested the following six hypotheses, two of which were methodologically oriented and four of which were substantive:

Methodological Hypotheses:

H1: Randomizing the order in which background information is presented to respondents will affect support for changing dam operations, as well as respondents' willingness to pay $25 for such changes, relative to the baseline replication treatment.

H2: Allowing respondents to select one of two options for operating the dam, rather than requiring respondents to vote on a proposal for changing dam operations, will affect support for changing dam operations, as well as respondents' willingness to pay $25 for such changes, relative to the baseline replication treatment.

Substantive Hypotheses:

H3: Providing respondents with information on the potential effects of changed dam operations on Native American tribes will affect support for changing dam operations, as well as respondents' willingness to pay $25 for such changes, relative to the baseline replication treatment.

H4: Providing respondents with information on the potential effects of changed dam operations on rural Western communities will affect support for changing dam operations, as

well as respondents' willingness to pay $25 for such changes, relative to the baseline replication treatment.

H5: Providing respondents with information on the potential effects of changed dam operations on both Native American tribes and rural Western communities will affect support for changing dam operations, as well as respondents' willingness to pay $25 for such changes, relative to the baseline replication treatment.

H6: Providing respondents with information on the potential effects of changed dam operations on air emissions will affect support for changing dam operations, as well as respondents' willingness to pay $25 for such changes, relative to the baseline replication treatment.

In sum, the survey was designed to provide experimental evidence about the differences in valuation responses that are obtained when survey respondents are provided with descriptions of different dimensions of value considerations for changing dam operations. Recall that the data for this study were obtained from respondents to a voluntary online survey employing willing participants; in an ideal setting, of course, the data would have been obtained from subjects randomly drawn from a list of individuals from a known population. However, recent developments have resulted in declining response rates for surveys of all modes, with the result that selection biases (systematically different propensities for people of different kinds to respond to surveys) call into question the representativeness of general population surveys (Anseel et al., 2010). The advent of Internet surveys now provides a reasonable alternative to other survey modes (see Berrens et al., 2003, as applied to CV studies), and recent research has demonstrated that carefully weighted non-probability samples can provide very close estimates of population parameters (Wang et al., 2014). These developments underlie our use of online survey data for the analyses in the following sections.

4. Replication Treatment

To the extent practicable given the difference in survey modes—the original Welsh et al. (1995) CV survey was administered via mail whereas our survey was Internet-based—our replication treatment provided respondents with the same information in the same visual format as did the original Welsh et al. (1995) survey (see Appendix C). Because of potential survey mode effects, as well as the possibility of preferences evolving over time, this replication treatment was not intended to precisely reproduce the estimates from the Welsh et al. (1995) CV study. Instead, its primary purpose was to establish a meaningful baseline against which to compare the results of the subsequent experimental treatments as described in Section 3.

To establish these baseline estimates, we began this treatment in the same manner as the original Welsh et al. (1995) survey—by showing respondents a picture of the Grand Canyon below the GCD and informing them that "the survey they you are about to take is part of a study of issues concerning operations of the Glen Canyon Dam." We stressed that respondents' opinions on these issues were one factor that government officials would consider when making decisions on the operations of the GCD.

After providing respondents with this general overview of the study purpose, we showed them a series of pages containing information relevant to operations of the GCD. Mirroring the original Welsh et al. (1995) study, we began by presenting background information on the GCD, the Glen Canyon Study Area, and how the GCD affects the Colorado River in the Study Area. The information we presented was identical to that in the original Welsh et al. (1995) study and included facts about the history, location, and purpose of the GCD, features of the Study Area below the GCD, and how operations of the GCD affect the flow of the Colorado River in the Study Area. To gauge respondents' comprehension of the information, we asked them two factual questions about what they had just read, an approach we employed after each page of information presented to respondents (for a total of six factual questions).

Again paralleling the structure, wording, and ordering of the original Welsh et al. (1995) study, we next presented respondents with information on natural resources in the study area. Specifically, we provided information on archaeological sites near the river, the beaches along the river, and the status of trout and native species of fish in the river. This information was followed by a page that summarized concerns that "some people" have about the beaches, archeological sites, and fish in the Study Area. In particular, respondents were informed of concerns over shrinking beaches, the disruption of archeological sites, and the viability of fish. As with the other information provided to respondents, the concerns presented to them were drawn from the original Welsh et al. (1995) study.

The final page of background information provided to respondents states that changing the operations of the dam could address some of the concerns about the natural resources—the beaches, archeological sites, and fish—in the Study Area. Respondents were also told about some additional possible effects of changing dam operations, including increases in some households' electric bills and higher costs for some farmers who use electricity to pump irrigation water.

After presenting respondents with all of this information—the background information on the operations of the GCD, an overview of natural resources in the Study Area, the concerns over these resources, and potential effects of changing operations—we informed respondents that they would be presented with a proposal for changing dam operations, as well as a description of the effects of that proposal, and that the proposal could cost them money in the form of higher taxes. We then told respondents that they would be asked if they would vote "yes" or "no" on the proposal, both if the proposal were costless to them and if the proposal were to cost them some positive dollar value. Drawing on the Welsh et al. (1995) study, we presented respondents with reasons why they might vote "yes" or "no" on the proposal.

We then presented respondents with the proposal for modifying dam operations, which would involve moderately reducing the daily fluctuations in the Colorado River level, as well as the projected effects of the proposal, including:

- A stabilization in the number and size of beaches;
- A decrease in the erosion threat to archeological sites;

- An increase in the area available for vegetation;
- Improvements in the conditions for fish;
- An increase in the electric bill for some households; and
- A small decline in income for 300 farmers in southern Utah.

Following this proposal we presented respondents with a question asking whether they would support the proposal if its passage would not cost them anything. Respondents were given the options of voting "no," voting "yes," or stating that they would choose not to vote. Respondents were then informed that the higher electric rates accompanying the proposal would not be able to make up for all of the revenue that would be lost under the proposal and that taxpayers would need to make up the difference. Respondents were then asked if they would vote for the proposal if its adoption would cost their household $25 in increased taxes every year for the foreseeable future. Respondents were provided with the following five response options:

- Definitely vote against the proposal
- Probably vote against the proposal
- Not sure whether they would vote for the proposal
- Probably vote for the proposal
- Definitely vote for the proposal

Table 3 presents the first set of results from the replication treatment. Specifically, under the condition that passage of the proposal would cost respondents nothing, the table presents the percentage of respondents who stated they would vote for the proposal to change dam operations, the percentage stating that they would vote against the proposal, and the percentage stating that they would choose not to vote. As a point of comparison, Table 3 also presents the analogous results from the original Welsh et al. (1995) study—results from when respondents were asked how they would vote if passage of the proposal would not cost them anything.

Table 3: Replication Treatment Results—No Cost

	Our Study	Welsh et al. (1995) Study
Vote for proposal to change operations	70.6%	71%
Vote against proposal to change operations	17.3%	17%
Would not vote	12.2%	12%

Table 3 makes clear that our "no cost" results were remarkably close to the "no cost" results as presented in Welsh et al. (1995), with 71 percent of respondents in both studies stating they would vote for the proposal for changing dam operations, 17 percent stating that they would vote against the proposal, and 12 percent stating that they would choose not to vote. Although this treatment was not intended to reproduce the original Welsh et al. (1995) estimates, the fact that they are so similar is suggestive—although not definitive—of preferences remaining fairly stable over two decades since the Welsh et al. (1995) survey was fielded. Additionally, the similarity of the results suggests that survey mode effects—the original Welsh et al. (1995) was fielded by mail whereas ours was Internet-based—are negligible. Regardless, the results presented above represent a valid baseline against which the results of the additional experimental treatments can be compared.

Table 4 presents the second set of results from the replication treatment. In particular, under the condition that passage of the proposal would cost respondents $25 in increased taxes each year for the foreseeable future, Table 4 presents the percentage of respondents who stated they would vote for the proposal to change dam operations, the percentage stating that they would vote against the proposal, and the percentage stating that they were unsure or would choose not to vote. We note that these results are for all individuals assigned to the replication treatment, not just those who stated they would vote to change operations at zero cost. Note that the original Welsh et al. (1995) study asked respondents whether they would vote for the proposal over a wide range of dollar costs. For this pilot study, by contrast, we asked respondents only to indicate their vote when costs would be $25. For that reason, Table 4 does not show analogous results from the Welsh et al. (1995) study.

Table 4: Replication Treatment Results—Cost of $25

	Our Study
Vote for proposal to change operations	46.6%
Vote against proposal to change operations	32.7%
Not sure/Would not vote	20.7%

The results in Table 4 demonstrate that nearly 47 percent of the respondents would vote for the proposal if it were to cost them $25 in increased taxes annually. This number is substantially lower than the 71 percent of respondents who would vote for the proposal if it were to cost them nothing. Nearly a third of the respondents—33 percent—state that they would vote against the proposal if its passage were to cost them $25, while approximately 20 percent of respondents were unsure as to how they would vote or would choose not to vote.

5. Baseline Randomized Information Treatment

As Section 4 made clear, the replication treatment presented respondents with a substantial amount of information relevant to a potential change in GCD operations. In particular, it provided them with background information on the operations of the GCD, an overview of natural resources in the Study Area, the concerns over these resources, and potential effects of changing operations. In order to maintain fidelity to the replication effort, all of this information was presented in the same order as it was in the original Welsh et al. (1995) study. Thus, our first post-replication treatment involved randomly varying the ordering of information presented in the replication treatment.

The purpose of this treatment is two-fold. First, it is possible that the replication results—the proportion of respondents supporting the proposal to change GCD operations—were at least partially attributable to the order in which information relevant to a potential change in GCD operations was presented, which tended to highlight the ecological dimensions. This treatment allows us to assess the extent to which this may be the case. Second, and more importantly, this treatment is necessary for valid administration of the additional experimental treatments we describe below. In these treatments we introduce additional dimensions of value that have the potential to affect preferences and valuations for changing GCD operations. We introduce these additional value dimensions by providing respondents with relevant information about them as part of the background information described in the previous section (See Appendix B for wording and Appendix C for visual reproduction). In order to avoid bias stemming from the order in which the information about these additional dimensions is presented in relation to the information about other dimensions, all background information must be randomly ordered. This treatment provides the baseline against which the experimental treatments assessing the effect of additional value dimensions on valuations and preferences over GCD operations can be validly compared.

To implement this treatment we began with the background information used in the replication treatment, which was described in Section 4. The content and ordering of all

background information can be found in the survey instrument in Appendix C. Separately for each page of information—the background information on the GCD and Study Area, the overview of natural resources in the Study Area, the summary of concerns over those resources, and the description of how changing GCD operations might address some concerns—we grouped the text into blocks of information on the same substantive topic. For example, on the page that overviews natural resources in the Study Area, one information block contains all text addressing beaches, the second information block contains all text describing the archeological sites, and the third block contains all information relevant to fish. The information groupings for all pages of background material are provided in Appendix C.

Instead of encountering all background information in the precise ordering found in the original Welsh et al. (1995) survey, respondents assigned to this treatment were exposed to randomly ordered blocks of information across all pages of background material. Continuing to use the page that overviews natural resources in the Study Area as an illustrative example, one respondent might see the page in a format where all fish-related information is at the top, all beach-related information is in the middle, and the description of archeological sites is at the bottom of the page. A second respondent would likely see the page in a completely different format—archeological information might be at the top, followed by fish-related information in the middle, and all information relevant to beaches at the bottom.

In addition to randomizing blocks of background information, this treatment also randomizes the order of the bulleted information in the proposal for changing dam operations. For randomization purposes in the proposal, each bullet was treated as its own grouping. See Appendices B and C for the specific content of the bulleted information in the proposal.

Table 5 presents the results of the randomized information treatment. It presents results under the condition where passage of the proposal would cost respondents nothing as well as under the condition where it would cost respondents $25 annually in additional taxes for the foreseeable future. To facilitate comparison, the replication treatment results—for both the “no cost” and “cost of $25” conditions—are also presented. The results demonstrate that

randomizing the order in which background information is presented, as well as randomizing the order of the bulleted information in the proposal, has neither a statistically significant nor substantively meaningful effect on respondent preferences for GCD operations. These null effects are present for both the "no cost" and the "cost of $25" conditions.

Table 5: Randomized Information Treatment Results

	No Cost		**Cost of $25**	
	Randomized Information Treatment	Replication Treatment	Randomized Information Treatment	Replication Treatment
Vote for proposal to change operations	71.0%	70.6%	42.5%	46.6%
Vote against proposal to change operations	17.3%	17.3%	33.7%	32.7%
Not sure/Would not vote	11.8%	12.2%	23.8%	20.7%

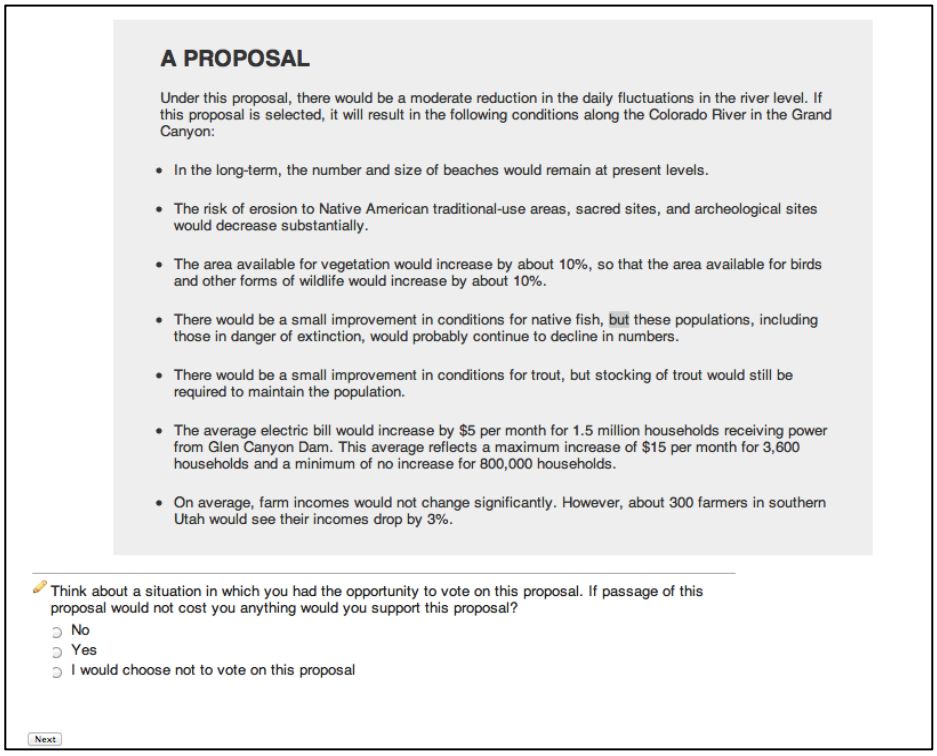
The results in Table 5 have important implications. In particular, the results make clear that the order in which the information was presented in the replication treatment did not have an effect on respondents' expressed preferences for operations of the GCD. Although perhaps surprising from a substantive standpoint, this result is appealing from a statistical standpoint because it means we can validly combine respondents assigned to either the replication treatment or the randomized information treatment into a single group. This increases the sample size of our baseline treatment group, which correspondingly increases the power to detect statistical differences between this baseline treatment group and our other experimental treatment groups.

However, as noted above, the most important purpose of this treatment was not to estimate the effect of information ordering on respondent valuations and preferences for GCD operations, but rather to establish a valid baseline against which the additional experimental treatments can be compared. As it happens, the effects of this treatment are neither statistically nor substantively different from the effects of the replication treatment, which allows us to use respondents assigned to either group as the baseline for future experimental comparisons.

6. Referendum Options Treatment

The original Welsh et al. (1995) survey, as well as our replication and randomized information treatments, asked respondents whether they would vote "yes" or "no" on a proposal for changing dam operations. Figure 1 illustrates the structure of the proposal, which first describes the nature of the change in dam operations—a moderate reduction in the daily fluctuations in the Colorado River level—before presenting the projected effects of the change in operations in a bulleted format.

Figure 1: Single Proposal Format for Valuation



The choice architecture underlying presentation of the proposal could have the effect of privileging the proposal. Specifically, the fact that respondents are presented with the proposal and then asked if they would support it renders it potentially susceptible to acquiescence bias, which is the tendency for individuals to agree with a statement or proposal regardless of its content. A substantial body of scholarly literature has

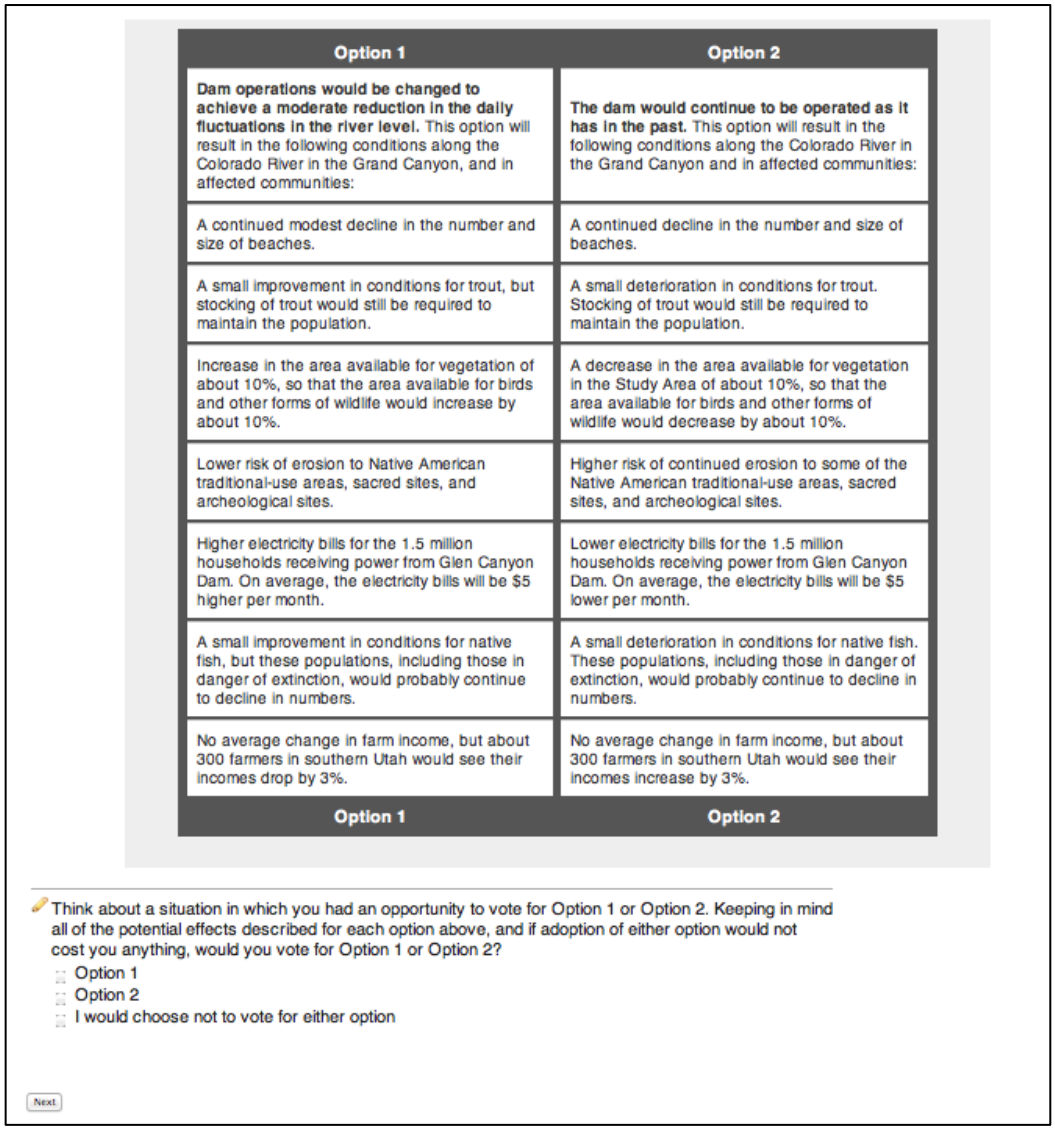
demonstrated the existence of acquiescence bias (see Krosnick and Presser (2010) for a review) and it has been shown to be of particular concern in "yes/no" contexts like the one underlying the proposal presented to respondents. Moreover, in the specific case of the proposal for changing GCD operations, the respondents may question why experts went to the expense and effort of constructing the proposal and asking their opinion about it if the proposal was not worthwhile.

