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

An Inclusive Value Approach

Phase 3B Project Research and Findings

September 2016

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Acknowledgements

The authors would like to thank the following individuals for their contributions to this study:

Nina Carlson, for assistance with survey administration, project management, and report writing.

Jeane Hardy, for administrative assistance and management.

Daniel Pae, for research assistance.

Tyler Self, for coding assistance.

Courtney Thornton, for coding assistance.

Dr. Samuel Workman, for technical consult, assistance with protocol development and execution, and data provision.

Abstract

This report describes an integrated research program that developed a replicable, multi-stage protocol for estimating non-use values for proposed alternative operations of the Glen Canyon Dam (GCD). Based on the options developed in the draft Glen Canyon Dam Long-Term Experimental and Management Plan Environmental Impact Statement (DEIS), this study evaluates the *net non-use value difference* between the DEIS "preferred alternative" (Alternative D) and the current operational program for the GCD.

Appropriate measurement of non-use values for a prospective change within a complex, coupled human and natural system (CHANS) like a river system requires careful consideration of the potential array of values that can be affected by both direct and indirect effects within the interconnected system. To ensure appropriate measurement, we employed a protocol, drawing on (a) analytical literature reviews of the theoretical (Loomis 2014) and substantive (Lowry et. al 2016) scholarship on non-use values potentially affected by hydropower operations, (b) a systematic text analysis of the content of two decades of public hearings in the U.S. concerning dam operations and hydropower, (c) an open-ended survey of multiple stakeholders on the Colorado River, (d) a confirmatory experimental survey to validate potential non-use value considerations, and (e) and a nationwide random probability sample of U.S. households to estimate net willingness to pay for alternative options for operating the GCD. Each component of the protocol is described in this report.

We found that non-use values for continuing current operational patterns at the GCD substantially outweigh those for the proposed preferred alternative, whether measured as a simple no-cost referendum or through estimates of household willingness to pay (WTP). A conservative estimate of median household WTP for continuing the current pattern of GCD operations is $20.19 per year. Estimated median WTP to change dam operations as described for the DEIS preferred alternative is $0.43 per year. The net household WTP to continue current dam operations is thus $19.76.

More generally, this study makes clear that – when attempting to inform decisions about changes in complex CHANS – the design of the study must reflect the diversity of non-use values that are engaged by the prospective change. Absent an inclusive representation of the affected non-use values, and a method that permits valuation of both sides of the ledger in a comparison of change and no-change alternatives, estimates developed will be incomplete and potentially misleading.

1. Introduction

Understanding non-use values affected by proposed operational changes to the Glen Canyon Dam (GCD) has been the topic of considerable prior investigation (Welsh et al., 1995; Duffield, 2016). These studies were completed as components of federally-mandated environmental assessments of GCD operations (e.g., see Lovich & Melis, 2007), and are important for bringing non-use 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). However, there is strong evidence that these studies overlooked a number of dimensions of non-use value likely affected by proposed operational changes to the GCD (Jenkins-Smith et al., 2015; Jones et al., 2016). For example, Jones et al. (2016) replicated the essential elements of a prominent prior contingent valuation non-use study (Welsh et al., 1995) and found that estimates of societal non-use value are highly sensitive to a broad set of additional value dimensions that were not included in the original (Welsh et al., 1995) non-use study about enhancing downstream environmental flow patterns from GCD.

This study primarily considers non-market non-use values associated with changing the operation of the GCD, though – as with any non-use study (e.g., Welsh et al., 1995; Duffield 2016) – it is possible that some study participants were considering non-market use values. Non-market values are attached to changes in goods and services (such as enjoyment of environmental goods or use of public lands for recreation) not reflected in market prices. Non-market values include both use values (as attached to recreation trips to public lands or waterways) and non-use values. Non-use (or passive use) values are those that are not directly related to an individual's in situ use of the valued resource (Loomis, 2014), including the value placed on the existence, option to use, or bequest of that resource.

An *inclusive* analysis of non-use values intended to meaningfully inform decisions about the operation of the GCD must possess two features. First, it must include all relevant dimensions of non-use value. Omission of relevant dimensions of value (DOV) from the analysis would invalidate conclusions about the economic value of the changes that would result from altering GCD operations. Second, the analysis must recognize and account for the diversity of preferences across options for GCD operations that exist within the U.S. population, particularly with respect to impacts across the array of non-use values that are likely to be affected. In comparing two options for the operation of the GCD, reasonable people can plausibly disagree about the preferable option and place value on the selection of their preferred alternative. Any analysis intended to inform decisions about GCD operations must be designed in a manner that reflects this reality. This is consistent with broader policy calls for managers of the GCD, in conflicts over operations between water managers and the electric power community, to "find ways to make their efforts more inclusive." (Fleck, 2016, pg. 174).