In addition to its potential susceptibility to acquiescence bias, the current structure of the proposal prevents assessment of whether some respondents may actually place a positive value on maintaining current dam operations. As it was administered in the original Welsh et al. (1995) survey, as well as in our replication and randomized information treatments, respondents who state that they would vote against the proposal are automatically assumed to value it at $0. The structure of the proposal does not render it possible for individuals to express a "negative" valuation or preference for the proposal. That is, there is no mechanism for individuals to express that they would actively prefer—be willing to pay some positive dollar amount—for the proposal to *not* go into effect (i.e. to maintain current dam operations). The lack of a mechanism for expressing such "negative" valuations is problematic in cases where the good being valued has effects across multiple dimensions and there is potential variation in whether respondents view these effects as positive or negative (see Bohara, Kerkvliet, & Berrens (2001); Atkinson et al. (2004); and Loureiro, Loomis, & Nahuelhual (2004)). In the case of the GCD as a major component of a coupled natural and human system, it is clear that changing operations will have effects across several dimensions—ecological, economic, cultural, and others—and it is likely that some of these effects would generally considered to be positive and others would be considered negative. In such a scenario, precluding respondents from expressing a positive preference or valuation for maintaining current operations will lead to biased inferences regarding respondents' preferences and valuations over GCD operations.

Consequently, our third experimental treatment is designed to address both the potential for acquiescence bias and the lack of a mechanism for expressing positive preferences and valuations for maintaining current dam operations. In this treatment we provide respondents with the same background information as we did in the randomized information treatment. That is, all background information is presented using the

randomized information block approach described in Section 5. However, instead of eliciting respondents' preferences and valuations for dam operations using a referendum on a specific proposal—the approach used in Welsh et al. (1995) and the replication and randomized information treatments presented above—in this treatment we elicit respondents' preferences and valuations through a referendum on two options for operating the dam. As illustrated in Figure 2 below, this approach to preference and valuation elicitation presents respondents with two options for operating the dam, which we refer to as Option 1 or Option 2. Substantively, the two options are maintaining current operations or changing operations in a manner that moderately reduces daily fluctuations in the Colorado River level. To eliminate the threat of bias attributable to information ordering, we randomized whether maintaining current dam operations—and by implication changing dam operations—was listed as Option 1 or Option 2. The programming underlying the choice facing the respondent kept track of whether Option 1 referred to maintaining current dam operations or changing operations. Figure 2 illustrates that the first row in each column describes the option for dam operations and each subsequent row summarizes the effect of that option for dam operations along a given dimension of value. These effects are generally presented in relation to the other option for dam operations.

Figure 2: Two-Option Format for Valuation



Option 1	Option 2
Dam operations would be changed to achieve a moderate reduction in the daily fluctuations in the river level. This option will result in the following conditions along the Colorado River in the Grand Canyon, and in affected communities:	**The dam would continue to be operated as it has in the past.** This option will result in the following conditions along the Colorado River in the Grand Canyon and in affected communities:
A continued modest decline in the number and size of beaches.	A continued decline in the number and size of beaches.
A small improvement in conditions for trout, but stocking of trout would still be required to maintain the population.	A small deterioration in conditions for trout. Stocking of trout would still be required to maintain the population.
Increase in the area available for vegetation of about 10%, so that the area available for birds and other forms of wildlife would increase by about 10%.	A decrease in the area available for vegetation in the Study Area of about 10%, so that the area available for birds and other forms of wildlife would decrease by about 10%.
Lower risk of erosion to Native American traditional-use areas, sacred sites, and archeological sites.	Higher risk of continued erosion to some of the Native American traditional-use areas, sacred sites, and archeological sites.
Higher electricity bills for the 1.5 million households receiving power from Glen Canyon Dam. On average, the electricity bills will be $5 higher per month.	Lower electricity bills for the 1.5 million households receiving power from Glen Canyon Dam. On average, the electricity bills will be $5 lower per month.
A small improvement in conditions for native fish, but these populations, including those in danger of extinction, would probably continue to decline in numbers.	A small deterioration in conditions for native fish. These populations, including those in danger of extinction, would probably continue to decline in numbers.
No average change in farm income, but about 300 farmers in southern Utah would see their incomes drop by 3%.	No average change in farm income, but about 300 farmers in southern Utah would see their incomes increase by 3%.
Option 1	Option 2

Think about a situation in which you had an opportunity to vote for Option 1 or Option 2. Keeping in mind all of the potential effects described for each option above, and if adoption of either option would not cost you anything, would you vote for Option 1 or Option 2?

- Option 1
- Option 2
- I would choose not to vote for either option

Next

After presenting respondents with the two options for dam operations, we described a situation in which they would have an opportunity to vote for Option 1 or Option 2. We then asked them whether they would vote for Option 1 or Option 2 if adoption of either option would not cost them anything. Respondents could then select Option 1, Option 2, or they could indicate that they would choose not to vote.

In order to elicit WTP, it is necessary to make the valuation questions for the two options comparable.[7] For that reason, we needed to present the "no change" option as one that (like the change option) would require that the respondent consider their willingness to pay to continue to operate the dam as it had been in the past. To accomplish this, upon selecting Option 1 or Option 2 under the condition of "no cost", we brought respondents to a screen stating that the option they chose (either change or no change in dam operations) was more expensive to operate and that it would therefore increase costs to taxpayers. We then presented respondents with a question asking whether they would vote for the option they had preferred at "no-cost'' even if its adoption would cost their household $25 in increased taxes every year for the foreseeable future. Respondents could state that they would "definitely vote against the option," "probably vote against the option," were "unsure if they would vote for the option," "probably vote for the option," or "definitely vote for the option."

There are several appealing features of this approach to eliciting preferences and valuations. First, it mitigates the potential for acquiescence bias by requiring respondents to actively choose between one of two options for dam operations, as opposed to stating whether they would or would not support a single proposal for changing dam operations. Second, it provides respondents with a mechanism for expressing a *negative* preference and valuation for changing dam operations, which can alternatively be framed as a positive preference or valuation for maintaining current operations. Moreover, as noted above, this mechanism is presented in a willingness to pay framework, as opposed to willingness to accept, which is the framework that most previous attempts to provide a mechanism for negative valuation have ultimately employed. Because individuals value gains and losses differently, combining estimates generated from willingness to pay and willingness to accept approaches is generally not thought to be a valid approach. The treatment employed in this study avoids such a problem because valuations for both maintaining and changing dam operations are elicited in a willingness to pay framework.

The design of this treatment allows us to perform two major analyses. First, it allows us to assess whether eliciting respondents' preferences through a referendum on two options for operating the dam, as opposed to a referendum on a proposal for changing dam operations,

[7] We could not, for example, meaningfully compare WTP for changed operations with a "willingness to accept" (WTA) compensation for keeping dam operations unchanged.

has an effect on support for changing dam operations. We make this assessment by comparing the responses of two groups of individuals—those assigned to the two options treatment described here and those assigned to the randomized information treatment described in the previous section—to the question of whether they prefer maintaining or changing dam operations if adoption of either policy was guaranteed to cost them nothing. Second, we are able to assess the extent to which respondents may place a positive value on maintaining dam operations. To make this assessment, we combine respondents' answers to the question of whether they prefer maintaining or changing with their responses to the question of whether respondents would vote for the option they prefer if it cost them $25 in additional taxes annually. Combining responses to these two questions allows us to classify respondents into one of five groups:

1. Prefer maintaining operations, and willing to pay $25 annually to do so;
2. Prefer maintaining operations, but not willing to pay $25 annually to do so;
3. Prefer changing operations, and willing to pay $25 annually to do so;
4. Prefer changing operations, but not willing to pay $25 annually to do so; and
5. Would choose not to vote.

To the extent that respondents fall into the first category—those who prefer maintaining operations and are willing to pay $25 to do so—we gain a preliminary sense of how many individuals hold a significant negative value for changing dam operations. In traditional contingent valuation studies, including the original Welsh et al. (1995) study, these individuals would be assumed to hold a value of $0 for changing dam operations. Through our research approach, we will be able to assess the extent to which this assumption may lead to biased willingness to pay estimates.

Table 6 presents the results of the "two options" treatment. The numbers in bold represent the results of the first major analysis—assessing the effect of eliciting respondents' preferences through a referendum on two options for dam operations, as opposed to a referendum on a single proposal for changing operations. Although the table indicates that a slightly lower percentage of respondents in the two options treatment would vote to change dam operations—67.8 percent versus 70.6 percent in the replication treatment—the results of a chi-square test reveal that the distribution of responses in the two treatments are not

statistically different from one another.[8] However the precision of these estimates can be increased in a more complete model, with adequate statistical controls. This more complete analysis is undertaken in Section 9.

Table 6: Referendum Options Treatment Results

	Two Options Treatment	Replication Baseline
Vote to change operations	**67.8%**	**70.8%**
Would pay $25	*46.9%*	*N/A*
Vote to maintain operations	**21.3%**	**17.3%**
Would pay $25	*6.9%*	*N/A*
Would not vote	**11.0%**	**12.0%**

As noted earlier, the primary contribution of this treatment is the ability to assess whether some fraction of respondents hold a positive value for maintaining dam operations. The results presented in Table 6 indicate that a non-trivial percentage of respondents do indeed hold such values. Specifically, Table 6 demonstrates that nearly 7 percent of respondents in the two options treatment would pay $25 to maintain current operations. This 7 percent, which is statistically different from zero, represents one-third of all respondents who would vote to maintain operations. Such a finding is noteworthy because, as discussed earlier, traditional contingent valuation studies typically assume these respondents to hold a $0 value for changing dam operations. Our results demonstrate that such an assumption is incorrect, as these respondents effectively hold a "negative" WTP for changing dam operations, which implies that any population WTP estimates for changing dam operations are potentially biased.

[8] The lack of a statistical difference between the two treatments is attributable in part to the fact that the estimated difference between the two treatment groups is modest in magnitude—on the order of 3-4 percentage points—coupled with the fact that each experimental treatment group only contains approximately 350 respondents. A power analysis reveals that, for a simple chi-square test of this kind, each group would need to contain approximately 3,700 respondents in order to detect a difference of the magnitude reported in Table 6.

7. Additional Value Consideration Treatments

The original Welsh et al. (1995) study provided respondents with information on value dimensions that are undoubtedly relevant to decisions regarding GCD operations, namely the ecological and cultural dimensions. However, the 1995 study did not provide information on other dimensions that are potentially relevant to individuals' preferences and valuations of GCD operations. Our fourth, fifth, and sixth experimental treatments are thus devoted to assessing the effects of introducing background information on additional value dimensions and considerations of respondents' expressed preferences and valuations of GCD operations. Specifically, we introduce information and summarize the potential effects of changed dam operations on: (i) Native American tribes; (ii) Rural Western communities; and (iii) both Native American tribes and rural Western communities.[9]

As discussed in Section 2, when evaluating the non-market value effects of changes in components of complex coupled human and natural systems, it is critical to take into account the manner in which the proposed changes will affect communities that have adapted to the prior system arrangements (Jacobs, 2011; Kareiva et al., 2012; Bromley, 2000). Loomis (2014) outlines the manner in which paternalistic altruism serves as the theoretical basis for including these additional value dimensions in a non-market framework. Changing dam operations is projected to result in increased electricity costs (or reduced transfer benefits) for many Native American tribes and rural Western communities, but these increased electricity costs *per se* are not a sufficient basis for including these additional value dimensions—these effects can be valued in a market setting. Rather, it is the respondents' desire for these communities to have continued access to cheaper electricity and related benefits—referred to as paternalistic altruism—that serves as the theoretical basis. This paternalistic altruism could stem from any number of sources, including maintaining a unique culture, mitigating threats to specific occupations or way of life, or others.

[9] The question wording for the added value dimensions was pre-tested in on-line applications by researchers and students in the OU Center for Energy, Security & Society.

To implement these treatments we began with the background information described in the randomized information treatment and structured the referendum on dam operations in the "two options" format described in the previous section. Then, on each page of background information presented to respondents—the summary of operations of the GCD and status of the Study Area, the overview of natural resources in the Study Area, the concerns over these resources, and the potential effects of changing operations—we inserted language relevant to the additional value dimensions covered by each respective treatment.[10] We also inserted language relevant to the additional value dimensions into the referendum on dam operations faced by respondents. Below we present the specific language inserted for each treatment. A visual presentation of each of these treatments is provided in Appendix C.

Although most of the insertions and modifications are treatment-specific—we describe these treatment-specific changes in respective sections below—there are some changes that are applicable to all three experimental treatments described in this section. These include:

- Changing the purpose of the study presented to respondents from "This study deals with the ways Glen Canyon Dam could be operated to benefit natural and cultural resources in the Study Area" to "This study deals with options for how the Glen Canyon Dam could be operated that would affect natural resources in the Study Area and the communities that have relied on the hydropower produced by the Glen Canyon Dam."
- Changing the title of the page presenting the overview of natural resources in the study area from "Natural Resources in the Study Area" to "Natural Resources in the Study Area and Rural Western Communities in the Region."
- Changing the text introducing the natural resources page from "The natural resources in the Study Area are located in and along the Colorado River below Glen Canyon Dam" to "The natural resources in the Study Area are located in and along the Colorado River below Glen Canyon Dam. Many of the small communities that have relied on hydropower from the Glen Canyon Dam are in rural parts of Arizona, Colorado, New Mexico and Utah."

[10] The content of the added value considerations was based on extensive discussions with experts on the relevant issues, resulting in iteratively refined information wording.

- Changing the title of the page summarizing concerns from "Some People are Concerned About These Resources" to "Some People are Concerned About These Resources and Communities."
- Changing the title of the page describing the effects of changing dam operations from "Scientists have learned that by changing the way water is released from the dam, primarily by reducing the size of daily fluctuations, some of the concerns about the natural resources in the Study Area could be addressed" to "Scientists have learned that by changing the way water is released from the dam, natural resources in the Study Area and residents of the surrounding rural communities could both be affected in a variety of ways."

All remaining changes are treatment-specific, and we describe them in their respective subsections below.

7.1 Native American Tribes

For the treatment introducing Native American tribes as a value dimension relevant to respondents' preferences for and valuations of dam operations, we inserted the following information block—with randomized placement along with existing information blocks—into the page overviewing natural resources in the study area:

- Over 50 American Indian Tribes receive allocations of electricity from the hydropower produced by the Glen Canyon Dam.
    - Included are the Navaho, Utes, Apache, Pueblo Indian communities, and many other tribes.
- These allocations provide low cost and stable electric power to the tribes, or are used to offset more costly electricity purchased from area utilities.
- The benefits to the tribes help tribal residential users and businesses, and are an important part of sustaining tribal communities and improving their economies.

For the page summarizing the concerns that people have about natural resources and communities in the study area, we inserted the following information block, which was again placed in randomized order among all existing information blocks:

- Many Native American Tribes rely on the low and stable prices of the electricity produced at the Glen Canyon Dam.
    - Over 50 American Indian Tribes receive economic benefits from hydropower produced at the Dam.
- Tribal businesses have relied on the low and stable electricity prices in creating and maintaining area employment.
- For many Tribal residences, electricity produced at the Glen Canyon Dam is more affordable than electricity produced at power plants that rely on fossil fuels.
- The low and stable price of electricity produced at the Glen Canyon Dam has contributed to the stability and growth of communities in Tribal areas.

On the final page of background information—describing how changing dam operations might affect natural resources and rural communities—we inserted the following information block, which was placed in random order along with all existing information blocks:

- Changing the way water is released through the dam will reduce the benefits of low cost electricity from the Glen Canyon Dam to over 50 American Indian Tribes.
- Some Tribes would need to replace the low-cost electricity from the Glen Canyon Dam with power from local utilities.
    - The cost of electricity from local utilities would be higher and more variable
    - Higher and more uncertain prices for electricity would make it more difficult for business to compete, thereby reducing jobs
    - Some communities in Tribal areas may decline as a result, as jobs and incomes are reduced and residents migrate to other areas

Finally, we inserted the following information block into the "two options" referendum facing respondents. As is the case with all other insertions, this one was placed in random order along with all existing information blocks. In the example below, "Option 1" is for Changing Dam Operations while "Option 2" is for Continued Dam Operations. This is merely illustrative, however, and the reverse order could also be the case for some respondents.

Option 1- Changed operations	Option 2- Continued operations
Reduced benefits from hydropower for over 50 Native American Tribes. These reduced benefits could pose a threat to the communities in Tribal areas as jobs are reduced and residents seek employment elsewhere	Continued benefits from hydropower production for over 50 Native American Tribes. These continued benefits would sustain jobs and support communities in Tribal areas.

Table 7 below presents the results of the treatment introducing implications for Native American tribes as a value dimension relevant to respondents' preferences for and valuations of dam operations. The treatment results are presented alongside the results for the "Two Options Referendum" treatment, which serves as the most appropriate baseline for purposes of comparison. The results in Table 7 demonstrate that the addition of implications for Native American tribes has an effect on preferences for changing dam operations that is both statistically significant and substantively large. Whereas over two-thirds of respondents in the baseline condition stated that they would vote to change operations—and nearly half of all respondents stated that they would be willing to pay $25 to do so—less than half of respondents assigned to the new treatment support changing operations, and only one-third would pay $25 to do so. Correspondingly, the proportion of respondents who would vote to maintain operations increases from 21 percent in the baseline condition to nearly 40 percent in the new treatment; the percentage of respondents who would pay $25 to maintain operations increases from 7 percent in the baseline condition to 17 percent in the new treatment. Clearly, introduction of the potential effects on Native American tribes as a value dimension has a substantial effect on respondents' preferences for and valuations of dam operations.

Table 7: Native American Treatment Results

	Treatment with Implications for Native Americans	Two Options Referendum
Vote to change operations	**49.5%**	**67.8%**
Would pay $25	*33%*	*46.9%*
Vote to maintain operations	**39.2%**	**21.3%**
Would pay $25	*16.5%*	*6.9%*
Would not vote	**11.4%**	**11.0%**

7.2 Rural Western Communities

For the treatment introducing rural Western communities as a value dimension relevant to respondents' preferences for and valuations of dam operations, we inserted the following information block—randomized with existing information blocks—into the page overviewing natural resources in the study area:

- Many rural areas and small communities in Arizona, Colorado, New Mexico, and Utah rely on hydropower produced at the Glen Canyon Dam. The economies of these communities depend heavily on ranching and farming.
- Hydropower provides low cost and stable power to farmers and ranchers.
    - These benefits help sustain the economies and ways of life in these rural communities.

For the page summarizing the concerns that people have about natural resources and communities in the study area, we inserted the following information block, which was again placed in randomized order among the existing information blocks:

- Rural ranching and farming communities in Colorado, New Mexico, Arizona, and Utah rely on the low and stable prices of the electricity produced at the Glen Canyon Dam.
    - Many farmers and ranchers in these communities rely on electricity for pumping water for irrigation
    - Farmers and ranchers, and the businesses that support them, have relied on the low and stable electricity prices in creating and maintaining area employment.
    - For many rural farming and ranching communities, electricity produced at the Glen Canyon Dam is more affordable than electricity produced at power plants that rely on fossil fuels.

On the final page of background information—describing how changing dam operations might affect natural resources and rural communities—we inserted the following information block, which was again placed in randomized order among the existing information blocks:

- Changes in the way the Glen Canyon Dam is operated are likely to reduce the economic well being of some of the small ranching and farming communities in the region.
    - Increased costs of electricity will limit the ability of some ranchers and farmers to irrigate crops and maintain livestock
    - These changes may lead to reductions in employment and reduced income for businesses in rural areas that serve ranchers and farmers,
    - As jobs diminish, some of these small rural ranching and farming communities will decline as residents seek employment elsewhere.

Finally, we inserted the following information block into the "two options" referendum facing respondents. As is the case with all other insertions, this one was placed in randomized order along with the existing information blocks. In the example below, "Option 1" is for Changing Dam Operations while "Option 2" is for Continued Dam Operations. This is just illustrative, however, and the reverse could also be the case for some respondents.

Option 1- Changed operations	**Option 2- Continued operations**
Higher and more variable electricity costs for some farmers, ranchers, and individuals living in small western communities. In some of these communities, increased costs could result in lost jobs and increased migration of residents to other areas.	Continued low and stable electricity prices for farmers, ranchers, and individuals living in small western communities. These continued low and stable electricity prices would sustain jobs, supporting populations in small farming and ranching communities.

Table 8 presents the results of the treatment introducing rural Western communities as a value dimension relevant to respondents' preferences for and valuations of dam operations. The rural Western community treatment results are presented alongside the results for the "Two Options Referendum" treatment, which serves as the most appropriate baseline for purposes of comparison.

The results in Table 8 demonstrate that—similar to the treatment including implications for Native American tribes—the rural Western community treatment has an effect on preferences for changing dam operations that is both statistically significant and substantively large. Whereas over two-thirds of respondents in the baseline condition stated that they would vote to change operations—and nearly half of all respondents stated

that they would be willing to pay $25 to do so—less than half of respondents assigned to the rural Western community treatment support changing operations, and only about one-third would pay $25 to do so. Correspondingly, the proportion of respondents who would vote to maintain operations increases from 21 percent in the baseline condition to over 37 percent in the rural Western community treatment; the percentage of respondents who would pay $25 to maintain operations increases from 7 percent in the baseline condition to 16 percent in the rural Western Community treatment. Clearly, introducing the effects on rural Western communities as a value dimension has a substantial effect on respondents' preferences for and valuations of dam operations.

Table 8: Rural Western Community Treatment Results

	Rural Western Community Treatment	Two Options Referendum
Vote to change operations	**49.1%**	**67.8%**
Would pay $25	*33.9%*	*46.9%*
Vote to maintain operations	**37.1%**	**21.3%**
Would pay $25	*16.4%*	*6.9%*
Would not vote	**13.8%**	**11.0%**

7.3 Native American Tribes + Rural Western Communities

Our third and final treatment with additional value considerations introduces the potential effects on both Native American tribes and rural Western communities as value dimensions relevant to respondents' preferences for and valuations of dam operations. In effect, our third treatment combines the potential effects on Native American tribes and rural Western communities into a single treatment. We implement this treatment by exposing respondents to all of the information blocks describing potential effects on Native American and rural Western communities, as described above in subsections 7.1 and 7.2.

Table 9 presents the results of the treatment introducing both Native American tribes and rural Western communities as value dimensions relevant to respondents' preferences for and valuations of dam operations. The results are presented alongside the results for the "Two Options Referendum" treatment, which serves as the most appropriate baseline for purposes of comparison. In addition, for further comparison, the respective results from the treatments for potential effects on Native American tribes and rural Western communities are also presented.

Table 9: Native American + Rural Western Community Treatment Results

	Native American + Rural Western Community Treatment	Two Options Referendum	Native American Treatment	Rural Western Community Treatment
Vote to change operations	**32.4%**	**67.8%**	**49.5%**	**49.1%**
Would pay $25	*21.8%*	*46.9%*	*33.0%*	*33.9*
Vote to maintain operations	**57.1%**	**21.3%**	**39.2%**	**37.1%**
Would pay $25	*30.3%*	*6.9%*	*16.5%*	*16.4%*
Would not vote	**10.5%**	**11.0%**	**11.4%**	**13.8%**

The results in Table 9 demonstrate that combining the Native American and rural Western community treatments has a cumulative effect on preferences for dam operations that is larger than the effect of either treatment by itself. Specifically, Table 9 reveals that less than one-third of respondents assigned to the Native American + rural Western community treatment would vote to change operations, a smaller number than the approximately 50 percent of respondents who would do so when each treatment was presented by itself, and a substantially smaller number than the 68 percent of respondents who would cast such a vote when neither value dimension is introduced. When the Native American and rural Western community treatments are combined, a solid majority of respondents—57 percent—would vote to maintain operations and over 30 percent of respondents would pay $25 to do so; less than one-third of respondents would vote to change operations. The pattern of results shown in Table 9 demonstrates that the inclusion of the value dimensions concerning Native American tribes and rural Western communities operate as complements, rather than substitutes, for one another.

8. Hypothetical Air Emissions Treatment

Changes in the operation of dams with hydropower generators, such as the GCD, have the potential to substantially change levels of harmful air emissions when reduced (increased) quantities of hydropower lead to increased (decreased) demand for electricity generated by burning fossil fuels. Thus, our final experimental treatment is designed to assess how changes in air emissions resulting from changes in dam operations would affect respondents' preferences for and valuations of hydropower. Unlike the Native American and rural Western community treatments, the air emissions treatment is completely hypothetical—the changes currently under consideration for operations of the GCD are unlikely to have the effects we describe in the treatment—but GCD operations provides an ideal context for assessing respondents' preferences for and valuations of the dimension of air quality. Because of the hypothetical nature of the treatment, we do not combine this treatment with the treatments that include effects on Native American tribes or rural Western communities, which were presented in Section 7.

Although this treatment is unlikely to be germane to the changes currently being considered for operations of the GCD, it is relevant to administrative and policy decisions concerning the addition or removal of the generators and/or dams that provide hydropower. This relevance comes from the fact that altering hydropower capacity will likely affect demand for electricity from conventional fossil fuel generators, and the associated levels of air emissions. For example, reducing hydropower capacity will require that electricity be replaced with power from some other source. To the extent that the replacement power comes from electricity generated with fossil fuels, the reduced hydropower capacity will have the net effect of increasing harmful air emissions. Similarly, increasing hydropower capacity will replace power that may otherwise have been generated by fossil fuels and, in doing so, *decrease* harmful air emissions. By gauging how respondents value the "clean air" characteristic of hydropower, the results described in this section are relevant to any decision concerning increasing or decreasing hydropower capacity.

We implement this treatment in much the same way as we did the Native American and rural Western community treatments—we provide respondents with information blocks on

the topic that are placed in randomized order alongside existing information blocks described in Section 6 of this report. Below we detail the specific changes we made to implement our air emissions treatment.

- Changing the purpose of the study presented to respondents from "This study deals with the ways Glen Canyon Dam could be operated to benefit natural and cultural resources in the Study Area" to "This study deals with the ways Glen Canyon Dam could be operated to benefit natural and cultural resources in the Study Area. It also concerns the possible effects of switching from hydropower produced at the dam to electricity produced at conventional power plants using fossil fuels."
- Changing the title of the page presenting the overview of natural resources in the study area from "Natural Resources in the Study Area" to "Natural Resources in the Study Area and Rural Western Communities in the Region."
- Changing the text introducing the natural resources page from "The natural resources in the Study Area are located in and along the Colorado River below Glen Canyon Dam" to "The natural resources in the Study Area are located in and along the Colorado River below Glen Canyon Dam. Many of the small communities that have relied on hydropower from the Glen Canyon Dam are in rural parts of Arizona, Colorado, New Mexico and Utah."
- Changing the title of the page summarizing concerns from "Some People are Concerned About These Resources" to "Some People are Concerned About These Resources and Communities."
- Changing the title of the page describing the effects of changing dam operations from "Scientists have learned that by changing the way water is released from the dam, primarily by reducing the size of daily fluctuations, some of the concerns about the natural resources in the Study Area could be addressed" to "Scientists have learned that by changing the way water is released from the dam, natural resources in the Study Area and residents of the surrounding rural communities could both be affected in a variety of ways."

For the treatment introducing air emissions as a value dimension relevant to respondents' preferences for and valuations of dam operations, we inserted the following information

block—placed in randomized order among existing information blocks—into the page overviewing natural resources in the Study Area:

- For over 50 years, hydropower produced at the Glen Canyon Dam has reduced the need to rely on electricity produced at conventional power plants that use coal, oil or natural gas.
- By replacing fossil fuels, the hydropower produced at the dam has helped reduce air pollution in Colorado, New Mexico, Arizona, and Utah.
- Over the history of the operations of the dam, hydropower has provided electricity without contributing to greenhouse gas emissions that cause the climate to change.

For the page summarizing the concerns that people have about natural resources and communities in the study area, we inserted the following information block, which was again randomized with all existing information blocks:

- For over 50 years, the hydropower produced at the Glen Canyon Dam has reduced reliance on conventional power plants using fossil fuels like coal, oil or natural gas.
    - Reliance on hydropower instead of fossil fuels has reduced air pollution.
    - Reduced air pollution has helped preserve the scenic beauty of the Grand Canyon.
    - Reduced air pollution has helped improve the health of residents in the region, who breathe cleaner air.
    - Using hydropower instead of fossil fuels has resulted in lower overall emissions of greenhouse gases that cause climate change.

On the final page of background information—describing how changing dam operations might affect natural resources and rural communities—we inserted the following information block, which was placed in randomized order among the other information blocks:

- Changes in the way the Glen Canyon Dam is operated will reduce the amount of hydropower produced, leading to greater use of electricity from conventional power plants using coal, oil and natural gas.

- Air quality in the region will decline as pollution from conventional power plants increases.
- The health of the local populations may be negatively affected by the increased air pollution, which contributes to a number of serious diseases.
- Visibility in the Study Area, including the Grand Canyon, may diminish due to increased air pollution.
- Greenhouse gas emissions will increase, as use of hydropower is replaced by use of electricity from burning fossil fuels.
- Adding to the amount of greenhouse gas emissions will contribute to changes in the global climate.

Finally, we inserted the following information block into the "two options" referendum facing respondents. As is the case with all other insertions, this one was placed in randomized order among the other information blocks. In the example below, "Option 1" represents Changing Dam Operations, while "Option 2" represents Continued Dam Operations. This is just illustrative, however, and the reverse could also be the case. The full presentation of this treatment, as seen by survey respondents, is shown in Appendix C.

Option 1- Changed operations	**Option 2- Continued operations**
Increase in the amount of air pollutants, including greenhouse gases, emitted into the atmosphere in the region near the dam. By decreasing air quality, these pollutants will likely negatively affect the visibility in the area near the Grand Canyon, and may have a negative effect on the health of individuals residing in the study area. By increasing the emissions of greenhouse gases, this option has the potential to increase the negative effects of climate change.	Continued decrease in the amount of air pollutants, including greenhouse gases, emitted into the atmosphere in the study area. By continuing to increase air quality, this option will positively affect the scenic beauty of the area, as well as the health of individuals residing in the study area. By continuing to decrease the emissions of greenhouse gases, this option has the potential to decrease the negative effects of climate change.

The results of the air emissions treatment are presented in Table 10 below. We present them alongside the results for the "Two Options Referendum" treatment (see Section 6 of this report), which represent the most appropriate basis for comparison. The results demonstrate that the addition of air emissions considerations substantially decreases support for changing GCD operations. Specifically, only about 37 percent of respondents

would vote to change dam operations, a significant decline from the 68 percent who supported changing operations in the "Two Options Referendum" treatment. In contrast, over half of respondents in the air emissions treatment would vote to maintain operations—compared to only about 21 percent expressing such preferences in the baseline treatment—and over one-quarter of all respondents would pay at least $25 to maintain operations. These results make clear that the non-market effects of hydropower on air emissions is a value dimension highly relevant to any debate over changing hydropower capacity.

Table 10: Hypothetical Air Emissions Treatment Results

	Hypothetical Air Emissions Treatment	Two Options Referendum
Vote to change operations	**36.7%**	**67.8%**
Would pay $25	*22.4%*	*46.9%*
Vote to maintain operations	**51.0%**	**21.3%**
Would pay $25	*27.8%*	*6.9%*
Would not vote	**12.3%**	**11.0%**

We should note that, in application to a non-hypothetical case, the air emissions value dimension should be included *along with* the other important value dimensions as described in Section 7. More generally, a complete account of non-market values for alternative dam operations for any operational scenario will require the inclusion of all of the significant and relevant value dimensions applicable to that scenario.

9. Validity Assessments of Study Results

Prior sections of this report have focused on the effects of the specific study treatments. Here we turn to the overall pattern of expressed preferences for GCD operations, in order to evaluate the possible sources of those preferences. In a study of this kind, the "causes" of preferences cannot be directly discerned, so instead we will focus on the pattern of correlations among the respondents' attributes, beliefs, and values and their stated preferences.

Our analysis focuses on the contribution of an array of respondent characteristics and the expressed preference for changing, or not changing, dam operations. Preferences are captured in two distinct ways:

1. *Continue Ops:* Prefer to retain current dam operations when the cost to the respondent is zero;
2. *WTP to Cont. Ops:* Prefer to retain current dam operations even if the cost is $25 per year in increased taxes (would vote "yes" on advisory referendum)

In each case, those who express the preference are compared to all other respondents who expressed a different preference or who declined to vote.[11] Given that these measures are binary (i.e., coded as "yes=1" and "no=0"), we use a logistic regression model to evaluate the correlates of each of our explanatory variables.

Each model includes as explanatory variables the category measures for each of the experimental treatments used in the study. Thus the effect of each of the treatments, and the statistical significance of the differences in each treatment from the base replication case (Treatment 1), are shown. The model includes the following explanatory variables:

1. *Experimental treatments* (#2 through #7), as defined in Section 3: The specific content of each treatment is shown in full in Appendix C;
2. *Visit GC in the Future*: Using question W15_futvisitgc from the survey (see Appendix B for full question wording), respondents were asked to indicate

[11] All models employ the survey data weighted on gender, region of residence, age, and race/ethnicity to match the national census.

whether they planned to visit the Grand Canyon in the future or not. Responses were coded as 1 for those that said yes, and 0 for those that said no.

3. *Policy Decisions*: Based on the question W18_dona (see Appendix B), this variable measures whether respondents think relying on measures of public opinion on environmental policy choices is "a good way" for government officials to make policy decisions. Responses were coded as 1 for those that said yes, and 0 for those that said no.
4. *Environmentalism Index*: Respondents' beliefs about the state of the environment, using an index comprised of seven different questions from the survey (W24_EP1, W25_EP2, W26_EP3, W27_EP4, W28_EP5, W29_EP10 and W30_EP11). These questions asked respondents to rate their level of environmental concern, perceptions of the extent of environmental damage, views on the robustness of the environment, and beliefs about the resilience of the environment to human activities. The scale ranges from 1 to 5, with a value of 1 indicating a low level of concern and worry about the environment and 5 indicating a high level of worry and concern.[12]
5. *Income*: Respondents' estimates of their annual household in 2013 (based on survey questions W51_inc50 to W54_inc200).
6. *Education*: Respondents' highest level of educational achievement, ranging from elementary or some high school to a doctorate degree (from question W2_edu).
7. *Rural* (vs. Urban and Suburban): A dichotomous measure of whether respondents live in rural areas or urban and suburban areas. Residence in a rural area was coded as 1, and residence in urban or suburban locations was assigned a value of 0 (from question W6_rural).
8. *Hydropower Preference*: Respondents' views on whether hydropower is a preferred way to generate electricity. Respondents were assigned a value of 1 if they viewed hydropower as a preferable source of electricity and 0 if they did not (from question W33_hydro).
9. *Political Ideology*: Respondents' self-placement on a scale of political ideology ranging from strongly liberal (=1) to strongly conservative (=7), based on question W44_ideol.

The logistic regression model results are shown in Table 11. The values in the columns are estimated odds ratios, where a value greater than one indicates that that there is a *positive* relationship between the explanatory variable and the odds of respondents expressing a preference or willingness to pay $25 in higher taxes to maintain dam operations (models 1 and 2, respectively), while a value below one indicates a *negative* relationship. The estimated odds ratios that are statistically significant are so indicated by the asterisks.

[12] The Cronbach's alpha for the index is 0.73.

Table 11: Sources of Operational Preferences and WTP

	Model 1: Continue Operations at No Cost	Model 2: WTP $25 to Continue Operations
Group 2 (vs. Group 1)	0.961	0.307
Group 3 (vs. Group 1)	1.375	2.773+
Group 4 (vs. Group 1)	3.234***	7.117***
Group 5 (vs. Group 1)	2.880***	7.199***
Group 6 (vs. Group 1)	5.696***	13.781***
Group 7 (vs. Group 1)	6.502***	15.255***
Visit GC in Future	1.045	1.499*
Policy Decisions	0.788+	1.507*
Environ. Index	0.689***	0.782*
Income	1.027+	1.017
Education	0.893*	0.977
Rural (vs. Urb & Sub)	1.116	1.317
Hydropower Pref.	1.417**	1.390*
Political Ideology	1.155***	1.059
Intercept	0.516	0.022***
Likelihood-ratio	348.825	285.431
Log-Likelihood	2655.330	1653.750
Number of Cases	2329	2331

Note: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.025$; + $p<0.05$ (for directional, 1-tailed hypothesis tests)

As indicated for respondents from Group 2 (which had the information presented in randomized order), expressed preferences and WTP $25 were not statistically different from the replication case (Group 1). However for Group 3, the difference in WTP $25 for maintaining current dam operation is statistically significant (in a one-tailed hypothesis test). When respondents could choose between the two options, they were significantly more likely to express WTP $25 to maintain dam operations than were those in the replication treatment (Group 1) – who could vote against the proposal but could not vote to pay to maintain current operations.[13]

[13] Another way to understand this finding is to see that, when given the option to choose to maintain current dam operations *and* to pay $25 in taxes to do so, the fraction of respondents choosing that option is significantly greater than zero. This is consistent with the findings described in Section 3.

Group 4 respondents, for whom potential effects of changing dam operations on Native American businesses and communities were described, were estimated to have higher odds of voting to retain current operations (Model 1) and increased odds of expressing WTP $25 per year in additional taxes to retain current operations (Model 2) in comparison to those receiving the replication treatment (Group 1). Similar effects are seen for respondents from Group 5, who saw information about potential effects on rural ranching and farming communities. For respondents in Group 6, the cumulative effect of seeing information about both Native American and rural ranching/farming communities was greater still.

For the final experimental treatment, when respondents were exposed to the hypothetical case in which changing dam operations resulted in increased emissions (Group 7), the odds of voting to maintain current operations, or to pay $25 in increased taxes to do so, were increased significantly relative to the replication case (Group 1). All of these results are consistent with the treatment-by-treatment findings described in Sections 3 through 8 of this report.

Respondent characteristics also proved to be important predictors of preferences for dam operations. These can be summarized as follows:

1. Respondents who indicated that they expected to visit the Grand Canyon in the future (*Visit GC in the Future*) were more likely to be willing to pay $25 to maintain current dam operations – relative to those who did not plan to visit the Canyon in the future. Put differently, those who did not plan to visit the Canyon were less likely to be willing to pay $25 in taxes to maintain current operations.
2. Respondents who thought it was appropriate that policy makers rely on information about public preferences in making environmental policy decisions (*Policy Decisions*) were less likely to vote to maintain current dam operations (Model 1), but were more likely to be willing to pay $25 more in annual taxes to maintain current operations (Model 2). Put differently, those who *did not* believe policy makers should rely on public preference information were less likely to be willing to pay more in taxes to maintain current dam operations.
3. Respondents who scored higher on the environmentalism index (*Environ. Index*) were significantly less likely to vote to maintain current dam operations (Model 1)

and to be willing to pay $25 more in taxes to do so (Model 2) than respondents who scored lower on the environmentalism index.

4. Higher *Income* had the effect of slightly increasing the odds that respondents would vote to maintain current dam operations at zero cost (Model 1). However, higher income respondents were no more likely to vote to increase taxes by $25 per year to maintain current dam operations (Model 2).
5. Higher *Education* levels had the effect of significantly decreasing the odds that respondents would vote to maintain current dam operations (Model 1), but had no effect on the expressed willingness to pay $25 to do so (Model 2).
6. The location of respondents' residences in rural, suburban or urban areas had no statistically significant effect on preferences or WTP $25 for dam operations.
7. Perceptions of hydropower (*Hydropower Prefs*) as a preferable source of electricity significantly increased the odds of preferring to maintain current dam operations (Model 1), and of expressed willingness to pay $25 in additional taxes to do so (Model 2).
8. Respondents who described themselves as more politically conservative (*Political Ideology*) were more likely to vote to maintain current dam operations (Model 1), but were no more likely to be willing to pay $25 to do so (Model 2) than respondents who described themselves as less politically conservative.

Overall, then, the expressed preferences for dam operations, and WTP $25 to achieve those options, were reasonably and consistently related to both the experimental treatments and to respondent attributes and beliefs. Interpretation of these relationships, and the articulation of clear theoretical expectations about them, is complicated by the existence of multiple and sometimes conflicting value considerations that survey respondents must engage when making choices about dam operations. Nevertheless, when addressing the implications of change in major components of complex coupled human and natural systems, as represented by the dams on the Colorado River, analysts must include and account for these kinds of complex choices.

We presented respondents with a fairly large amount of information throughout the course of each treatment, and it is possible that this information provision could have affected respondents' ability to provide valid information in two primary ways. First, it is possible that providing large amounts of information would result in responses that do not reflect

respondents' true preferences and values—there would be large amounts of measurement error. This would have the effect of biasing contrasts across treatments toward zero. As we found statistically significant and substantively large differences across treatments, we do not believe general information overload to be an issue.