In December 2015, the U.S. Department of the Interior (DOI), through the Bureau of Reclamation and National Park Service, issued a Public Draft of the *Glen Canyon Dam Long-Term Experimental and Management Plan Environmental Impact Statement* (DEIS). The DEIS identifies and analyzes the potential implications of alternative ways to manage monthly and hourly releases of water from GCD, focusing chiefly on changes in resources directly along the Colorado River in the reach below the GCD. The alternatives considered include "no-action" (continuation of current policy), and a range of alternative actions that would achieve different objectives. Under the "no-action" alternative (Alternative A in the DEIS), release volumes are determined by historic monthly patterns that are (partially) responsive to peaks in demand for electricity. The DOI's "preferred alternative" (Alternative D) would establish condition-dependent flow and non-flow actions that would be triggered by resource conditions. In either case, the way GCD is operated will have a range of effects that are likely to have diverse implications for U.S. residents. Some of these effects may be observed in market prices (e.g., the change in value of the electricity produced at the GCD), but other effects will occur in non-priced goods that U.S. residents may value, but not directly use (such as preservation of culturally significant sites along the river, or sustaining iconic rural ways of life).

Recognizing the importance of non-use values, the DOI commissioned a national survey-based choice experiment stated preference study of non-use values for the alternatives listed in the DEIS (Duffield et al., 2016). The DOI-commissioned study includes comparisons made to the earlier national survey-based contingent valuation analysis of Welsh et al. (1995). However, that analysis considers an even more restricted set of dimensions of non-use value than those examined in the initial studies (i.e., Welsh et al., 1995). In particular, the DOI-commissioned study only analyzes the potential effects of GCD operational changes on downstream riverside beaches and populations of native and non-native fish in the narrow stretch of the Colorado River below the GCD (Duffield et al., 2016:11). Because of this restriction on non-use considerations, the study does not allow for a complete expression of the diversity of non-use values held – some of which may be traded off against each other in the full population. Moreover, households that prefer the current policy (or operational pattern) are not given an opportunity to indicate their willingness to pay for preserving the current policy, even when these households appear to represent a significant fraction of the population. As a result, the study is unable to provide a net estimate of WTP for any one alternative, relative to current policy.

The failure to consider the full array of relevant non-use value considerations associated with the operation of the GCD, and the failure to include non-use values for hydropower operations, is inconsistent with considerable evidence of public preferences. 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 et al., 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). Our concern is that the exclusion of a fuller array of non-use value considerations – which if considered might increase *or* decrease WTP for changing CGD operations – has significantly affected the estimations of non-use value for the proposed changes in the operation of the GCD.

The objective of this analysis is to demonstrate how a more inclusive approach can be applied to understanding and measuring the full range of dimensions of non-use value, and provide a more accurate picture of the implications of operational changes to the GCD. The dimensions of non-use value in this research project are intended to be comprehensive, or more fully synoptic, reflecting the first necessary feature of an analysis of the array of values likely to be affected by changing the operation of the GCD. In addition to including the effects on riverside beaches and fish, this study also includes the effects of proposed operational changes to GCD on riverside vegetation/wildlife, recreation and tourism, cultural sites and Native Americans, non-pecuniary externalities associated with hydropower, air quality (including visibility, health effects, and climate change), governance, and preserving the traditional ways of life of farmers, ranchers, and associated rural Western communities.[1] Previous work provides both theoretical and exploratory empirical evidence (Loomis, 2014; Jenkins-Smith et al., 2015; Jones et al., 2016) that U.S. households value these dimensions, and this informed their inclusion in the study.

Embedded within a highly-detailed, multi-step protocol developed over several years, the analysis described in this report estimates the non-use values associated with operational changes to the GCD using a survey-based contingent valuation (CV) method, and a national advisory referendum format (Carson & Groves, 2007). Our specific valuation exercise is based on an approach for conducting CV exercises in a manner consistent with the decision structure typically faced by policymakers (Carlson et al., 2016). In doing so, our analysis recognizes and accounts for the diversity of preferences and the different sources of non-use values across options for dam operations—the second necessary feature of an analysis intended to inform decisions over GCD operations. In brief, the approach starts by presenting survey respondents with information on the effects that are likely to occur under the current operational system and the effects that are likely to occur under the proposed operational change. It then provides respondents with an opportunity to indicate whether—given the likely effects under each operational regime—they would prefer to

[1] Preservation of distinctive and culturally iconic ways of life, attached to particular resource production patterns, can take on non-use value in the form of paternalistic altruism (Jones et al., 2016; Loomis 2014, McConnell, 2007).

continue with current operations or adopt the proposed operational change. The exercise closes by asking respondents whether they would vote for or against their preferred policy option, at a cost of a randomly selected dollar amount, to implement the changes or continue the current pattern of operations. The data generated from this exercise allow for a direct estimate of household willingness to pay (WTP) for maintaining current operations, relative to the DOI's "preferred alternative" in the DEIS (and vice versa). More importantly, the approach allows for combining the two estimates to provide an estimate of *net* household willingness to pay for a continuation of current policy.

This approach to measuring non-use values is appealing for at least two reasons. First, in contrast to the traditional approach to CV, which has several limitations for the purposes of informing policy decisions (Carlson et al., 2016), this approach is designed to mirror the structure of decisions faced by policymakers and provide evidence that is directly relevant to those decisions. Second, as discussed above, this approach to non-use valuation explicitly recognizes and incorporates the potential for the diversity of non-use values that exist across options for dam operations. It recognizes that some respondents may prefer to continue current operations while others may prefer operational changes. The typical approach to CV assumes that individuals not valuing a proposed operational change have a $0 willingness to pay (see, e.g., Duffield 2016), but this is inconsistent with the reality of contested policy settings where individuals may actively oppose the proposed change. Bounding minimum WTP to $0 may be a reasonable approach if the proposed change can be rejected or easily avoided by potentially affected individuals. However, in the case of a non-rejectable good (Loureiro et al., 2004), such as a change in dam operations that affects a complex bundle of non-market values, it is problematic to constrain the analysis to only investigate non-use values for changing dam operations—individuals may hold strong preferences for continuing the current regime. The approach employed in this study relaxes this constraint and explicitly estimates the values that individuals place on each option for dam operations. As such, it allows for a more useful estimate of the *net* societal non-use value for maintaining current operations of the GCD, compared to adopting the proposed alternative.

This report details the findings of the study described above. Section 2 describes the protocol for identifying and characterizing the dimensions of non-use value included in the study. In particular, it describes how an in-depth review of the literature, analysis of Congressional hearings, stakeholder value elicitations, and pilot experiments contributed to the identification and characterization of these values. Section 3 presents the results of a nationwide survey that validated the inclusion of the dimensions identified by the protocol described in Section 2. It also details the sample, data, and methods that underlie the results and briefly discusses their implications. Section 4 presents the results of a nationwide random probability sample survey designed to allow for the estimation of median household WTP for both maintaining and changing dam operations, as well as the median household net WTP to maintain current operations. The final sections of the report present some concluding remarks (Section 5) and provide references (Section 6) as well as relevant Appendix material (Section 7).

2. Identification of Non-Market Value Dimensions

2.1 Background

The operation of large dams on a river system generates many benefits, from flood control, water storage and diversion (e.g., supporting irrigated agriculture and the ways of life of dependent communities), to reservoir recreation and hydropower production. Hydropower provides further ancillary benefits as a renewable, highly flexible, non-fossil fuel source in an energy grid or portfolio (Matek, 2015; Key et al., 2013; and Pizzimenti & Olsen, 2010). There can also be a variety of significant negative effects, such as the alteration of downstream riverine ecosystems and environmental flows. Operational patterns on a river system are therefore likely to generate a mix of both benefits and costs, differentially affecting diverse households. For example, operational patterns may endanger some fish species and habitats, while a new recreational fishery emerges elsewhere in the system. Likewise, differing communities and cultural aspects can be both enhanced and degraded, both on the river and in connected geographies. With changing circumstances (e.g., population growth, drought, climate change) and social concerns (e.g., availability of low-cost, renewable energy), resource management agencies confront questions of the potential re-purposing of river basin systems or of operational changes of existing hydroelectric dams. Inherent trade-offs often exist between, say, riverine protection and recovery of pre-development conditions on one hand versus renewable hydropower production and water diversions and delivery on the other. These kinds of tradeoffs are well-documented in the mutually exclusive value expressions contained in broad compilations of "desired future conditions" for GCD operations and the downstream river system (see Colorado River Study Group, 2016).

Large, complex, highly-engineered river systems represent excellent examples of coupled human and natural systems (CHANS)—complex systems comprised of human and environmental interactions (Liu et al., 2007). By construction, CHANS management will affect environmental as well as non-environmental goods and services. The science of CHANS focuses on the patterns and processes that link human and natural systems, including reciprocal interactions and feedbacks, and understanding scale phenomena (Liu et al., 2007). Periodically, re-consideration of the current operational patterns of key engineered-elements, e.g., dams and diversionary structures, etc., of these rivers is either desired or legally required. In the U.S., this can range from federal dam re-licensing, to re-examining the legally-allowed purposes for a system of reservoir operations, to required or needed updating of Environmental Impact Statements, as is the current case with the GCD. The GCD, with the Lake Powell Reservoir behind it and its downstream reaches below, leading into the Grand Canyon, represents a key operational element in the broader system, with irrigation diversions and hydroelectricity production and delivery into the Western Electricity Grid extending out across a broad multi-state region. As a CHANS, significant operational changes on the GCD will have ripple effects across the region.