Second, and more worrying from an internal validity perspective, it is possible that respondents across the seven treatments were differentially affected by the amount of information provided. We investigated this possibility in two ways. First, on the final page of the survey we included the following text: "Scholars have learned that information often influences the way in which people answer survey questions. With this in mind, we are interested in whether you are taking the time to read the text that precedes each question. So, in order to demonstrate that you have read this text, please ignore the question below and click on the blue dot." The question referenced in the quote above asks respondents to select the type of device on which they took the survey. Instead of doing so, respondents should click a blue dot on the page. Table 12 presents the percentage of respondents that clicked on the blue dot across each of the seven treatments.

Table 12: Analysis of Attention and Effort

Treatment	Percent that clicked on blue dot	Mean number of minutes taken to complete survey
1	31.9%	24.8
2	35.9%	27.0
3	37.5%	26.4
4	37.1%	26.8
5	35.3%	26.2
6	44.7%	27.5
7	41.9%	26.6

As shown in Table 12, there is modest variation in the percentages of respondents across treatments that correctly responded to the instructions in the blue dot question. Formal statistical tests indicate no significant differences in the percentage of respondents that clicked the blue dot across each of the seven treatments, indicating that variations in information load did not differentially dispose respondents to read (or ignore) the information and instructions provided in the survey. Second, as shown in the third column of Table 12, we analyzed the mean number of minutes taken to complete the survey across

each of the seven treatments, and though there were nominal differences in time taken (on average, treatment 6 took 2.7 minutes longer to complete than did treatment 1), we found no statistically significant differences across the treatments. Together, these results allay our concerns about potential bias resulting from differential levels of information provision. The next section summarizes our findings and discusses the implications for analyses of WTP for modifying GCD operations.

10. Summary and Conclusions

As described in Section 2, the Anthropocene epoch is characterized by extensive interactions among natural systems and managed human institutional arrangements. Complex coupled human and natural systems, such as river systems with managed flows intended to produce a mix of ecosystem, energy, water and recreational resources, will necessarily implicate multiple dimensions of societal value. Once a set of institutional arrangements are in place, individuals and communities will adapt (or optimize) to the conditions created by those arrangements. When the larger society places non-market value on the preservation of those communities and the ways of life of their residents, changes in system operations will impose social costs.

This study began as an effort to address the puzzle that prior studies have found a positive, and substantial, willingness to pay to constrain production of hydropower despite evidence that a sizable majority of the public views hydropower in a positive light. After setting out some background context for increasing awareness of the multiple dimensions of non-market values for large coupled human and natural systems, we addressed this puzzle from several directions. Specifically, in the preceding sections of this report we analyzed the effects of variations in the presentation of information, the approach used to structure choices, and the inclusion of additional relevant dimensions of value on expressions of value. These lines of inquiry led to several important results.

First, we found that the traditional presentation of the choice to survey respondents in contingent valuation exercises can bias expression of value. When the survey choice architecture provided respondents with no way to register WTP to avoid the option (as in the replication case), the results were statistically significantly skewed in favor of net WTP to change dam operations. Our analysis suggests that, by structuring alternatives as a single proposal for changing dam operations, prior studies may have over-estimated WTP for changing dam operations. Our alternative approach frames the choice as an alternative between two options, allowing respondents to express a *positive value* for maintaining dam operations. Even when we replicated the information and considerations used in the Welsh

et al. (1995) study, a significant percentage of our respondents expressed a willingness to pay to keep dam operations unchanged. These kinds of "negative values" for changing dam operations had not been accounted for in prior estimations of WTP.

Second, our analysis makes clear that the inclusion of several previously omitted dimensions of social value—including effects of changing (or not changing) dam operations on Native American tribes, rural Western communities, and hypothetical levels of air emissions—is important for fully capturing non-market values. We showed that these additional dimensions of value are relevant to public non-market value expressions regarding dam operations, and thus to expected estimates of WTP for the effects of changing operations. Relative to a baseline case where they are excluded, including information about the potential effects of changing dam operations on Native American tribes, rural Western communities, and air quality significantly and substantially decreases WTP for changing GCD operations. In fact, the results suggest that there may be a significant fraction of the population with a *positive* WTP for maintaining dam operations, a result at odds with previous research on the issue, but fully consistent with the public's overwhelmingly positive view of hydropower.

Models of the relationships between individual attributes and beliefs shown in Section 9 demonstrate that the expressions of value obtained from survey respondents are reasonable and plausible, and are consistent with an account of choice in which individuals are forced to trade off important dimensions of value. In short, the findings provide a reasonable and theoretically consistent account of non-use value expression for non-rejectable goods when changes in complex institutional arrangements are being considered.

In sum, when accounting for the broad range of social values that are affected by the management of the GCD, our pilot study demonstrates that public willingness to pay for changes in dam operations is more complex than has been portrayed in earlier CV studies. One implication is that prior measures of non-market and non-use values for changes in the operation of the GCD may have substantially over-estimated public WTP for such changes. A broader implication is that the characterization and measurement of non-market values for hydropower operations, and for the operation of the systems of generators on dams in major U.S. rivers, will require an approach that recognizes that these operations constitute

sets of institutional arrangements to which communities and individuals have adapted. Changes in these institutional arrangements may disrupt communities, their ways of life, and may therefore engage societal non-market values in ways not captured in traditional studies. Thus, if policy makers are to take into account fairness and the social externalities associated with those communities that have adapted to existing institutional arrangements of management of modern rivers, a more balanced and inclusive approach to measurement of non-market values is required.

Appendix A: Survey Data Collection

This study is based on a nationwide Internet sample of 2,465 respondents from the 48 contiguous states conducted April 22-24, 2014.

Background. Technological developments and telecommunications trends, such as the declining number of wired phones, the increasing use of cellular phones, and the continuing expansion of high speed Internet services, have made probabilistic (often referred to as "random") sampling of the U.S. national population for the administration of lengthy surveys on complex issues infeasible for several reasons.

- The total universe of households without phone service of any kind is unknown.
- The wired telephone system no longer includes a sufficient number of U.S. households to represent the national population, and members of households that do have wired service differ systematically from households without wired phones.
- The number of households with wired phones that are used almost exclusively for other than routine phone calls, such as home alarms or medical alert services, is unknown.
- The numbers of individuals and households having both a wired phone and a cell phone or those having more than one cell phone are unknown.
- The number of households and individuals having access to Internet service suitable for taking Internet surveys is unknown.
- The numbers of individuals who have access to Internet services from their place of employment is unknown, and of those, the number of individuals who are allowed to take surveys while at work is unknown.
- Cellular telephones are unsuitable for lengthy surveys that may distract respondents who are otherwise occupied, and surveys conducted using cell phones may incur costs to prospective respondents that discourage survey participation.
- Face-to-face interviews or printed postal surveys of the U.S. general public require long collection periods and are prohibitively expensive for many research projects.

Increasingly, academic-quality opinion survey research of the U.S. public on complex subjects, such as privacy and security, is being conducted via the Internet. These factors present special challenges for probabilistic sampling because insufficient information

exists about rapidly evolving telecommunication patterns, Internet accessibility, and the demographic composition of those who have suitable Internet access.

With increasing Internet access, the demographics of the online population are becoming more representative of the U.S. population as a whole, but samples recruited to participate in Internet surveys cannot be truly random samples of the U.S. public. All surveys, regardless of collection methods, include an element of self-selection because even if a perfectly random sample could be constructed, the final decision to participate must be made voluntarily by each respondent, and thus some degree of self-selection is unavoidable. This means that even when derived from a theoretically perfectly random sample, the demographic characteristics of survey respondents may not perfectly reflect U.S. population parameters. Non-probabilistic samples, such as those used to administer surveys of the general public via the Internet, involve greater degrees of self-selection because participants first voluntarily agree to enter a pool or stream of citizens willing to take surveys online, and then each member of that group who attempts to take an online survey must decide whether or not to participate in a given survey opportunity. This requires the administration of Internet surveys that are as demographically representative as possible, careful weighting of the sample to match U.S. Census characteristics, and it warrants caution in presenting findings as statistically representative of views of the entire adult U.S. population.

Sampling. Sampling for this survey was accomplished by Survey Sampling International (SSI) using a proprietary methodology known as Dynamix, which provides direct access to millions of potential survey respondents, including members of 34 standing panels plus a variety of online communities, social media, and affiliate partnerships to build a constantly evolving stream of potential survey participants. Prospective survey respondents access SSI's website directly or through trusted partnerships or via social media or numerous other Internet portals where invitations are posted to maximize diversity. Each individual is screened and dynamically profiled. Rather than being sampled for specific individual surveys, respondents are offered one of various available projects for which they qualify at the time they choose to participate in a survey. This increases the probability of survey engagement, reduces dropout rates, and allows prospects to take a survey at a time of their convenience.

If certain demographic categories are underrepresented during the dynamic sampling process, email invitations are employed to bring the sample into balance with key population parameters. Assuming a sample size of 1,000, the sample frame and selection process would achieve comparable results within a + 3 percent range 19 times out of 20. Security checks and quality verifications are used on all sources before respondents can begin any survey. All external sources undergo a partner verification process that scores individuals based on a series of quality control checkpoints, including digital fingerprinting to prevent duplication, spot checking via third party verification to prove identity, benchmarking against known external data points, and an algorithm that dynamically monitors the sample on a number of personality and psychographic measures.

A variety of incentives from SSI or from affiliate organizations are employed based on the nature and length of surveys and progress of the dynamic sampling process. This sampling process broadens access beyond standing panel memberships by including individuals who are not interested in joining a research panel and who may only rarely choose to participate in online survey research. It does not limit the sampling process to one or a few sample sources, one or a few modes of contact, or a single selection method.

But regardless of its advantages, neither Dynamix nor any other Internet sampling methodology provides a probabilistic sample that can be represented as truly random. While the possibilities of systematic bias can be reduced to minimum levels that allow replication of survey findings, they cannot be eliminated entirely. One source of systematic bias that can be minimized is demographic representativeness.

Sample Weighting. To assure that the sample matched the most recent Census estimates as closely as possible, we weighted the data. The weighting process involves three related steps. The first step is to calculate for each survey respondent the proportion of the U.S. population for the survey year that shares the same demographic characteristics of gender, age, race, ethnicity, and census region as the respondent. The second step is to calculate the proportion of fellow survey participants who share the same demographic characteristics as the respondent being weighted. Finally, the

proportion of the general population sharing those demographic attributes is divided by the proportion of survey respondents sharing those same characteristics. The result is a weight factor that can be applied to responses from that individual survey participant to adjust them to general population characteristics. A weight value of one means that responses from a specified participant are used without adjustment. A weight value greater than one means that a participant with a given set of demographic attributes is underrepresented in the survey sample (relative to the general population), and responses from that participant receive greater statistical emphasis than responses from survey participants who are represented in direct proportion to the general population. Conversely, a weight value smaller than one means that a respondent having a given set of demographic attributes is overrepresented in the survey sample (relative to the general population), and responses from that participant receive less emphasis than fellow respondents who are represented in direct proportion to the general population. We calculated weight factors to six decimal places.

Demographic Representativeness. Table A1 compares key national and regional population parameters to the demographic weighted characteristics of respondents to this survey. Notice that, after weighting, educational attainment was higher among our respondents than for the national population as a whole. But overall, the weighted demographic attributes of respondents to this survey have a high level of comparability to national population demographics.

Table A 1: Demographic Representativeness of Respondents (Weighted)

Demographic Category	% U.S. Population (Ages 18+)	% Survey
Gender[14]		
Women	51.4	50.7
Men	48.6	49.3
Age[15]		
18–29	22.0	21.3
30–49	34.6	35.8
50 and above	43.4	42.8
Education[16]		
High School Graduate or higher	86.8	98.1
Bachelor's Degree or higher	28.2	47.5
Ethnicity[17]		
Hispanic	14.8	13.8
Non-Hispanic	85.2	86.4
Race[18]		
White alone	79.3	80.2
Black or African American alone	12.5	11.4
American Indian / Alaska Native alone	1.1	0.3
Asian alone	5.2	4.8
Native Hawaiian or other Pacific Islander alone	0.2	>0.1
Two or more races	1.7	2.7
Household Income[19]		
$0–49,999	48.6	51.8
$50–99,999	29.9	32.9
$100–199,999	17.0	10.1
$200,000 or more	4.6	5.1

Data Collection. For the protection of participants, both the survey questions and the survey protocol were approved by the Institutional Review Board of the University of Oklahoma. The instrument was programmed to allow the survey to be self-administered

[14] U.S. Census Bureau 2013a.
[15] Ibid.
[16] U.S. Census Bureau 2013b.
[17] U.S. Census Bureau 2013a.
[18] Ibid.
[19] U.S. Census Bureau 2012.

at the preferred time and pace of each respondent within clearly defined time constraints. To afford continuity of attention and to make best use of factual information provided to each respondent during the course of the survey, a maximum of 45 minutes was allowed for completion of any single Web page in the survey (typically containing one to three survey questions), and a maximum total elapsed time of two hours from start to finish was allowed to complete the survey. Average completion time was 27.8 minutes. Participation was restricted only to individuals 18 years of age or above. Each respondent who completed the survey received points credited by SSI or incentives from affiliates equal to a five dollar stipend. Decisions to participate were entirely voluntary.

Appendix B: Frequency Report and Data Summary

W1_age: How old are you?

	Mean
WATER SURVEY 2014	46.1

W2_edu: What is the highest level of education you have COMPLETED?

WATER SURVEY 2014	%
1-Elementary or some high school	1.9
2-High school graduate/GED	17.8
3-Some college/vocational school	32.8
4-College graduate	28.2
5-Some graduate work	4.4
6-Master's degree	11.2
7-Doctorate (of any type)	2.4
8-Other degree [verbatim]	1.3

W3_gend: Are you male or female?

	Female	Male
%	0	1
WATER SURVEY 2014	50.7	49.3

W6_rural: Which of the following categories best describes the location of your primary residence?

WATER SURVEY 2014	%
1-Urban	35.5
2-Suburban	47.9
3-Rural	16.6

W6_oldvote: Think about a situation in which you had the opportunity to vote on this proposal. If passage of this proposal would not cost you anything would you support this proposal? [Asked only of Groups 1 and 2]

	No	Yes	I would choose not to vote on this proposal
%	1	2	3
Group 1	17.2	70.6	12.3
Group 2	17.2	71.0	11.8

W7_newvote: Think about a situation in which you had an opportunity to vote for Option 1 or Option 2. Keeping in mind all of the potential effects described for each option above, and if adoption of either option would not cost you anything, would you vote for Option 1 or Option 2? [Asked only of Groups 3-7]

%	Maintain 1	Change 2	I would choose not to vote on either option 3
Group 3	21.3	67.8	11.0
Group 4	39.2	49.5	11.4
Group 5	37.1	49.1	13.8
Group 6	51.0	36.7	12.3
Group 7	57.1	32.4	10.5

W8_cv: Would you vote for this proposal/option [Groups 1 and 2 get "proposal". Groups 3-7 get "option"] if adoption of this option would cost your household $_25_ in increased taxes **every year** for the foreseeable future? [Groups 1 and 2 voted to change dam operations or not]

%	Definitely No 1	Probably No 2	Not sure 3	Probably Yes 4	Definitely Yes 5
Group 1	14.6	18.1	20.8	33.3	13.2
Group 2	17.3	16.5	23.7	30.2	12.2

[Groups 3-7 voted for one of two options – change dam operations or retain current operations]

%	Definitely No 1	Probably No 2	Not sure 3	Probably Yes 4	Definitely Yes 5
Group 3-7 Respondents Who Originally Voted to Maintain Dam Operations					
Group 3	12.3	22.9	32.3	29.2	3.2
Group 4	9.7	30.2	18.1	36.0	6.1
Group 5	13.8	16.1	25.9	33.4	10.8
Group 6	6.1	13.5	25.8	36.5	18.2
Group 7	12.2	13.1	21.3	47.0	6.5

%	Definitely No 1	Probably No 2	Not sure 3	Probably Yes 4	Definitely Yes 5
Group 3-7 Respondents Who Originally Voted to Change Dam Operations					
Group 3	5.5	12.4	12.9	52.7	16.6
Group 4	4.7	12.9	15.7	44.5	22.3
Group 5	3.2	4.6	23.3	50.3	18.7
Group 6	5.8	7.5	25.6	44.3	16.9
Group 7	2.1	5.8	23.8	57.9	10.4

W11_tax: Do you believe your taxes will increase if this proposal/option [Groups 1 and 2 get "proposal". Groups 3-7 get "option"] passes?

%	No 0	Yes 1
WATER SURVEY 2014	25.4	74.6

W12_consider: Do you think public officials will consider the results of this study, along with other evidence, in deciding how Glen Canyon Dam should be operated in the future?

	No	Yes
%	0	1
WATER SURVEY 2014	41.0	59.0

W13_should: Do you think that public officials should consider the results of this study, along with other evidence, in deciding how Glen Canyon Dam should be operated in the future?

	No	Yes
%	0	1
WATER SURVEY 2014	5.7	94.3

W14_visirgc: Have you ever been to the Grand Canyon?

	No	Yes
%	0	1
WATER SURVEY 2014	61.0	39.0

W15_futvisitgc: Do you plan to visit the Grand Canyon in the future?

	No	Yes
%	0	1
WATER SURVEY 2014	29.0	71.0

W18_dona: Is this a good way for government officials to make policy choices about options to address environmental problems?

	No	Yes
%	0	1
WATER SURVEY 2014	24.6	75.4

W24_EP1: The so-called "ecological crisis" facing humankind has been greatly exaggerated.

	Strongly Disagree				Strongly Agree
	1	2	3	4	5
WATER SURVEY 2014	28.1	24.8	24.6	13.4	9.1

W25_EP2: Humans will eventually learn enough about how nature works to be able to control it.

	Strongly Disagree				Strongly Agree
	1	2	3	4	5
WATER SURVEY 2014	21.6	26.1	30.9	14.7	6.8

W26_EP3: Humans are severely abusing the environment.

	Strongly Disagree 1	2	3	4	Strongly Agree 5
WATER SURVEY 2014	3.7	5.5	18.0	31.3	41.4

W27_EP4: Humans were meant to rule over the rest of nature.

	Strongly Disagree 1	2	3	4	Strongly Agree 5
WATER SURVEY 2014	32.8	20.8	25.7	11.7	9.0

W28_EP5: When humans interfere with nature it often produces disastrous consequences.

	Strongly Disagree 1	2	3	4	Strongly Agree 5
WATER SURVEY 2014	2.4	5.3	22.4	35.5	34.5

W29_EP10: We are approaching the limit of the number of people the earth can support.

	Strongly Disagree 1	2	3	4	Strongly Agree 5
WATER SURVEY 2014	11.9	14.1	29.9	25.8	18.4

W30_EP11: The balance of nature is strong enough to cope with the impacts of modern industrial nations.

	Strongly Disagree 1	2	3	4	Strongly Agree 5
WATER SURVEY 2014	24.7	31.2	26.5	12.1	5.4

W33_hydro: Electricity from hydropower using dams

%	Preferable 9	Not Preferable 10	NA
W33_hydro_prf	56.9	9.3	33.8

W44_ideol: On a scale of political ideology, individuals can be arranged from strongly liberal to strongly conservative. Which of the following categories best describes your views?

%	Strongly liberal 1	2	3	Middle of the road 4	5	6	Strongly conservative 7
WATER SURVEY 2014	7.4	14.4	11.8	34.3	12.6	13.7	5.9

W45_Hisp: Do you consider yourself to be Hispanic, Latino, or Spanish or to have Hispanic, Latino, or Spanish origins?