For economic analyses, the sides of this analytical ledger will include a variety of effects; these can be both direct and indirect, and market and non-market in nature, and consideration of non-use values expands the perspective. Non-market valuation refers to attempts to assign monetary values to goods or services not priced or traded in a functioning market (Boyle et al., 2003). Efforts at fully assessing non-market values include survey-based, stated preference assessments of non-use values, also referred to as "passive use values," which are not attached to any direct in situ use of the good or service (e.g., see Harpman et al., 1995; Loomis, 2005). Non-use values may be composed of bequest, option and existence values (e.g., values from simply knowing that something exists). The original introduction of non-use values into required governance assessments and economic analyses of proposed changes to river systems played an important role in more fully considering environmental effects in the U.S. and elsewhere (Harpman et al., 1995; Welsh et al., 1995, Berrens et al., 1996; Loomis et al., 2005). For example, consideration of non-use values can greatly expand the set of affected geographies and populations, which is important for projects that may be federally-supported or authorized. On the other hand, the presence of non-use values is not restricted to environmental preservation or conservation effects, as applications are now commonly seen to a wide variety of social effects, rural ways of life and working landscapes (Berrens et. al., 1998; Kallas et al., 2007; Kopp, 1995; Lockwood et. al., 1994; Noonan, 2003; Willis, 2013; Bennett et. al, 2004;

Bergstrom & Ready, 2009), including even measured non-use values for publicly-funded downtown sports stadiums (Johnson et al., 2012). Further, they are neither necessarily restricted to environmental effects on any particular location or river stretch in an inter-connected system, nor to any exclusive value frame, perspective, or ideology, across a contested public policy domain.

Understanding non-market monetary values—including non-use values—for proposed operational changes has become an important way to inform decisions on resource management. However, historically what has <u>not</u> been measured and included in operational change assessments are non-market values connected to altered hydropower production. Yet, it is not uncommon to see community groups identifying a bundle of important values connected to dams and hydropower, many of a non-market nature with potential for non-use values (e.g., CREDA, 2010). For example, as communities have optimized around current operations and renewable hydropower production, changes could affect rural electricity dependence, creating social and cultural disruptions. Operational changes to dams may disrupt rural livelihoods and ways of life (e.g., ranching, family farming) that individuals see value in preserving (a non-use value in the form of "paternalistic altruism" as defined in Loomis [2014]). Operational changes to hydropower may also alter the use of a renewable energy source, or affect the ability to add other intermittent renewables (e.g., wind and solar) in an electricity grid (Matek, 2015; Key et al., 2013; Pizzimenti & Olsen, 2010).[2] These values may take the form of non-use values, which might be traded off with other non-use values (Klingmair et al., 2015; Jones et al., 2016).

When non-use values are brought into analyses the affected geographies and populations are greatly expanded, restricted only by legal standing (e.g., in a defined benefit-cost analysis). For operational changes on large dams in federally-regulated river systems, this standing moves out of a regional context and into a national sample. Therefore, decisions about the kind or type of non-use values (and the segments of a diverse population who hold them) that are included in economic analyses of operational changes are critically

[2] See Gowrisankaran et al. (2016) for the significant social costs associated with intermittency in an electrical power grid.

important and require careful and explicit consideration. Nevertheless, such decisions are often hidden in interpretations of a small set of focus group participants, buried in the survey design, and otherwise obscured. Yet, inside a CHANS, we might reasonably expect that an array of distinct kinds of non-use values, attached to the preferences of diverse populations, will be held for the multi-dimensional changes derived from operational alternatives.

Measuring survey-based non-use values for the effects of operational changes in selected, singular stretches or components of complex CHANS risks ignoring important social and cultural dimensions of value (e.g., social disruptions to ways of life from particular production patterns), and other environmental values elsewhere in the connected system (e.g., "green versus green" trade-offs) (Jones et al., 2016). This can lead to biased net willingness to pay (WTP) estimates for proposed operational changes, biased benefit-cost analyses (BCAs) and hence misinformed/inefficient policy outcomes. Measurement of non-use values needs to be done with an *inclusive approach* that is not biased towards one value frame in contested, multi-dimensional policy domains.

2.2 Summary of Approach

Providing decision makers with useful, valid information about the effects of operational changes on non-market, non-use values within a complex CHANS requires that the full array of potentially affected non-use values be considered. To implement such an approach, this section describes the protocol used for identification, characterization, and validation of relevant categories or "dimensions" of non-use value that are included in the survey scenarios we use in our contingent valuation exercise. We designed this protocol to systematically identify the array of resources to be characterized and valued, reducing the likelihood that key non-use value dimensions are excluded. Leaving out key dimensions of value (DOV) can result in biased and misleading estimates of non-market values. This protocol is also designed to evaluate the salience of identified DOV by members of the public, in order to ensure that irrelevant dimensions (those of little or no importance to the public) are excluded from the analysis. In this section, we describe the replicable protocol that we use to identify and characterize those dimensions that are (a) grounded in economic theory, (b) consistent with expert understanding of potential changes expected to result from the operational change, (c) evident in systematic analyses of public discussion about the issue, and (d) salient for expressions of willingness to pay for the identified changes induced by the operational change.

2.3. The Need For a Comprehensive and Replicable Protocol

In estimating non-use values, the "good" that is being valued is the bundle of effects or impacts that an operational change has on resources *for which members of the affected public may hold non-use values*. In a CHANS, programmatic changes often produce multiple impacts that positively or negatively affect the discrete (but operationally connected) arguments in a given individual's utility function. For example, consider individual (i) in equation 2.1.

$$\boldsymbol{u_i^1 - u_i^0 = f(\Delta q_1, \Delta q_2, \Delta q_3, \dots \Delta q_n)} \qquad (\mathbf{2.1})$$

Her change in utility resulting from the operational change ($u_i^1 - u_i^0$) is a function of the changes across multiple dimensions of value (Δq) that she attaches to some number (n) of valued non-use resources affected by the operational change (i.e., beaches, visibility, fish, and health). The nature and sources of these values can be quite diverse, ranging from existence value for environmental resources to "paternalistic altruism" for social and cultural resources (see reviews in Loomis, 2014; Lowry et al., 2016). A single programmatic change may lead to improvements along some DOV but decrements on others (i.e., an operational change may increase the size and stability of beaches, but decrease access to portions of a river). Thus, to determine her "net" change in utility ($u_i^1 - u_i^0$), one must account for changes in all of the resources she values (e.g., beaches, habitat and a renewable source in the energy portfolio). If in aggregate, the positives outweigh the negatives, her utility increases; if negatives outweigh the positives, her utility decreases; and if the negatives and positives exactly offset one another, then she is indifferent to the change.

Furthermore, in stated preference settings, if a DOV relevant to an individual (in that changes to the omitted value dimension affect utility) were to be excluded from equation (2.1) then the net change in utility captured by the researcher would be biased; the latent change in net utility may be different than what is observed when relevant value dimensions are ignored. For instance, imagine in a hypothetical scenario wherein identical stated preference surveys for changing dam operations were conducted except that in one survey a change in some d_j value dimension was described whereas in the other survey it was omitted. If Δdj was universally perceived as a utility increment, then it follows that

$$\boldsymbol{u_i}(\Delta \boldsymbol{d_j}, \Delta \boldsymbol{q_n}) > \boldsymbol{u_i}(\Delta \boldsymbol{q_n}) \qquad \textbf{(2.2)}$$

which says that the utility change after implementation of the policy would be larger for the same individual in the case where the increment was described than in the case where it was omitted. Clearly, omission of $\Delta \boldsymbol{d_j}$ in this instance would lead to a downward biased estimate of WTP for the policy change because the good to be valued has been mis-specified. Conversely, in cases where $\Delta \boldsymbol{d_j}$ is perceived as a decrement, estimated WTP when the decrement is ignored would be upward biased (e.g., hydropower production would be reduced by the change in dam operations, which would lower an individual's WTP for the change if both the change in hydropower were described to them in the survey **and** they obtained non-use value from hydropower).

As noted in the prior section of this report, the inclusion of the relevant array of DOV is of particular importance when the public holds diverse values for the policy change in question and when individuals cannot escape (or "opt out" of) the effects of that change. In that case, the policy change will result in net gains for some and losses for others. This situation requires that analysts recognize the diversity of non-use values, identify the relevant array of potential DOV, and allow respondents to choose a preferred option (change or not change) and place a value on that option relative to the "unpreferred" option (as demonstrated in Carlson et al., 2016). Many applications of non-market measurement and analysis under conditions of diversity of values fail to do this, and therefore produce biased analyses of prospective net non-use value changes.

As noted, operational changes to the GCD are made within a complex CHANS, in which an alteration may lead to ripple effects across natural and social systems. Thus, we designed a survey protocol to measure the implications of changes across an *array* of DOV. Some of these changes would potentially be perceived as positive and others negative (Jones et al., 2016; Carlson et al., 2016). The challenge for survey design is that omission of relevant effects (and, therefore, omitting relevant DOVs) is likely to bias non-use valuations of an operational change, while including irrelevant effects may overwhelm the survey respondents—leading them to reject, misinterpret, or ignore the scenario when formulating and expressing these valuations. The challenge for researchers is to systematically identify the array of resource changes that may influence non-use valuation, while assuring that survey respondents are not overwhelmed by the number and description of these resources/changes. The protocol we describe, and employ in this study, is designed to achieve both of these ends.

While approaches for designing the scenarios presented to survey respondents in contingent valuation (CV) exercises have varied, they generally employ a combination of (a) expert elicitation coupled with (b) qualitative interviews and focus groups, followed by (c) survey pilot tests (Boyle, 2003). The elicitation of expert opinion is often employed to identify and characterize the linkages between operational changes and resource levels, while the use of qualitative focus groups is intended to provide input and/or validation of the extent to which these changes are linked to non-use DOV. Once scenarios are crafted, pilot surveys are used to validate the effects of scenario variation (i.e., variation in cost) on expressed valuation. What remains unknown is whether the full set of resource changes and corresponding DOV have been identified for inclusion. Alternative studies, using somewhat differing scenario design protocols and different sources of expert advice, might identify different sets of resources and DOV for inclusion in the survey scenario. What is needed is a more *comprehensive* and *replicable* protocol that reduces the likelihood that relevant resource changes and non-use DOV are omitted, and assures reasonable comparability of the scenarios that would be developed and employed by different non-market valuation researchers and provided to decision-makers.