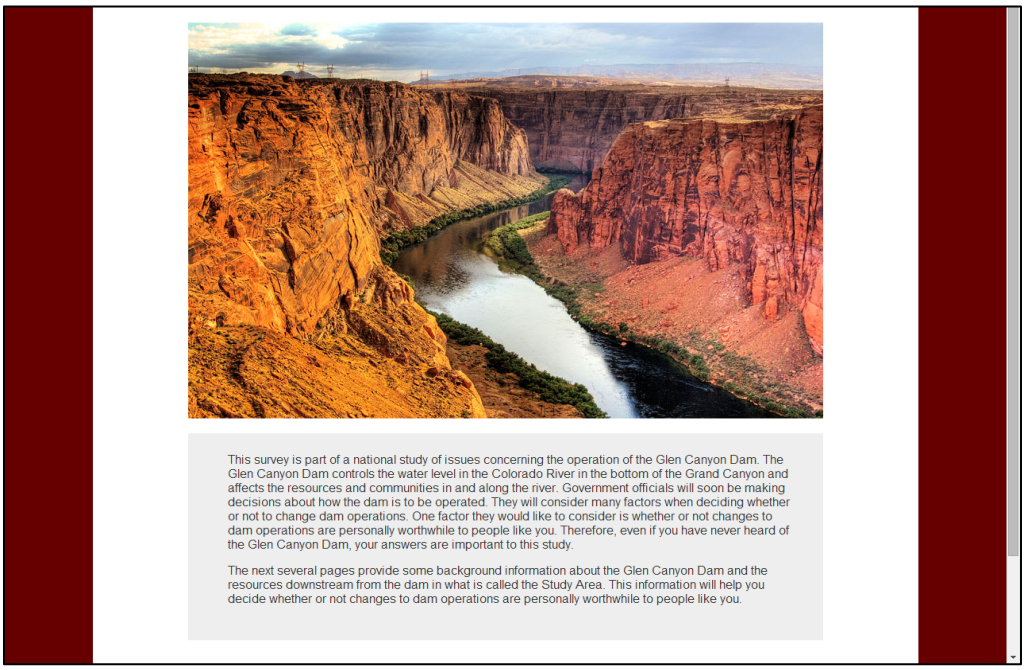
%	No 0	Yes 1
WATER SURVEY 2014	86.4	13.6

W46_race: Which of the following best describes your race?

WATER SURVEY 2014	%
1-White	80.2
2-Black, African American, or Negro	11.4
3-American Indian or Alaska Native	0.3
4-Asian	4.8
5-Native Hawaiian or Pacific Islander	0.0
6-Two or more races	0.8
7-Some other race (please specify)	2.7

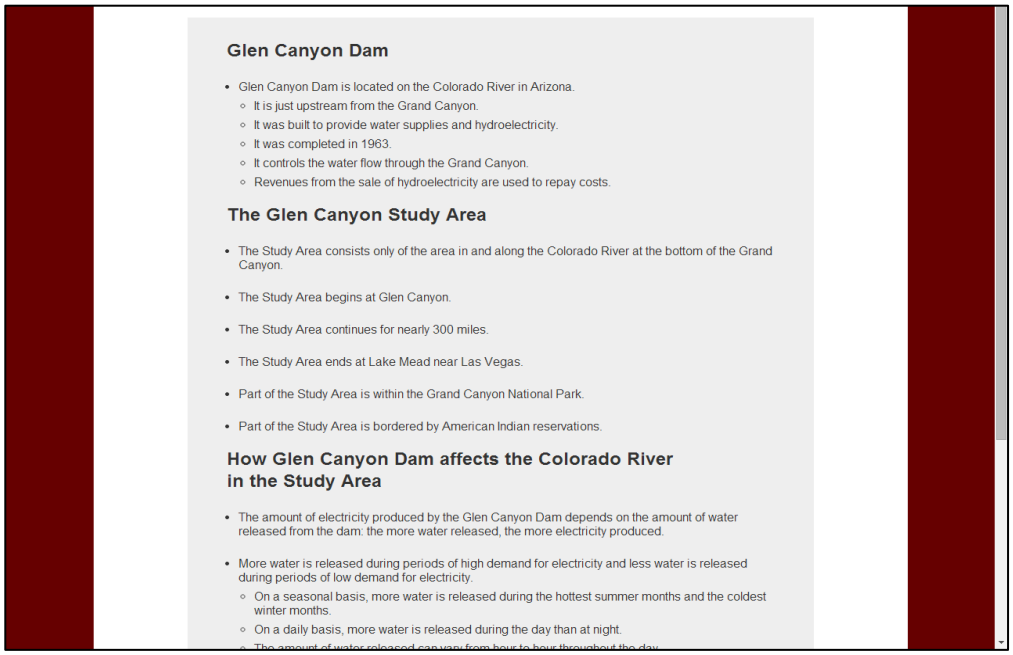
Appendix C: Experimental Survey Treatments

Treatment 1- Replication Treatment



This survey is part of a national study of issues concerning the operation of the Glen Canyon Dam. The Glen Canyon Dam controls the water level in the Colorado River in the bottom of the Grand Canyon and affects the resources and communities in and along the river. Government officials will soon be making decisions about how the dam is to be operated. They will consider many factors when deciding whether or not to change dam operations. One factor they would like to consider is whether or not changes to dam operations are personally worthwhile to people like you. Therefore, even if you have never heard of the Glen Canyon Dam, your answers are important to this study.

The next several pages provide some background information about the Glen Canyon Dam and the resources downstream from the dam in what is called the Study Area. This information will help you decide whether or not changes to dam operations are personally worthwhile to people like you.



Glen Canyon Dam

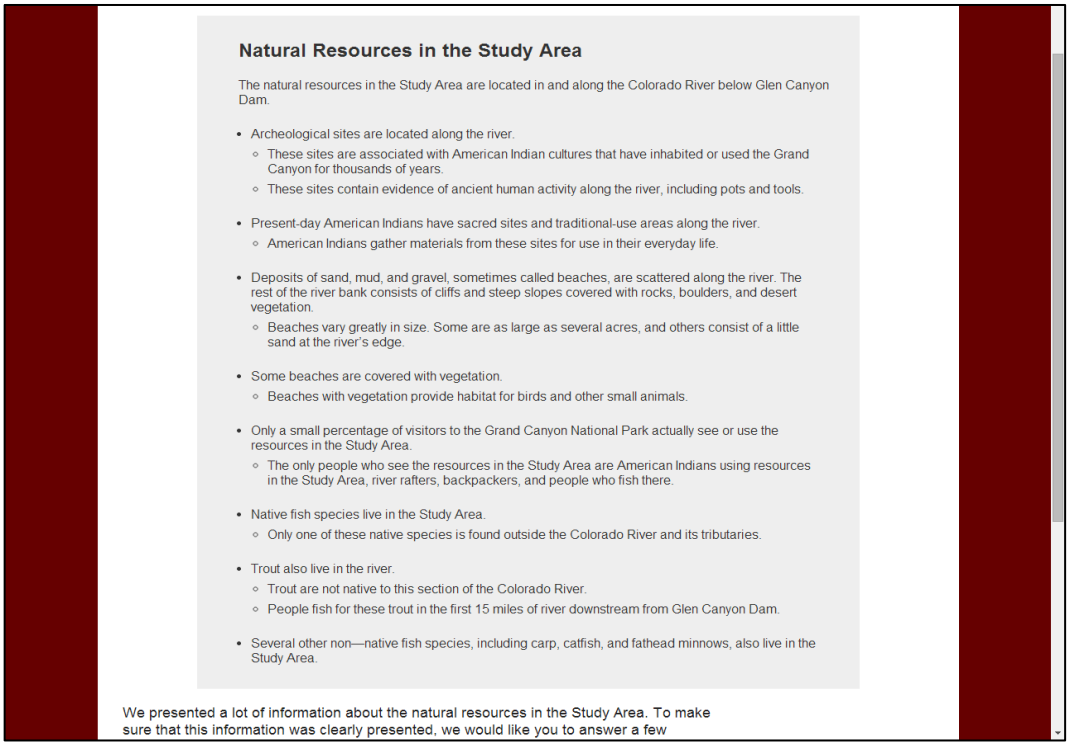
- Glen Canyon Dam is located on the Colorado River in Arizona.
  - It is just upstream from the Grand Canyon.
  - It was built to provide water supplies and hydroelectricity.
  - It was completed in 1963.
  - It controls the water flow through the Grand Canyon.
  - Revenues from the sale of hydroelectricity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

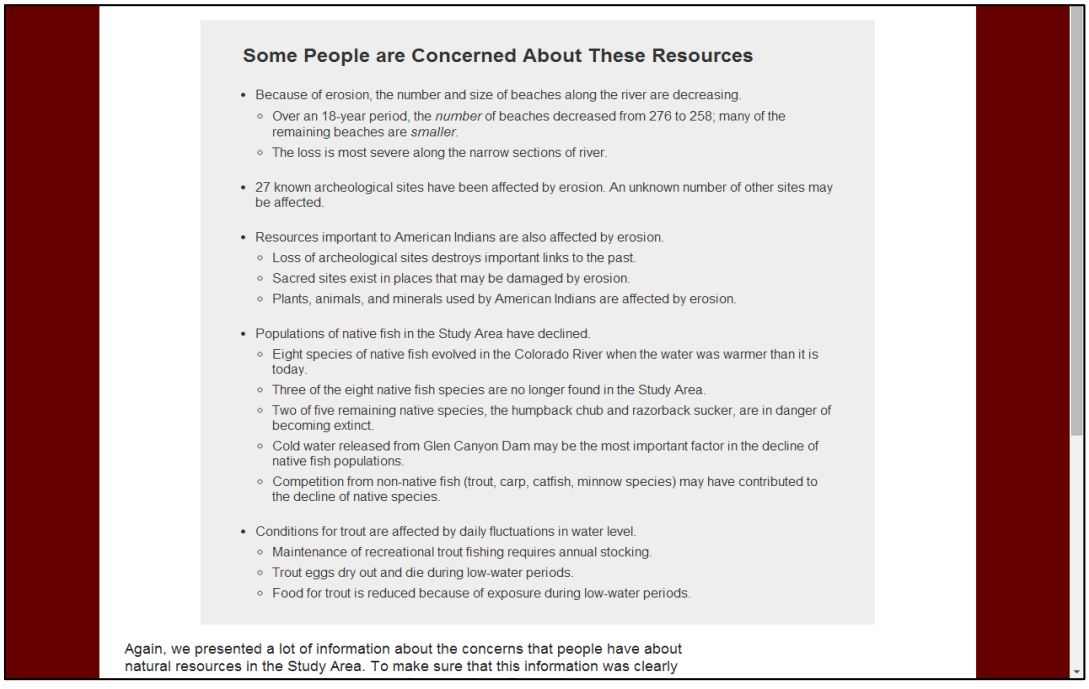
The Glen Canyon Study Area

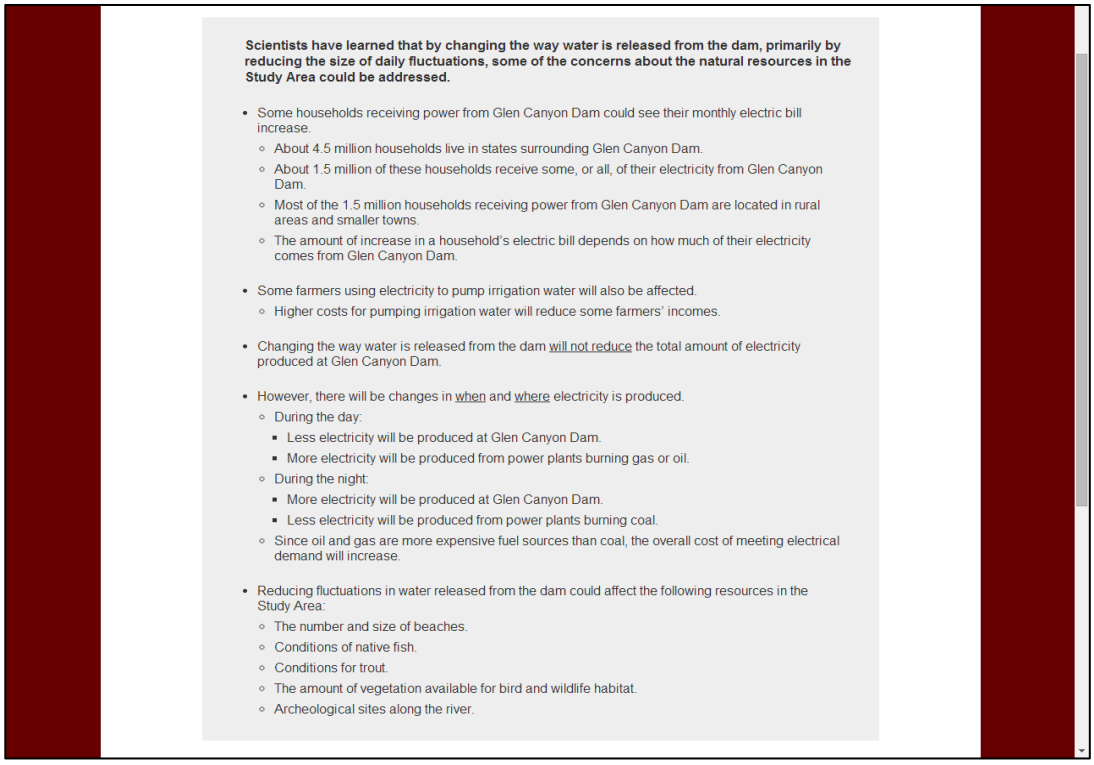
- The Study Area consists only of the area in and along the Colorado River at the bottom of the Grand Canyon.
- The Study Area begins at Glen Canyon.
- The Study Area continues for nearly 300 miles.
- The Study Area ends at Lake Mead near Las Vegas.
- Part of the Study Area is within the Grand Canyon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

How Glen Canyon Dam affects the Colorado River in the Study Area

- The amount of electricity produced by the 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.
  - The amount of water released can vary from hour to hour throughout the day.

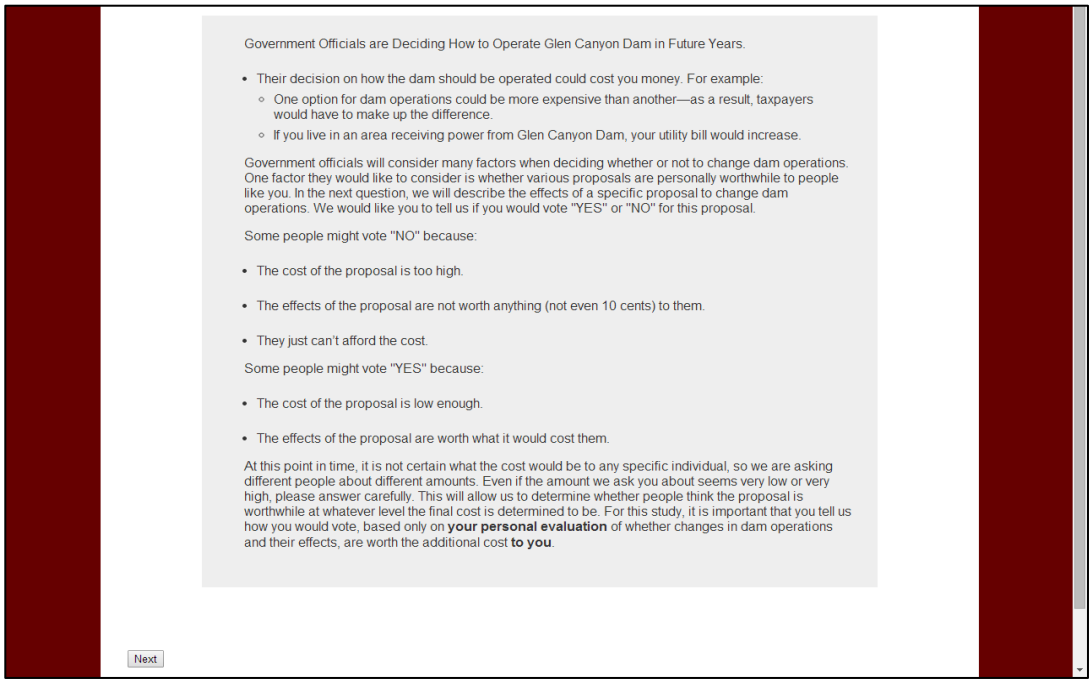

Natural Resources in the Study Area
The natural resources in the Study Area are located in and along the Colorado River below Glen Canyon Dam.
• Archeological sites are located along the river.
◦ These sites are associated with American Indian cultures that have inhabited or used the Grand Canyon for thousands of years.
◦ These sites contain evidence of ancient human activity along the river, including pots and tools.
• Present-day American Indians have sacred sites and traditional-use areas along the river.
◦ American Indians gather materials from these sites for use in their everyday life.
• Deposits of sand, mud, and gravel, sometimes called beaches, are scattered along the river. The rest of the river bank consists of cliffs and steep slopes covered with rocks, boulders, and desert vegetation.
◦ Beaches vary greatly in size. Some are as large as several acres, and others consist of a little sand at the river's edge.
• Some beaches are covered with vegetation.
◦ Beaches with vegetation provide habitat for birds and other small animals.
• Only a small percentage of visitors to the Grand Canyon National Park actually see or use the resources in the Study Area.
◦ The only people who see the resources in the Study Area are American Indians using resources in the Study Area, river rafters, backpackers, and people who fish there.
• Native fish species live in the Study Area.
◦ Only one of these native species is found outside the Colorado River and its tributaries.
• Trout also live in the river.
◦ Trout are not native to this section of the Colorado River.
◦ People fish for these trout in the first 15 miles of river downstream from Glen Canyon Dam.
• Several other non—native fish species, including carp, catfish, and fathead minnows, also live in the Study Area.
We presented a lot of information about the natural resources in the Study Area. To make sure that this information was clearly presented, we would like you to answer a few


Some People are Concerned About These Resources
• Because of erosion, the number and size of beaches along the river are decreasing.
◦ Over an 18-year period, the *number* of beaches decreased from 276 to 258; many of the remaining beaches are *smaller*.
◦ The loss is most severe along the narrow sections of river.
• 27 known archeological sites have been affected by erosion. An unknown number of other sites may be affected.
• Resources important to American Indians are also affected by erosion.
◦ Loss of archeological sites destroys important links to the past.
◦ Sacred sites exist in places that may be damaged by erosion.
◦ Plants, animals, and minerals used by American Indians are affected by erosion.
• Populations of native fish in the Study Area have declined.
◦ Eight species of native fish evolved in the Colorado River when the water was warmer 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.
◦ Cold water released from Glen Canyon Dam may be the most important factor in the decline of native fish populations.
◦ Competition from non-native fish (trout, carp, catfish, minnow species) may have contributed to the decline of native species.
• Conditions for trout are affected by daily fluctuations in water level.
◦ Maintenance of recreational trout fishing requires annual stocking.
◦ Trout eggs dry out and die during low-water periods.
◦ Food for trout is reduced because of exposure during low-water periods.
Again, we presented a lot of information about the concerns that people have about natural resources in the Study Area. To make sure that this information was clearly



Scientists have learned that by changing the way water is released from the dam, primarily by reducing the size of daily fluctuations, some of the concerns about the natural resources in the Study Area could be addressed.

- Some households receiving power from Glen Canyon Dam could see their monthly electric bill increase.
  - About 4.5 million households live in states surrounding Glen Canyon Dam.
  - About 1.5 million of these households receive some, or all, of their electricity from Glen Canyon Dam.
  - Most of the 1.5 million households receiving power from Glen Canyon Dam are located in rural areas and smaller towns.
  - The amount of increase in a household's electric bill depends on how much of their electricity comes from Glen Canyon Dam.
- Some farmers using electricity to pump irrigation water will also be affected.
  - Higher costs for pumping irrigation water will reduce some farmers' incomes.
- Changing the way water is released from the dam will not reduce the total amount of electricity produced at Glen Canyon Dam.
- However, there will be changes in when and where electricity is produced.
  - During the day:
    - Less electricity will be produced at Glen Canyon Dam.
    - More electricity will be produced from power plants burning gas or oil.
  - During the night:
    - More electricity will be produced at Glen Canyon Dam.
    - Less electricity will be produced from power plants burning coal.
  - Since oil and gas are more expensive fuel sources than coal, the overall cost of meeting electrical demand will increase.
- Reducing fluctuations in water released from the dam could affect the following resources in the Study Area:
  - The number and size of beaches.
  - Conditions of native fish.
  - Conditions for trout.
  - The amount of vegetation available for bird and wildlife habitat.
  - Archeological sites along the river.



Government Officials are Deciding How to Operate Glen Canyon Dam in Future Years.

- Their decision on how the dam should be operated could cost you money. For example:
  - One option for dam operations could be more expensive than another—as a result, taxpayers would have to make up the difference.
  - If you live in an area receiving power from Glen Canyon Dam, your utility bill would increase.

Government officials will consider many factors when deciding whether or not to change dam operations. One factor they would like to consider is whether various proposals are personally worthwhile to people like you. In the next question, we will describe the effects of a specific proposal to change dam operations. We would like you to tell us if you would vote "YES" or "NO" for this proposal.