2.4 A Multi-Method Approach to the Identification and Characterization of Dimensions of Non-Market, Non-Use Value

Building on a prior theoretical review of potential effects related to hydropower (Loomis, 2014), and initial empirical experiments (Jones et al., 2016; Jenkins-Smith et al., 2015), the protocol employed in this study uses five distinct sources of evidence to identify, characterize, and corroborate the linkages between potential operational changes to the GCD and non-use values:

1. The Public Draft of the Glen Canyon Dam Long-Term Experimental and Management Plan Environmental Impact Statement (DEIS);
2. An analytical review of relevant research on non-market valuation, prepared by scientists at Sandia National Laboratories and the University of New Mexico (Lowry et al., 2016);
3. Statements made in Congressional hearings on issues associated with hydropower and water storage;
4. A survey of engaged stakeholders that represent a diverse array of perspectives on Glen Canyon Dam operations; and
5. A representative survey of the U.S. public

As a whole, these sources of evidence allow for the identification and characterization of the DOV that should be included in a comprehensive and replicable CV exercise that is designed to measure non-use values associated with changes to the operations of the GCD. Systematic analysis of the evidence provided by these sources accomplishes four critical tasks: (1) reduces the likelihood that potentially important DOV that are affected by changing dam operations are omitted; (2) allows for a characterization of how these DOV may be impacted by different operational alternatives to the GCD; (3) provides information about the relative importance of each DOV to members of the public (permitting systematic evaluation of whether each DOV is of consequence for non-use valuation before inclusion/exclusion in the CV survey); and (4) indicates respondents' ability (or inability) to understand the researcher's characterization of the effect on the DOV, as described in a survey setting. This section of the report describes our use of the first four sources of evidence to accomplish the first two tasks—identify and characterize the DOV that may influence individual willingness to pay (WTP) for two alternatives for operating the GCD described in the DEIS, alternative A, the "no-action alternative" and alternative D, the DOI "preferred alternative." Section 3 of this report employs an experimental design in a representative survey of the U.S. public to identify the DOV that are relevant to public preferences for alternative A or D, and analyzes respondent ability (and willingness) to read and understand the description of the effects of options A and D on each DOV when choosing the alternative they prefer.

2.4.1 Draft Environmental Impact Statement (DEIS)

As required by the National Environmental Policy Act of 1969 (NEPA) and subsequent amendments, federal agencies must prepare Environmental Impact Statements (EIS) that describe the environmental effects of all actions that significantly affect the human environment. As part of this process, NEPA requires that agencies start with a "public scoping process," where stakeholders and members of the public are given an opportunity to provide input on the concerns that should be addressed in the EIS. Public concerns often (but not always) fall into one of three categories: ecological concerns, social concerns, and economic concerns. In theory, the research included in the EIS should (among other things) characterize the impact of each alternative (possible action) on the range of concerns that were identified in the scoping process (see, e.g., Eccleston, 1999). These steps, as outlined by NEPA, are designed to identify and characterize a comprehensive list of the concerns that ought to be considered when making a policy decision. In some cases, these concerns are rooted in non-market values that are not reflected in market prices, such as concerns about aesthetics, ecological diversity, history, or culture. As such, the DEIS provides a natural starting point for identifying and characterizing the DOV that may influence household WTP for the "no-change alternative" and the "preferred alternative."

A review of the DEIS indicates that the "no-change" and "preferred alternative" may differentially impact the following resources:

- River beaches and water hydrology
- Native and non-native fish
- Vegetation and wildlife
- Recreation and tourism
- Native American cultural resources
- Hydropower
- Air quality/visibility
- Greenhouse gas emissions

The DEIS scoping process thus provides evidence that members of the public hold non-market values for all of these resources, so (at minimum) these DOV should be represented in a CV exercise that is designed to measure relative preferences for and valuations of the alternatives (DEIS, 2015). In addition to identifying these DOV, the DEIS characterizes the predicted impact of each alternative on each resource. This information informed the description of the impacts used in the CV survey (see Appendix 2 for the description of the resources). We use the DEIS to identify the "base" set of DOV that should be represented on the CV survey.

2.4.2 Analytical Literature Review

The second phase of our protocol sought to identify and characterize other "candidate" DOV that, if salient to the public, should be represented on the survey. This phase consisted of an extensive literature review, broadly surveying the scientific literature that addresses potential sources of non-use value associated with changes in water storage, river systems, and dams (Lowry et al., 2016; and Loomis, 2014).[3] The review encompassed both substantive categories (the resources) that are impacted by changes in water storage, river systems, and dams (e.g., species loss, shocks to established communities, expected changes in cultural communities, changes in habitat, etc.) and the theoretical bases in economics that link these changes to losses/gains in non-use values (e.g., existence, bequest, altruism, etc.) that are held by members of the public. The review required an evaluation of the published peer-reviewed literature in multiple disciplines. A summary finding of the review is that:

> *Estimates of non-market values that are used to inform decisions regarding dam operations and/or other water management alternatives must consider the entire spectrum of market and non-market values and the tradeoffs (both positive and negative) between those values over time and space, with consideration for shifting preferences in an uncertain environment.* (Lowry et al., 2016:1)

[3] While conducted as parts of a larger research program, none of the authors for this report were authors of these separate, independent prior reviews, each of which included one or more authors with significant experience in non-market valuation. While these types of reviews may seem an obvious prerequisite, it is often challenging to find the most appropriate material. Peer-reviewed work of relevance to social implications and value change in complex systems appears in journals spanning many academic subfields, as is evident in Lowry et al. (2016).