Some people might vote "NO" because:

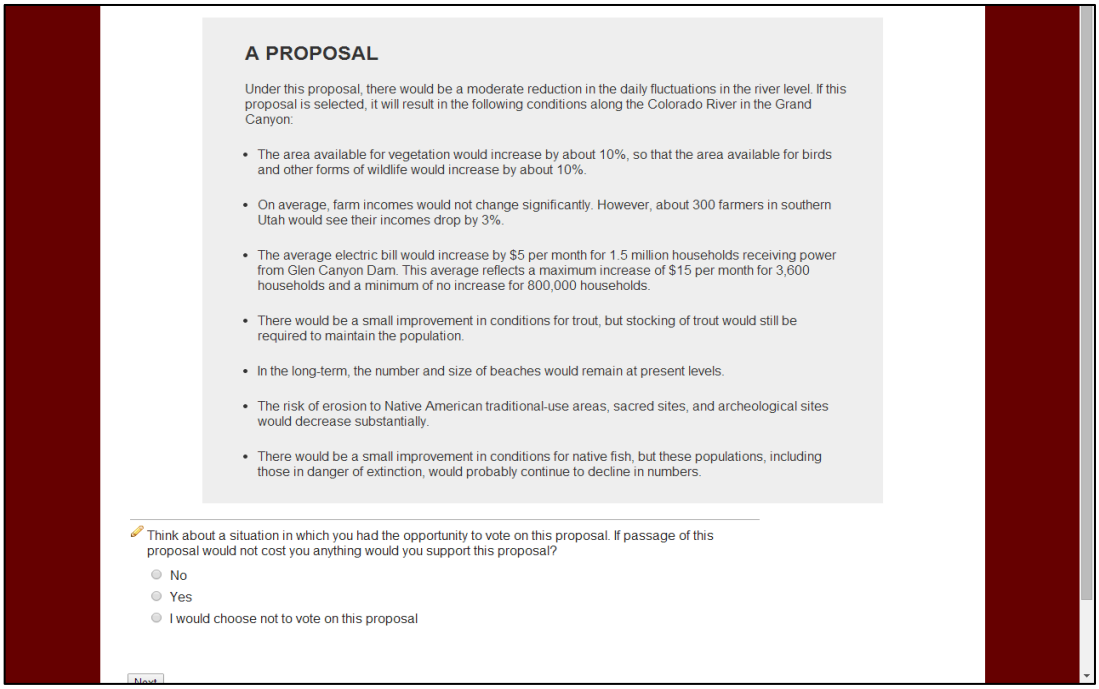
- The cost of the proposal is too high.
- The effects of the proposal are not worth anything (not even 10 cents) to them.
- They just can't afford the cost.

Some people might vote "YES" because:

- The cost of the proposal is low enough.
- The effects of the proposal are worth what it would cost them.

At this point in time, it is not certain what the cost would be to any specific individual, so we are asking different people about different amounts. Even if the amount we ask you about seems very low or very high, please answer carefully. This will allow us to determine whether people think the proposal is worthwhile at whatever level the final cost is determined to be. For this study, it is important that you tell us how you would vote, based only on **your personal evaluation** of whether changes in dam operations and their effects, are worth the additional cost **to you**.

Next



A PROPOSAL

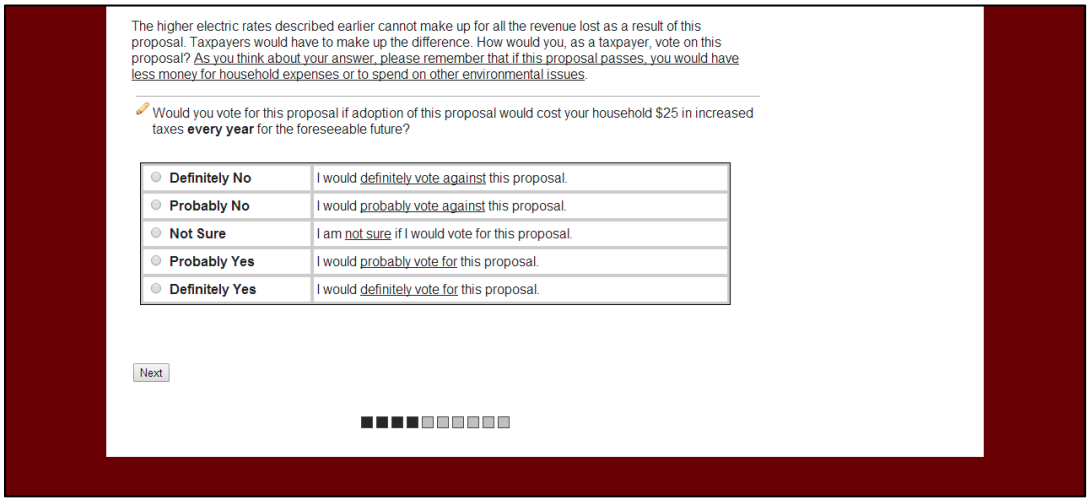
Under this proposal, there would be a moderate reduction in the daily fluctuations in the river level. If this proposal is selected, it will result in the following conditions along the Colorado River in the Grand Canyon:

- The area available for vegetation would increase by about 10%, so that the area available for birds and other forms of wildlife would increase by about 10%.
- On average, farm incomes would not change significantly. However, about 300 farmers in southern Utah would see their incomes drop by 3%.
- The average electric bill would increase by $5 per month for 1.5 million households receiving power from Glen Canyon Dam. This average reflects a maximum increase of $15 per month for 3,600 households and a minimum of no increase for 800,000 households.
- There would be a small improvement in conditions for trout, but stocking of trout would still be required to maintain the population.
- In the long-term, the number and size of beaches would remain at present levels.
- The risk of erosion to Native American traditional-use areas, sacred sites, and archeological sites would decrease substantially.
- There would be a small improvement in conditions for native fish, but these populations, including those in danger of extinction, would probably continue to decline in numbers.

Think about a situation in which you had the opportunity to vote on this proposal. If passage of this proposal would not cost you anything would you support this proposal?

- No
- Yes
- I would choose not to vote on this proposal

Next



The higher electric rates described earlier cannot make up for all the revenue lost as a result of this proposal. Taxpayers would have to make up the difference. How would you, as a taxpayer, vote on this proposal? As you think about your answer, please remember that if this proposal passes, you would have less money for household expenses or to spend on other environmental issues.

Would you vote for this proposal if adoption of this proposal would cost your household $25 in increased taxes **every year** for the foreseeable future?

Definitely No	I would definitely vote against this proposal.
Probably No	I would probably vote against this proposal.
Not Sure	I am not sure if I would vote for this proposal.
Probably Yes	I would probably vote for this proposal.
Definitely Yes	I would definitely vote for this proposal.

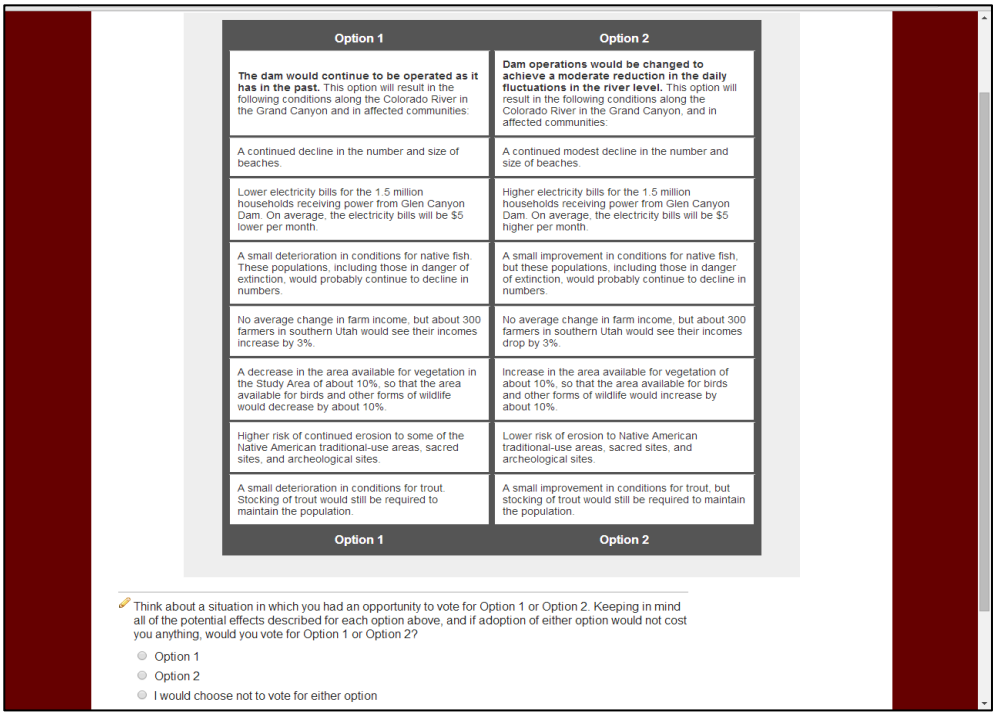
Next

Treatment 2- Randomized Information Treatment

This treatment is identical to the replication treatment, but information blocks and proposal bullets were presented in randomized order. Therefore the images are not shown here.

Treatment 3- Two Options Treatment.

This treatment is identical to the Randomized Information Treatment, but we replace the "Proposal" image and wording with the following:

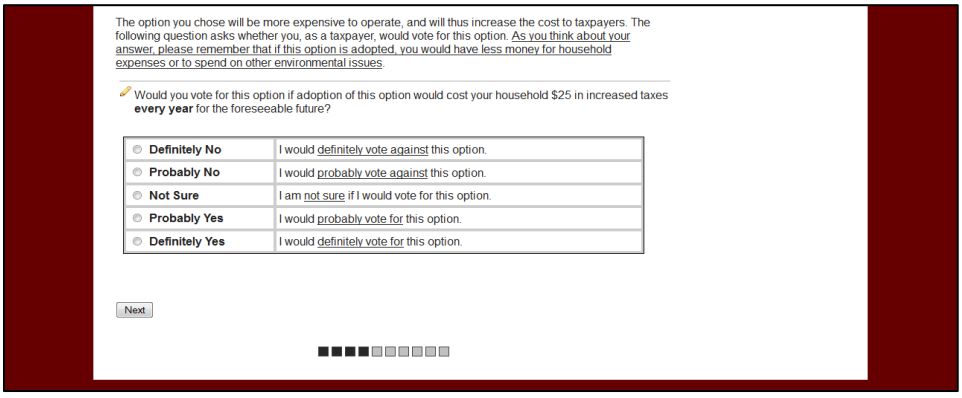


Option 1	Option 2
The dam would continue to be operated as it has in the past. This option will result in the following conditions along the Colorado River in the Grand Canyon and in affected communities:	**Dam operations would be changed to achieve a moderate reduction in the daily fluctuations in the river level.** This option will result in the following conditions along the Colorado River in the Grand Canyon, and in affected communities:
A continued decline in the number and size of beaches.	A continued modest decline in the number and size of beaches.
Lower electricity bills for the 1.5 million households receiving power from Glen Canyon Dam. On average, the electricity bills will be $5 lower per month.	Higher electricity bills for the 1.5 million households receiving power from Glen Canyon Dam. On average, the electricity bills will be $5 higher per month.
A small deterioration in conditions for native fish. These populations, including those in danger of extinction, would probably continue to decline in numbers.	A small improvement in conditions for native fish, but these populations, including those in danger of extinction, would probably continue to decline in numbers.
No average change in farm income, but about 300 farmers in southern Utah would see their incomes increase by 3%.	No average change in farm income, but about 300 farmers in southern Utah would see their incomes drop by 3%.
A decrease in the area available for vegetation in the Study Area of about 10%, so that the area available for birds and other forms of wildlife would decrease by about 10%.	Increase in the area available for vegetation of about 10%, so that the area available for birds and other forms of wildlife would increase by about 10%.
Higher risk of continued erosion to some of the Native American traditional-use areas, sacred sites, and archeological sites.	Lower risk of erosion to Native American traditional-use areas, sacred sites, and archeological sites.
A small deterioration in conditions for trout. Stocking of trout would still be required to maintain the population.	A small improvement in conditions for trout, but stocking of trout would still be required to maintain the population.
Option 1	Option 2

Think about a situation in which you had an opportunity to vote for Option 1 or Option 2. Keeping in mind all of the potential effects described for each option above, and if adoption of either option would not cost you anything, would you vote for Option 1 or Option 2?

- Option 1
- Option 2
- I would choose not to vote for either option

The question asking whether the respondent would pay $25 to support their preferred option took the following form:



The option you chose will be more expensive to operate, and will thus increase the cost to taxpayers. The following question asks whether you, as a taxpayer, would vote for this option. As you think about your answer, please remember that if this option is adopted, you would have less money for household expenses or to spend on other environmental issues.

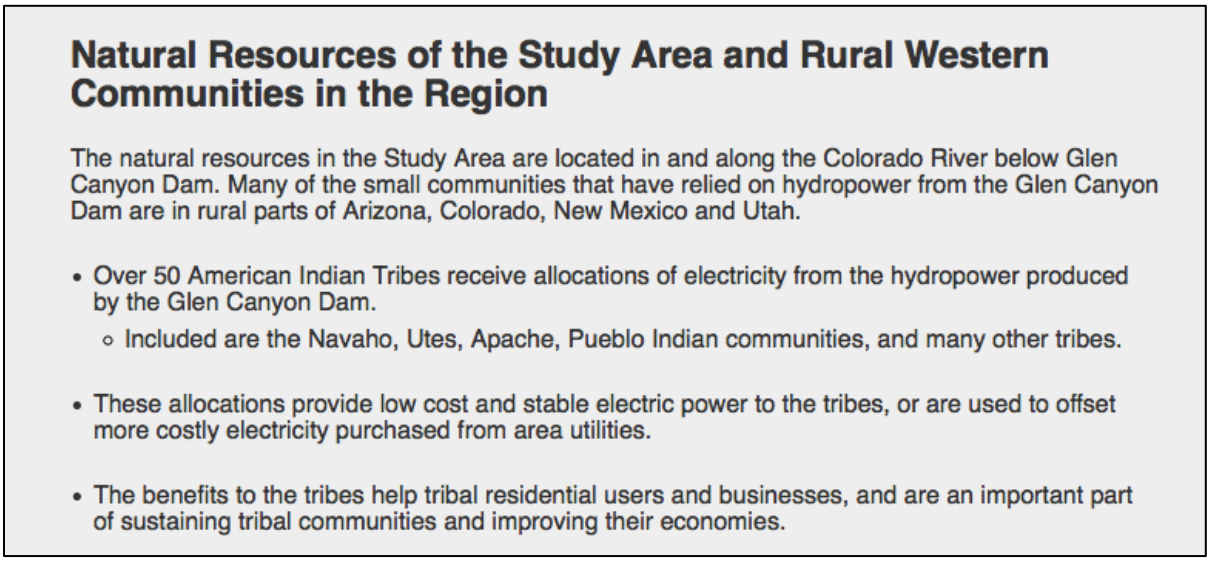
Would you vote for this option if adoption of this option would cost your household $25 in increased taxes **every year** for the foreseeable future?

Definitely No	I would definitely vote against this option.
Probably No	I would probably vote against this option.
Not Sure	I am not sure if I would vote for this option.
Probably Yes	I would probably vote for this option.
Definitely Yes	I would definitely vote for this option.

Next

Treatment 4- Native American Treatment

This treatment added the following information block to the page describing natural resources and communities in the study area:

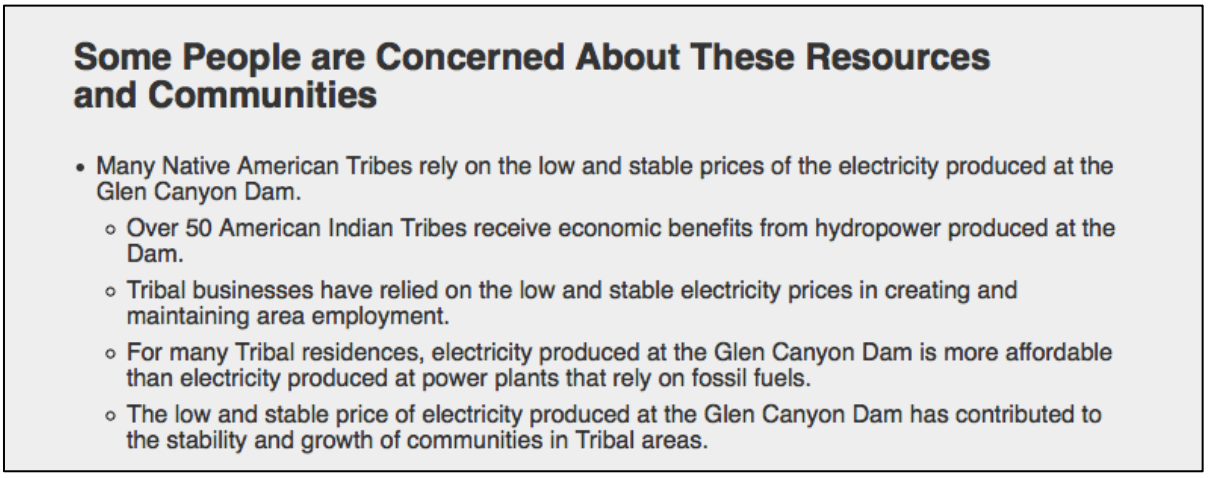


Natural Resources of the Study Area and Rural Western Communities in the Region

The natural resources in the Study Area are located in and along the Colorado River below Glen Canyon Dam. Many of the small communities that have relied on hydropower from the Glen Canyon Dam are in rural parts of Arizona, Colorado, New Mexico and Utah.

- Over 50 American Indian Tribes receive allocations of electricity from the hydropower produced by the Glen Canyon Dam.
  - Included are the Navaho, Utes, Apache, Pueblo Indian communities, and many other tribes.
- These allocations provide low cost and stable electric power to the tribes, or are used to offset more costly electricity purchased from area utilities.
- The benefits to the tribes help tribal residential users and businesses, and are an important part of sustaining tribal communities and improving their economies.

We add the following information block to the page describing concerns over natural resources and communities in the study area:



Some People are Concerned About These Resources and Communities

- Many Native American Tribes rely on the low and stable prices of the electricity produced at the Glen Canyon Dam.
  - Over 50 American Indian Tribes receive economic benefits from hydropower produced at the Dam.
  - Tribal businesses have relied on the low and stable electricity prices in creating and maintaining area employment.
  - For many Tribal residences, electricity produced at the Glen Canyon Dam is more affordable than electricity produced at power plants that rely on fossil fuels.
  - The low and stable price of electricity produced at the Glen Canyon Dam has contributed to the stability and growth of communities in Tribal areas.

We add the following information block to the page describing potential effects of changing dam operations on the natural resources and communities in the study area:

Scientists have learned that by changing the way water is released from the dam, natural resources in the Study Area and residents of the surrounding rural communities could both be affected in a variety of ways.

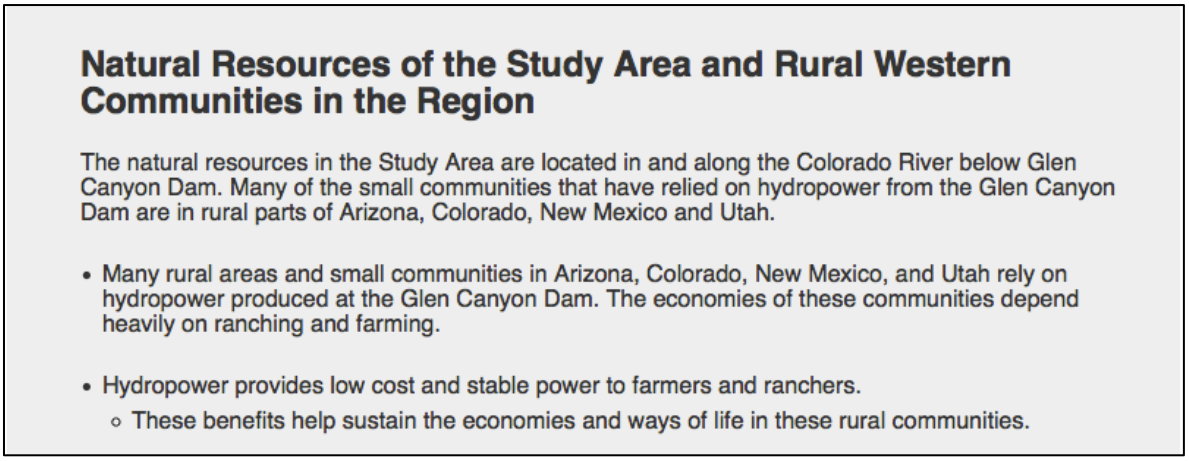
- Changing the way water is released through the dam will reduce the benefits of low cost electricity from the Glen Canyon Dam to over 50 American Indian Tribes.
- Some Tribes would need to replace the low-cost electricity from the Glen Canyon Dam with power from local utilities.
  - The cost of electricity from local utilities would be higher and more variable.
  - Higher and more uncertain prices for electricity would make it difficult for businesses to compete, thereby reducing jobs.
  - Some communities in Tribal areas may decline as a result, as jobs and incomes are reduced and residents migrate to other areas.

We add the following information to the table, presenting respondents with the two options for operating the dam:

Option 1	Option 2
Reduced benefits from hydropower for over 50 Native American Tribes. These reduced benefits could pose a threat to the communities in Tribal areas as jobs are reduced and residents seek employment elsewhere	Continued benefits from hydropower production for over 50 Native American Tribes. These continued benefits would sustain jobs and support communities in Tribal areas.

Treatment 5- Rural Western Community Treatment

For this treatment we add the following information block to the page describing natural resources and communities in the study area:

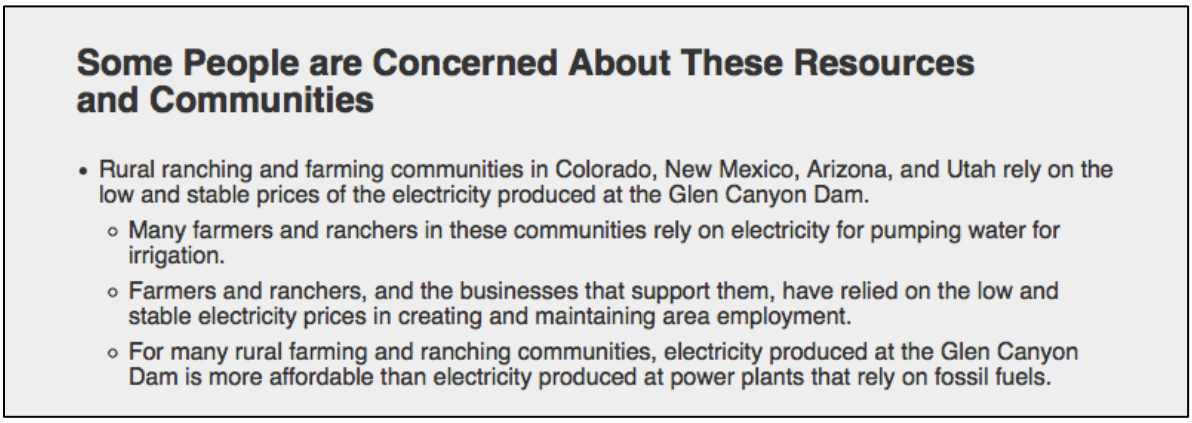


Natural Resources of the Study Area and Rural Western Communities in the Region

The natural resources in the Study Area are located in and along the Colorado River below Glen Canyon Dam. Many of the small communities that have relied on hydropower from the Glen Canyon Dam are in rural parts of Arizona, Colorado, New Mexico and Utah.

- Many rural areas and small communities in Arizona, Colorado, New Mexico, and Utah rely on hydropower produced at the Glen Canyon Dam. The economies of these communities depend heavily on ranching and farming.
- Hydropower provides low cost and stable power to farmers and ranchers.
  - These benefits help sustain the economies and ways of life in these rural communities.

We add the following information block to the page describing concerns over natural resources and communities in the study area:



Some People are Concerned About These Resources and Communities

- Rural ranching and farming communities in Colorado, New Mexico, Arizona, and Utah rely on the low and stable prices of the electricity produced at the Glen Canyon Dam.
  - Many farmers and ranchers in these communities rely on electricity for pumping water for irrigation.
  - Farmers and ranchers, and the businesses that support them, have relied on the low and stable electricity prices in creating and maintaining area employment.
  - For many rural farming and ranching communities, electricity produced at the Glen Canyon Dam is more affordable than electricity produced at power plants that rely on fossil fuels.

We add the following information block to the page describing potential effects of changing dam operations on the natural resources and communities in the study area:

Scientists have learned that by changing the way water is released from the dam, natural resources in the Study Area and residents of the surrounding rural communities could both be affected in a variety of ways.

- Changes in the way the Glen Canyon Dam is operated are likely to reduce the economic well being of some of the small ranching and farming communities in the region.
  - Increased costs of electricity will limit the ability of some ranchers and farmers to irrigate crops and maintain livestock.
  - These changes may lead to reductions in employment and reduced income for businesses in rural areas that serve ranchers and farmers.
  - As jobs diminish, some of these small rural ranching and farming communities will decline as residents seek employment elsewhere.

We add the following information to the table, presenting respondents with the two options for operating the dam:

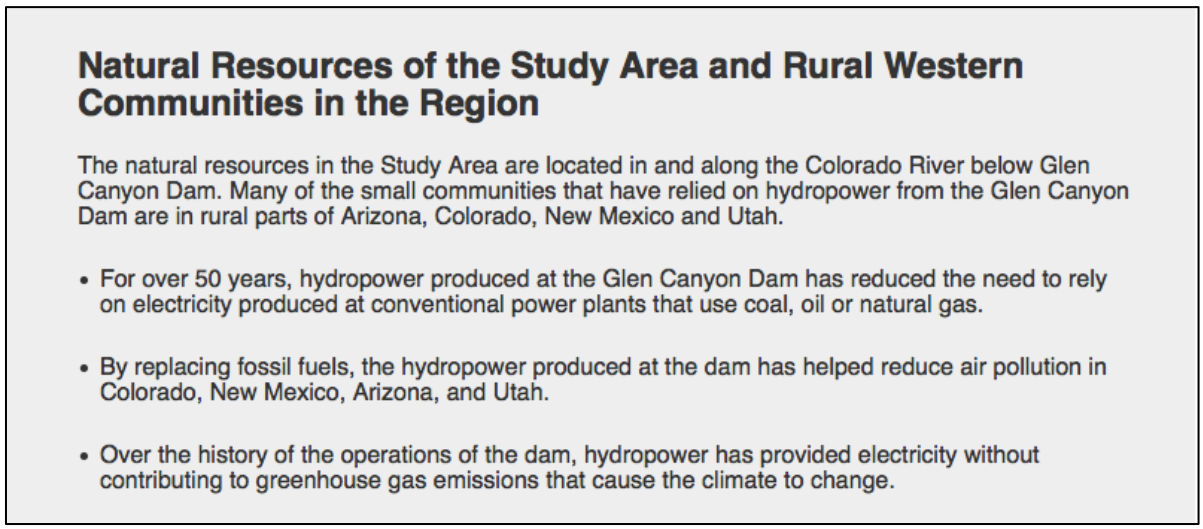
Option 1	Option 2
Higher and more variable electricity costs for some farmers, ranchers, and individuals living in small western communities. In some of these communities, increased costs could result in lost jobs and increased migration of residents to other areas.	Continued low and stable electricity prices for farmers, ranchers, and individuals living in small western communities. These continued low and stable electricity prices would sustain jobs, supporting populations in small farming and ranching communities.

Treatment 6- Native American + Rural Western Community Treatment

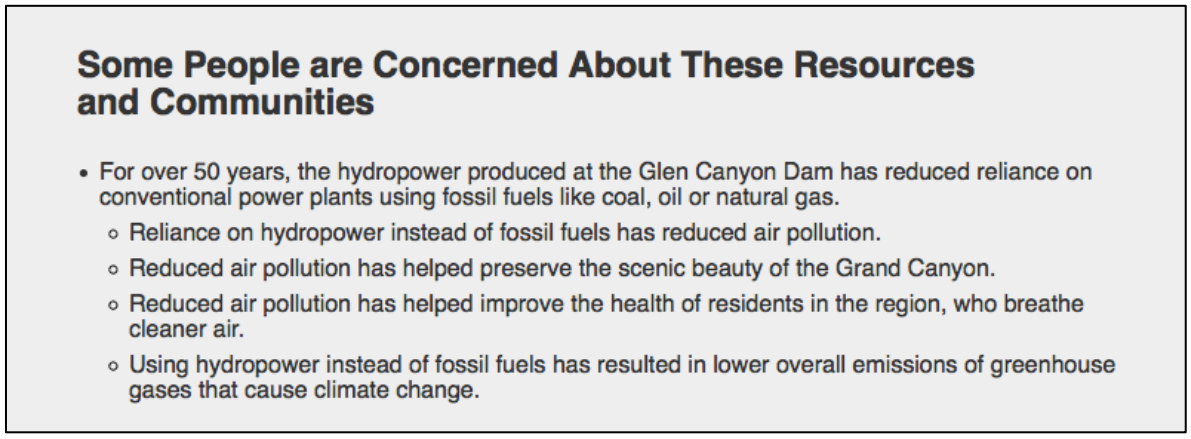
For this treatment we add all of the information blocks presented separately in the Native American and Rural Western Community treatments. The components are all shown in the prior two subsections, and are therefore not repeated here.

Treatment 7- Hypothetical Air Emissions Treatment

For this treatment we add the following information block to the page describing natural resources and communities in the study area:



We add the following information block to the page describing concerns over natural resources and communities in the study area:



We add the following information block to the page describing potential effects of changing dam operations on the natural resources and communities in the study area:

Scientists have learned that by changing the way water is released from the dam, natural resources in the Study Area and residents of the surrounding rural communities could both be affected in a variety of ways.

- Changes in the way the Glen Canyon dam is operated will reduce the amount of hydropower produced, leading to greater use of electricity from conventional power plants using coal, oil and natural gas.
  - Air quality in the region will decline as pollution from conventional power plants increases.
  - The health of the local populations may be negatively affected by the increased air pollution, which contributes to a number of serious diseases.
  - Visibility in the Study Area, including the Grand Canyon, may diminish due to increased air pollution.
  - Greenhouse gas emissions will increase, as use of hydropower is replaced by use of electricity from burning fossil fuels.
  - Adding to the amount of greenhouse gas emissions will contribute to changes in the global climate.

We add the following information to the table, presenting respondents with the two options for operating the dam:

Option 1	Option 2
Increase in the amount of air pollutants, including greenhouse gases, emitted into the atmosphere in the region near the dam. By decreasing air quality, these pollutants will likely negatively affect the visibility in the area near the Grand Canyon, and may have a negative effect on the health of individuals residing in the region. By increasing the emissions of greenhouse gases, this option has the potential to increase the negative effects of climate change.	Continued decrease in the amount of air pollutants, including greenhouse gases, emitted into the atmosphere in the study area. By continuing to increase air quality, this option will positively affect the scenic beauty of the area, as well as the health of individuals residing in the region. By continuing to decrease the emissions of greenhouse gases, this option has the potential to decrease the negative effects of climate change.

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Non-Market Values for Alternative Operations of the Glen Canyon Dam:

Experiments in Choice and Valuation

Hank Jenkins-Smith & Carol L Silva

Center for Energy, Security & Society
A Joint Center of The University of Oklahoma & Sandia National Laboratories

The UNIVERSITY of OKLAHOMA

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Overview

1. **The Research Puzzle**
2. Research Goals and Approach
3. Treatment #1: Replication
4. Treatment #2: Randomization of Information
5. Treatment #3: Structuring Alternative Options
6. Treatments #4-6: Tribes and Western Communities
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The Puzzle

- Hydropower is broadly perceived to be a stable, domestic, and renewable form of energy
- Yet studies of social preferences indicate a willingness to pay to *reduce* reliance on hydropower
  - Why is that?
  - Do such studies miss important value dimensions when attempting to measure public preferences?

Preferred Future Energy Sources

- *Asked in May, 2012: "*Now think about the overall mix of all sources of energy for the U.S. We currently get about 83 percent of our energy from fossil fuels, 9 percent from nuclear energy, 3 percent from hydroelectric dams on rivers and lakes, and 5 percent from other renewable sources (wood, biofuels, wind, waste products, geothermal, and solar).We want to know approximately what percentage of the total U.S. energy supply over the next 20 years you would like to see come from each of these four sources."
  - What percent of our energy should come from *[fuel type]*, which currently provide about *[XX]*% of total U.S. energy?

Average Preferred 2032 Energy Mix

- What percent of our energy should come from *hydroelectric dams* on rivers and lakes, which currently provide about 3% of total U.S. energy?
- What percent of our energy should come *from renewable sources* (wood, biofuels, wind, waste products, geothermal, and solar), which currently provide about 5% of total U.S. energy?

Preferred Percentage by Source of Energy in 2032		
	Percent in 2012	Preferred % in 2032
Fossil Fuels	83	32
Nuclear	9	13
Hydro	3	20
Renewables	5	35

Perceived Energy Attributes by Source

"Now we want to know what kinds of qualities you associate with different ways of reliably generating large quantities of electricity for industries, businesses, and homes. Please check the descriptions you associate with each of the following sources of energy."

	Coal	Oil	Nuclear	Natural Gas	Hydro	Wind	Solar
Clean	6.9%	7.5%	31.5%	42.1%	77.4%	85.7%	85.4%
Renewable	11.7	10.2	25.5	21.3	65.3	77.2	73.3
Safe	23.1	24.4	13.8	35.4	64.2	72.9	77.9
Plentiful	31.3	21.9	31.9	41.2	44.3	49.7	52.7
Preferred	9.6	8.8	16.7	31.3	56.9	60.2	64.8

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Research Goals

- Analyze issues related to valuation of nonmarket effects of changing Glen Canyon Dam operations
- Assess sensitivity of previous estimates of WTP for effects of changing operations to:
  - Presentation of information
  - Approach used to structure choices
  - Inclusion of omitted dimensions of value

Research Approach

- Attempt to replicate 1995 Welsh et al. study
- Then implement experiments that can be compared to replication baseline:
  - Presentation of information
  - Structuring of choices
    - Allow for "negative valuation" of changing dam operations
      - Can also be thought of as positive valuation for maintaining dam operations
  - Introduction of omitted dimensions of value

Experimental Treatments

Treatment	Concept	Sample Size
1. Replication	Used Welsh et al (1995) language and format, in Internet survey mode	341
2. Adds randomized presentation of info. to #1	Replication with the exception of randomizing the order of information	345
3. Adds referendum choice options to #2	Permits respondent to vote for one of two options, rather than one "proposal"	352
4. Adds Native American effects to #3	Adds information and potential effects of changed operations on Tribes	343
5. Adds rural Western community effects to #3	Adds information and potential effects of changed operations on rural communities	397
6. Combines #4 and #5	Combines information and potential effects on Tribes and rural communities	345
7. Adds hypothetical air emission effects to #3	Includes hypothetical effects of increased air emissions (*not* combined with 4-6)	342

Research Approach

- National survey of 2,465 individuals
  - Internet-based and weighted to Census

Collected:	April 22-24, 2014
Average time:	26 minutes
Participant Source:	SSI "Dynamix" Panel
Respondent Mix:	Close to Census
Weights:	2013 Census Estimates

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Treatment #1

- Replication of Welsh et al (1995) approach
  - Introduce purpose of survey
  - Background information
    - Provided a map of the study area
  - Overview of natural resources in the study area
  - Concerns about the resources
  - Projected effects of changing operations
  - Solicit views on changing operations
    - Value preference more than $25?
- Online survey images (desktop, tablets, smart phones)

This survey is part of a national study of issues concerning the operation of the Glen Canyon Dam. The Glen Canyon Dam controls the water level in the Colorado River in the bottom of the Grand Canyon and affects the resources and communities in and along the river. Government officials will soon be making decisions about how the dam is to be operated. They will consider many factors when deciding whether or not to change dam operations. One factor they would like to consider is whether or not changes to dam operations are personally worthwhile to people like you. Therefore, even if you have never heard of the Glen Canyon Dam, your answers are important to this study.

The next several pages provide some background information about the Glen Canyon Dam and the resources downstream from the dam in what is called the Study Area. This information will help you decide whether or not changes to dam operations are personally worthwhile to people like you.

Glen Canyon Dam

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

The Glen Canyon Study Area

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

How Glen Canyon Dam affects the Colorado River in the Study Area

- The amount of electricity produced by the 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.
  - The amount of water released can vary from hour to hour throughout the day.

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.

- Archeological sites are located along the river.
  - These sites are associated with American Indian cultures that have inhabited or used the Grand Canyon for thousands of years.
  - These sites contain evidence of ancient human activity along the river, including pots and tools.
- Present-day American Indians have sacred sites and traditional-use areas along the river.
  - American Indians gather materials from these sites for use in their everyday life.
- Deposits of sand, mud, and gravel, sometimes called beaches, are scattered along the river. The rest of the river bank consists of cliffs and steep slopes covered with rocks, boulders, and desert vegetation.
  - Beaches vary greatly in size. Some are as large as several acres, and others consist of a little sand at the river's edge.
- Some beaches are covered with vegetation.
  - Beaches with vegetation provide habitat for birds and other small animals.
- Only a small percentage of visitors to the Grand Canyon National Park actually see or use the resources in the Study Area.
  - The only people who see the resources in the Study Area are American Indians using resources in the Study Area, river rafters, backpackers, and people who fish there.
- Native fish species live in the Study Area.
  - Only one of these native species is found outside the Colorado River and its tributaries.
- Trout also live in the river.
  - Trout are not native to this section of the Colorado River.
  - People fish for these trout in the first 15 miles of river downstream from Glen Canyon Dam.
- Several other non—native fish species, including carp, catfish, and fathead minnows, also live in the Study Area.

Some People are Concerned About These Resources

- Because of erosion, the number and size of beaches along the river are decreasing.
  - Over an 18-year period, the *number* of beaches decreased from 276 to 258; many of the remaining beaches are *smaller*.
  - The loss is most severe along the narrow sections of river.
- 27 known archeological sites have been affected by erosion. An unknown number of other sites may be affected.
- Resources important to American Indians are also affected by erosion.
  - Loss of archeological sites destroys important links to the past.
  - Sacred sites exist in places that may be damaged by erosion.
  - Plants, animals, and minerals used by American Indians are affected by erosion.
- Populations of native fish in the Study Area have declined.
  - Eight species of native fish evolved in the Colorado River when the water was warmer 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.
  - Cold water released from Glen Canyon Dam may be the most important factor in the decline of native fish populations.
  - Competition from non-native fish (trout, carp, catfish, minnow species) may have contributed to the decline of native species.
- Conditions for trout are affected by daily fluctuations in water level.
  - Maintenance of recreational trout fishing requires annual stocking.
  - Trout eggs dry out and die during low-water periods.
  - Food for trout is reduced because of exposure during low-water periods.

Scientists have learned that by changing the way water is released from the dam, primarily by reducing the size of daily fluctuations, some of the concerns about the natural resources in the Study Area could be addressed.

- Some households receiving power from Glen Canyon Dam could see their monthly electric bill increase.
  - About 4.5 million households live in states surrounding Glen Canyon Dam.
  - About 1.5 million of these households receive some, or all, of their electricity from Glen Canyon Dam.
  - Most of the 1.5 million households receiving power from Glen Canyon Dam are located in rural areas and smaller towns.
  - The amount of increase in a household's electric bill depends on how much of their electricity comes from Glen Canyon Dam.
- Some farmers using electricity to pump irrigation water will also be affected.
  - Higher costs for pumping irrigation water will reduce some farmers' incomes.
- Changing the way water is released from the dam will not reduce the total amount of electricity produced at Glen Canyon Dam.
- However, there will be changes in when and where electricity is produced.
  - During the day:
    - Less electricity will be produced at Glen Canyon Dam.
    - More electricity will be produced from power plants burning gas or oil.
  - During the night:
    - More electricity will be produced at Glen Canyon Dam.
    - Less electricity will be produced from power plants burning coal.
  - Since oil and gas are more expensive fuel sources than coal, the overall cost of meeting electrical demand will increase.
- Reducing fluctuations in water released from the dam could affect the following resources in the Study Area:
  - The number and size of beaches.
  - Conditions of native fish.
  - Conditions for trout.
  - The amount of vegetation available for bird and wildlife habitat.
  - Archeological sites along the river.

Government Officials are Deciding How to Operate Glen Canyon Dam in Future Years.

- Their decision on how the dam should be operated could cost you money. For example:
  - One option for dam operations could be more expensive than another—as a result, taxpayers would have to make up the difference.
  - If you live in an area receiving power from Glen Canyon Dam, your utility bill would increase.

Government officials will consider many factors when deciding whether or not to change dam operations. One factor they would like to consider is whether various proposals are personally worthwhile to people like you. In the next question, we will describe the effects of a specific proposal to change dam operations. We would like you to tell us if you would vote "YES" or "NO" for this proposal.