This echoes an argument in Loomis (2014, pg. 5), with respect to the GCD:

> *"[M]anagement of large coupled human-environmental systems requires us to confront the weighing of local impacts (many of which may be non-market in nature) against contributions to regional and even global impacts and trends (many of which may also be non-market in nature).*

Motivated by this point, the analytical review concludes that the following broad categories of resources (all of which hold demonstrable non-use values) may be impacted by changes in water storage, river systems, and dams: water supply, recreation, air quality, environmental resources, social resources, and a category of "other resources" (such as flood control and risk reduction).

The analytical literature review provided a more inclusive set of DOV that could be represented on a CV survey. However, many of the DOV identified are not applicable to this study because (1) they are not impacted by the operational change under consideration or (2) they are impacted, but the impact is similar or does not vary across the proposed operational changes. Note that the analytical literature review corroborated many of the DOV that were included in the DEIS, and are listed above. The additional DOV, not accounted for in the DEIS, include the following:

- Health effects of air pollution
- "Ways of life" for farmers and ranchers tied to a particular distribution of hydropower (as associated rural communities)
- Climate change impacts, and relative reliance on a renewable resource rather than fossil fuels
- Additional ancillary benefits of hydropower (grid flexibility for accommodating resilience)

These DOV (and the associated potential changes resulting from changes in dam operations) were *not* included in the DEIS, and are therefore candidate DOV that require validation on the representative survey of the U.S. public. The analytical literature review was used as the basis for characterizing the impacts of the alternatives on these DOV on the CV survey (see Appendix 2).

2.4.3 Systematic Analysis of Public Comments and Testimony

Policy changes, ranging from proposed legislation to regulatory rule-making, are the subject of formal testimony, spoken comments in open hearings or other forums, and written responses to invitations for public comments (Workman, 2015; 62-75). An important attribute of these forums is that they elicit *reasons* for positions for and against a policy or program option, often with explicit reference to the values that underlie these policy positions. Over many decades, U.S. Congressional hearings on hydropower and/or water storage have elicited arguments from a broad range of stakeholders both in favor of and against modifying the hydropower operations of dams, and the repurposing of rivers. In addition to policy preferences, these arguments reveal information about the DOV that structure and justify these preferences.

The third phase of our protocol included a systematic analysis of the oral and written testimony of 34 Congressional hearings spanning two decades of public input on hydropower, dam operations, and the natural resources, public lands, and affected communities associated with them. The hearings, held between 1994 and 2013, produced 409 testimonies by 269 unique witnesses that represented a variety of non-governmental organizations (both for-profit and non-profit), governmental agencies, as well as state, local, and tribal constituencies. Upon entry into a database, we read each testimony and identified the specific argument that was made for or against the policy or program option under consideration in the hearing. As we read these arguments, we coded the DOV that were described in support of or opposition to a position. In aggregate, these values represent the DOV that the population of witnesses considered when formulating and justifying their positions about hydropower and water storage. The DOV and associated resources that were identified in this analysis are listed in Table 2.1.

Table 2.1: Candidate Dimensions of Value in Congressional Testimony

Dimensions of Value	Resources	% (n)
Culture	*Native American Livelihood and Justice, History/Culture of Hydropower, and Rural/Farming/Ranching Way of Life*	10.3 (42)
Recreation	*Fishing, tourism, rafting, boating, and hiking*	5.9 (24)
Water	*Drinking water/water quality, storage/supplies, flood control/safety, irrigation, water flows, and water rights/ownership*	52.3 (214)
Hydropower	*Reliability of energy production, cost of hydropower, and reduction in air pollution/fossil fuel consumption*	22.2 (91)
Economic	*Sunk costs, localized economic benefits, general costs/expenses, and general savings/revenues*	45.5 (186)
Environment	*Aesthetics, species protection, and habitat conservation*	34.2 (140)
Governance	*Legal expectations, decision making processes, bureaucratic burden, and collaboration*	36.7 (150)

This list provided another, independently derived set of candidate DOV that might be represented on a CV survey. However, several of these candidate DOV are not relevant to this study because (1) they are not impacted by the operational change under consideration (e.g., water availability, irrigation, water rights); (2) they are impacted, but the impact is similar or does not vary across the alternatives; or (3) the impacts represent market, rather than non-market values (i.e., economic arguments about costs/expenses). With these exclusions in mind, the third phase of our protocol identified the following resources as candidate DOV:

- River beaches
- Native and non-native fish
- Vegetation and wildlife
- Recreation and tourism
- Cultural sites and Native Americans
- Hydropower
- Air quality/visibility
- Greenhouse gas emissions
- Climate change impacts of hydropower
- "Ways of life" for farmers and ranchers tied to a particular distribution of hydropower
- Governance concerns

With the exception of governance concerns (affecting non-use values associated with previously negotiated arrangements, expectations, and authority in the decision making process), all of these resources were independently identified in the DEIS and/or the analytical literature review. This convergence of listed resources across different streams of evidence increases our confidence that we have identified the primary and recurrent DOV that, over the last several decades, have shaped preferences for dam operations in the U.S.