Some people might vote "NO" because:

- The cost of the proposal is too high.
- The effects of the proposal are not worth anything (not even 10 cents) to them.
- They just can't afford the cost.

Some people might vote "YES" because:

- The cost of the proposal is low enough.
- The effects of the proposal are worth what it would cost them.

At this point in time, it is not certain what the cost would be to any specific individual, so we are asking different people about different amounts. Even if the amount we ask you about seems very low or very high, please answer carefully. This will allow us to determine whether people think the proposal is worthwhile at whatever level the final cost is determined to be. For this study, it is important that you tell us how you would vote, based only on **your personal evaluation** of whether changes in dam operations and their effects, are worth the additional cost **to you**.

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A PROPOSAL

Under this proposal, there would be a moderate reduction in the daily fluctuations in the river level. If this proposal is selected, it will result in the following conditions along the Colorado River in the Grand Canyon:

- The area available for vegetation would increase by about 10%, so that the area available for birds and other forms of wildlife would increase by about 10%.
- On average, farm incomes would not change significantly. However, about 300 farmers in southern Utah would see their incomes drop by 3%.
- The average electric bill would increase by $5 per month for 1.5 million households receiving power from Glen Canyon Dam. This average reflects a maximum increase of $15 per month for 3,600 households and a minimum of no increase for 800,000 households.
- There would be a small improvement in conditions for trout, but stocking of trout would still be required to maintain the population.
- In the long-term, the number and size of beaches would remain at present levels.
- The risk of erosion to Native American traditional-use areas, sacred sites, and archeological sites would decrease substantially.
- There would be a small improvement in conditions for native fish, but these populations, including those in danger of extinction, would probably continue to decline in numbers.

Think about a situation in which you had the opportunity to vote on this proposal. If passage of this proposal would not cost you anything would you support this proposal?

- ○ No
- ○ Yes
- ○ I would choose not to vote on this proposal

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Replication Results

	Welsh et al. (1995) Study	Our Study
Vote for proposal to change operations	71%	70.6%
Not vote for proposal to change operations	17%	17.3%
Would not vote	12%	12.2%

- Nearly identical results
  - Provides a baseline for exploring effects of:
    - Presentation of information
    - Structuring of alternatives
    - Additional value dimensions

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   - **No effect on WTP**
5. Treatment #3: Structuring Alternative Options
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4. Treatment #2: Randomization of Information (no effect)
5. **Treatment #3: Structuring Alternative Options**
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Treatment #3: Structuring Alternatives

- Original study structured choice as referendum on a proposal for changing dam operations
  - Focuses valuation on the proposed *change*
- We structured choice as referendum allowing for selection between one of two options
  - Conceptually more appropriate
  - Necessary for estimation of *positive* values placed on maintaining dam operations

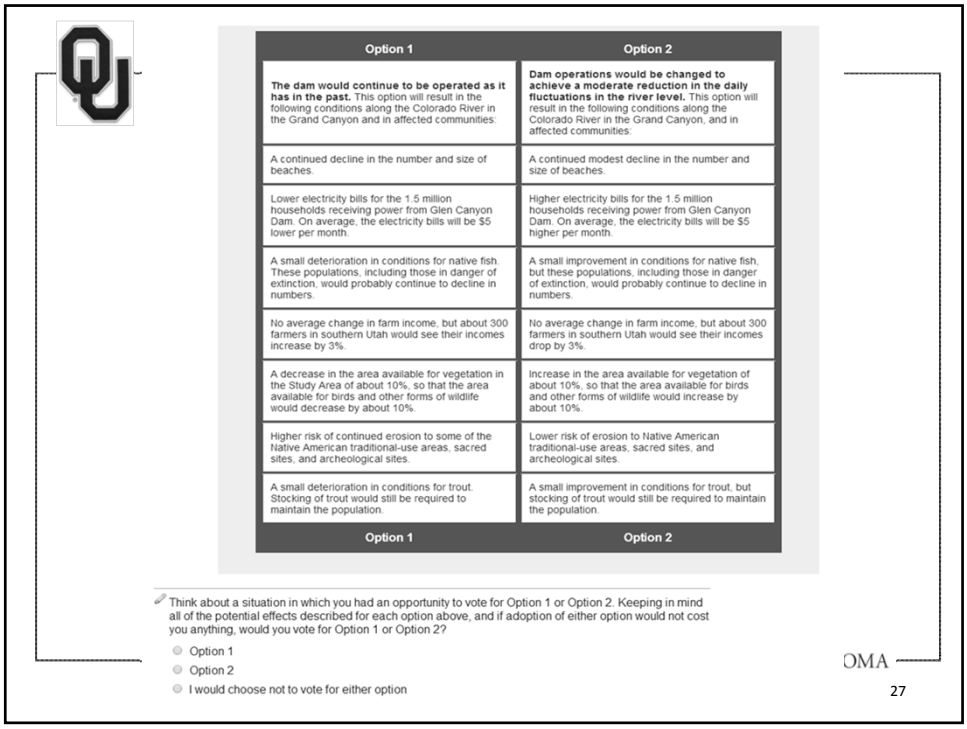
A PROPOSAL

Under this proposal, there would be a moderate reduction in the daily fluctuations in the river level. If this proposal is selected, it will result in the following conditions along the Colorado River in the Grand Canyon:

- The area available for vegetation would increase by about 10%, so that the area available for birds and other forms of wildlife would increase by about 10%.
- On average, farm incomes would not change significantly. However, about 300 farmers in southern Utah would see their incomes drop by 3%.
- The average electric bill would increase by $5 per month for 1.5 million households receiving power from Glen Canyon Dam. This average reflects a maximum increase of $15 per month for 3,600 households and a minimum of no increase for 800,000 households.
- There would be a small improvement in conditions for trout, but stocking of trout would still be required to maintain the population.
- In the long-term, the number and size of beaches would remain at present levels.
- The risk of erosion to Native American traditional-use areas, sacred sites, and archeological sites would decrease substantially.
- There would be a small improvement in conditions for native fish, but these populations, including those in danger of extinction, would probably continue to decline in numbers.

Think about a situation in which you had the opportunity to vote on this proposal. If passage of this proposal would not cost you anything would you support this proposal?

- No
- Yes
- I would choose not to vote on this proposal



Option 1	Option 2
The dam would continue to be operated as it has in the past. This option will result in the following conditions along the Colorado River in the Grand Canyon and in affected communities:	**Dam operations would be changed to achieve a moderate reduction in the daily fluctuations in the river level.** This option will result in the following conditions along the Colorado River in the Grand Canyon, and in affected communities:
A continued decline in the number and size of beaches.	A continued modest decline in the number and size of beaches.
Lower electricity bills for the 1.5 million households receiving power from Glen Canyon Dam. On average, the electricity bills will be $5 lower per month.	Higher electricity bills for the 1.5 million households receiving power from Glen Canyon Dam. On average, the electricity bills will be $5 higher per month.
A small deterioration in conditions for native fish. These populations, including those in danger of extinction, would probably continue to decline in numbers.	A small improvement in conditions for native fish, but these populations, including those in danger of extinction, would probably continue to decline in numbers.
No average change in farm income, but about 300 farmers in southern Utah would see their incomes increase by 3%.	No average change in farm income, but about 300 farmers in southern Utah would see their incomes drop by 3%.
A decrease in the area available for vegetation in the Study Area of about 10%, so that the area available for birds and other forms of wildlife would decrease by about 10%.	Increase in the area available for vegetation of about 10%, so that the area available for birds and other forms of wildlife would increase by about 10%.
Higher risk of continued erosion to some of the Native American traditional-use areas, sacred sites, and archeological sites.	Lower risk of erosion to Native American traditional-use areas, sacred sites, and archeological sites.
A small deterioration in conditions for trout. Stocking of trout would still be required to maintain the population.	A small improvement in conditions for trout, but stocking of trout would still be required to maintain the population.
Option 1	Option 2

Think about a situation in which you had an opportunity to vote for Option 1 or Option 2. Keeping in mind all of the potential effects described for each option above, and if adoption of either option would not cost you anything, would you vote for Option 1 or Option 2?

- Option 1
- Option 2
- I would choose not to vote for either option

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Results

	Welsh et al. (1995) Study	Our Replication	Two Options Treatment
Vote for to change operations	71%	70.6%	67.8%
Vote to maintain operations	17%	17.3%	21.3%
Would not vote	12%	12.2%	11.0%

- Results indicate that one respondent in five will vote to maintain current dam operations
- This approach permits assessment of the value placed on *not changing* dam operations

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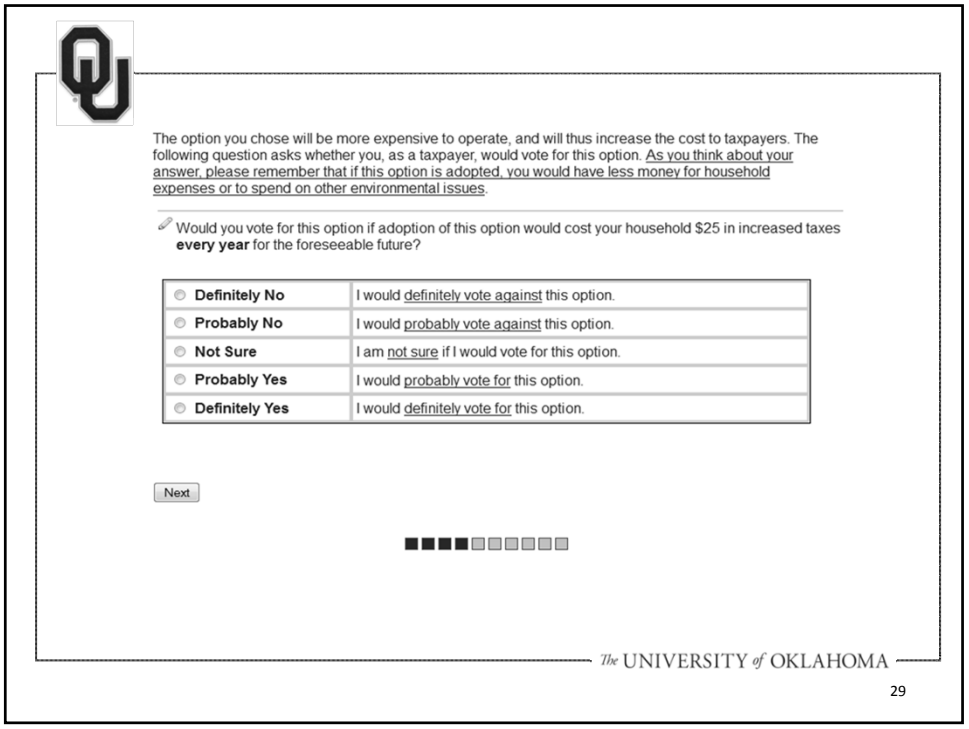

Results

	Baseline-Replication of Welsh et al.	Two Options Treatment
Vote to change operations	**70.6%**	**67.8%**
Would you pay $25?	NA	46.9
Vote against proposal (i.e. to maintain operations)	**17.3%**	**21.3%**
Would you pay $25?	NA	6.9
Would not vote	**12.2%**	**11.0%**

- Nominally larger number of respondents chose to leave dam operations unchanged when offered two options
  - 6.9% would pay $25 to leave operations unchanged
- Appears to be a subtle but important effect:
  - A single "proposal" appears to privilege the proposed change

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Overview

1. The Research Puzzle
2. Research Goals and Approach
3. Treatment #1: Replication
4. Treatment #2: Randomization of Information (no effect)
5. Treatment #3: Structuring Alternative Options
6. **Treatments #4-6: Tribes and Western Communities**
7. Treatment #7: Hypothetical Air Emissions Effects
8. Summary and Implications
9. Next Steps

Treatments #4-6: Omitted Value Dimensions

- Welsh et al. study valued only selected effects of changing dam operations
- Additional categories of nonmarket values may affect respondents' choices (Loomis 2014):
  - *Paternalistic altruism:*
    - Effects on Native American tribes
    - Effects on rural Western communities
  - *Externalities:*
    - Effects on air emissions
      - Relevant to general discussions surrounding hydropower

Omitted Value Dimensions

- Experimental treatments (random assignment):
  - #4: Native American tribes
  - #5: Rural Western communities
  - #6: Native American tribes + rural Western communities
- Information on these topics was provided in background material and presentation of alternatives for operating the dam
  - Introduced in random order
  - Example: Native American treatment

Background Information

Natural Resources of the Study Area and Rural Western Communities in the Region

The natural resources in the Study Area are located in and along the Colorado River below Glen Canyon Dam. Many of the small communities that have relied on hydropower from the Glen Canyon Dam are in rural parts of Arizona, Colorado, New Mexico and Utah.

- Over 50 American Indian Tribes receive allocations of electricity from the hydropower produced by the Glen Canyon Dam.
  - Included are the Navaho, Utes, Apache, Pueblo Indian communities, and many other tribes.
- These allocations provide low cost and stable electric power to the tribes, or are used to offset more costly electricity purchased from area utilities.
- The benefits to the tribes help tribal residential users and businesses, and are an important part of sustaining tribal communities and improving their economies.

Concerns

Some People are Concerned About These Resources and Communities

- Many Native American Tribes rely on the low and stable prices of the electricity produced at the Glen Canyon Dam.
  - Over 50 American Indian Tribes receive economic benefits from hydropower produced at the Dam.
  - Tribal businesses have relied on the low and stable electricity prices in creating and maintaining area employment.
  - For many Tribal residences, electricity produced at the Glen Canyon Dam is more affordable than electricity produced at power plants that rely on fossil fuels.
  - The low and stable price of electricity produced at the Glen Canyon Dam has contributed to the stability and growth of communities in Tribal areas.

Effects

Scientists have learned that by changing the way water is released from the dam, natural resources in the Study Area and residents of the surrounding rural communities could both be affected in a variety of ways.

- Changing the way water is released through the dam will reduce the benefits of low cost electricity from the Glen Canyon Dam to over 50 American Indian Tribes.
- Some Tribes would need to replace the low-cost electricity from the Glen Canyon Dam with power from local utilities.
  - The cost of electricity from local utilities would be higher and more variable.
  - Higher and more uncertain prices for electricity would make it difficult for businesses to compete, thereby reducing jobs.
  - Some communities in Tribal areas may decline as a result, as jobs and incomes are reduced and residents migrate to other areas.

Alternatives

For effects on Native American tribes…

Option 1	Option 2
Reduced benefits from hydropower for over 50 Native American Tribes. These reduced benefits could pose a threat to the communities in Tribal areas as jobs are reduced and residents seek employment elsewhere	Continued benefits from hydropower production for over 50 Native American Tribes. These continued benefits would sustain jobs and support communities in Tribal areas.

And for rural Western Communities…

Option 1	Option 2
Higher and more variable electricity costs for some farmers, ranchers, and individuals living in small western communities. In some of these communities, increased costs could result in lost jobs and increased migration of residents to other areas.	Continued low and stable electricity prices for farmers, ranchers, and individuals living in small western communities. These continued low and stable electricity prices would sustain jobs, supporting populations in small farming and ranching communities.

Results

	Replication With Two Options	Native American	Rural Western Communities	Native American + Rural Western Communities
Vote to *change* operations	**67.8%**	**49.5%**	**49.1%**	**32.4%**
Would pay $25	46.9	33.0	33.9	21.8
Vote to *maintain* operations	**21.3%**	**39.2%**	**37.1%**	**57.1%**
Would pay $25	6.9	16.5	16.4	30.3
Would not vote	**11.0%**	**11.4%**	**13.8%**	**10.5%**

Results

- *Paternalistic altruism* can have a large effect on support for maintaining dam operations
- Effect is *cumulative* when Native American and Western community treatments combined into single treatment
  - Nearly 60% of respondents support maintaining operations
  - Over 30% willing to pay at least $25 to maintain operations
    - Strong evidence for "Negative" WTP
    - Would be treated as $0 valuation in most CV studies, including Welsh et al. study

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Treatment #7: Air Emissions

- Added as pilot study with a hypothetical case
  - *GCD changes may or may not affect air emissions*
- Relevant to debates about whether to build or remove dams that provide hydropower
  - Net impact on distribution of sources of electricity
- Stand-alone treatment only
  - In targeted application, would need to include other relevant non-market value dimensions

Background Information

Natural Resources of the Study Area and Rural Western Communities in the Region

The natural resources in the Study Area are located in and along the Colorado River below Glen Canyon Dam. Many of the small communities that have relied on hydropower from the Glen Canyon Dam are in rural parts of Arizona, Colorado, New Mexico and Utah.

- For over 50 years, hydropower produced at the Glen Canyon Dam has reduced the need to rely on electricity produced at conventional power plants that use coal, oil or natural gas.
- By replacing fossil fuels, the hydropower produced at the dam has helped reduce air pollution in Colorado, New Mexico, Arizona, and Utah.
- Over the history of the operations of the dam, hydropower has provided electricity without contributing to greenhouse gas emissions that cause the climate to change.

Concerns

Some People are Concerned About These Resources and Communities

- For over 50 years, the hydropower produced at the Glen Canyon Dam has reduced reliance on conventional power plants using fossil fuels like coal, oil or natural gas.
  - Reliance on hydropower instead of fossil fuels has reduced air pollution.
  - Reduced air pollution has helped preserve the scenic beauty of the Grand Canyon.
  - Reduced air pollution has helped improve the health of residents in the region, who breathe cleaner air.
  - Using hydropower instead of fossil fuels has resulted in lower overall emissions of greenhouse gases that cause climate change.

Hypothetical Effects

Scientists have learned that by changing the way water is released from the dam, natural resources in the Study Area and residents of the surrounding rural communities could both be affected in a variety of ways.

- Changes in the way the Glen Canyon dam is operated will reduce the amount of hydropower produced, leading to greater use of electricity from conventional power plants using coal, oil and natural gas.
  - Air quality in the region will decline as pollution from conventional power plants increases.
  - The health of the local populations may be negatively affected by the increased air pollution, which contributes to a number of serious diseases.
  - Visibility in the Study Area, including the Grand Canyon, may diminish due to increased air pollution.
  - Greenhouse gas emissions will increase, as use of hydropower is replaced by use of electricity from burning fossil fuels.
  - Adding to the amount of greenhouse gas emissions will contribute to changes in the global climate.

Alternatives

Option 1	Option 2
Increase in the amount of air pollutants, including greenhouse gases, emitted into the atmosphere in the region near the dam. By decreasing air quality, these pollutants will likely negatively affect the visibility in the area near the Grand Canyon, and may have a negative effect on the health of individuals residing in the region. By increasing the emissions of greenhouse gases, this option has the potential to increase the negative effects of climate change.	Continued decrease in the amount of air pollutants, including greenhouse gases, emitted into the atmosphere in the study area. By continuing to increase air quality, this option will positively affect the scenic beauty of the area, as well as the health of individuals residing in the region. By continuing to decrease the emissions of greenhouse gases, this option has the potential to decrease the negative effects of climate change.

Results

	Replication With Two Options	Air Emissions
Vote to change operations	**67.8%**	**36.7%**
Would vote to pay $25	46.9	22.4
Vote to maintain operations	**21.3%**	**51.0%**
Would vote to pay $25	6.9	27.8
Would not vote	**11.0%**	**12.3%**

Results

- Air quality dimension has large effect on support for maintaining dam operations
  - Over half of respondents voted to maintain operations
  - Over a quarter said they would pay at least $25 to do so
- Substantial implications for policy analysis
  - Adding, upgrading generators and capacity
  - Removing generators or dams

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8. **Summary and Implications**

Summary of Findings

- Structuring alternatives as a referendum choice between two options allows respondents to consider *bundles* of distinct value attributes
  - In contrast to Welsh et al (1995) on single proposal for changing operations
    - A single proposal appears to privilege that proposal
  - More appropriate conceptually in that options may require *tradeoffs* across different attributes
  - Allows for expression of "negative" valuations
    - Meaningful proportion of respondents place positive value on maintaining current dam operations

Summary of Findings

- *Paternalistic altruism* considerations appear to cause respondents to be substantially more likely to support maintaining current dam operations
  - Effects on Native American tribes
  - Effects on rural Western communities
  - Combination of the two
- Respondents place significant value on low-emissions characteristics of hydropower
  - Large implications for debates over adding/removing dams, or upgrading generator capacity

Implications

- Suggests that respondents have *positive* WTP for maintaining operations when accounting for additional relevant nonmarket effects
  - In stark contrast to Welsh et al. (1995) findings
  - Phase II experiments do not permit estimation of population WTP
    - Will require full cv study
    - Appropriate treatment of "negative" values in calculation of WTP will require development of new estimation techniques

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