2.4.4 Survey of Stakeholders from a Diverse Array of Perspectives

The list of candidate DOV obtained from the analytical literature review and Congressional hearings, as described above, pertains quite broadly to issues concerning hydropower and water storage. The next step was to ensure that these dimensions are of relevance specifically to the GCD case, and that important DOV have not been omitted. This was accomplished by engaging stakeholders from a wide range of perspectives about their assessments of the DOV directly implicated by prospective changes in GCD operations, as described in the DEIS.

The choice of which stakeholder groups to engage was based on (a) the group members' knowledge of the interactions within the complex system that may affect aspects of non-market values in response to policy and program changes, and (b) their informed insights on potential DOV that did not appear in either the literature review or the analysis of public testimony. We implemented a web-based survey of stakeholders in March and April 2016, to all listed members of the steering committees of three Colorado River stakeholder groups, including a farm association, a species conservation group, and an electric power distribution association.[4] The stakeholders were asked to assess the *importance* of the effects identified in the literature review and from the Congressional hearing testimony, and were then asked *if any other important effects* need to be added to the list.

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[4] The Office of the Vice President for Research at the University of Oklahoma funded the design and implementation of the stakeholder survey. The survey was implemented under a design protocol that was approved by the OU Institutional Review Board.

Overall 34 respondents (some of whom aggregated responses for several members of their respective groups) agreed to take the survey, out of a complete list of 148 individuals, for a 22% response rate.[5] The survey introduction briefly described the categories of prospective changes that may result from changing the operation of the GCD as specified by the DEIS preferred alternative, followed by this summary statement:[6]

> *This is a very brief summary of a complex set of changes. An extended description of these changes can be seen in a draft government report on the impacts of the proposed change in operations of the Glen Canyon Dam. This report can be accessed on the web at http://ltempeis.anl.gov/documents/draft-eis/Executive_Summary.pdf.* [20% of respondents clicked the link]

Respondents were then asked to rate the importance of these changes in making judgments about how the GCD is operated:

> *Government officials will need to decide whether to change the operation of the Glen Canyon Dam. In your view, how important should the following effects be in reaching a decision about whether to change dam operations?*

Each potential effect was rated on a scale from *not at all important* (0) to *extremely important* (10). The mean values for the importance ratings are shown in Table 2.2. Results indicated that some effects (i.e., water storage and hydropower production) were clearly seen as more important than others (i.e., riverside habitat and cultural values). Nevertheless, all of the effects were rated above mid-scale (5), indicating that they warrant consideration for the CV survey.

[5] The 22% response rate is an estimated lower bound, because it counts groups of respondents who jointly answered the survey as a single completed survey.
[6] See Appendix 2 for these descriptions.

Table 2.2: Importance of Effects for the Decision to Change Dam Operations

Dimension of Value	Sample Mean
Water storage	9.1
Hydropower production	8.6
Sustainable rural communities	7.2
Air emissions	6.4
Endangered fish	6.2
Recreation	5.2
Riverside habitat	5.1
Cultural values	5.1

Following the rating exercise, the stakeholder survey respondents were asked:

> *Can you think of any other effect that government officials should take into account in deciding whether to change dam operations that is not included in the list provided above?* [35% of respondents said yes, they could think of other effects]

Responses to this question fell into one of three categories:

1. **Hydropower replacement**: "The cost of replacing the lost hydropower production capacity. Who bears those costs? What is the effect on tribal and minority or low-income populations from this shift?"
   "Maybe it's included in "hydropower production" issues, but the uses and values associated with the revenues from power production are critical (e.g., salinity control, recovery program for [endangered] fishes)."

2. **Social inequalities**: "Some of the impacts resulting from the change in operation of the facilities at Glen Canyon may benefit persons who can afford to fish the river and raft the river whereas those changes will increase the price of electricity and possibly decrease the availability of water for irrigation which may have a far greater and far reaching impact on poorer people living in rural agricultural communities that are dependent on those resources."
   "Economic and social impacts on area and local residents."

3. **Governance and existing agreements**: "Complying with existing Law of the River and meeting water delivery obligations."
   "Overriding the proposed management changes at Glen Canyon Dam is BoR's Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lakes Powell and Mead - good to 2026. The proposed action may not interfere with this, but should be taken into account."

When combined, the quantitative and qualitative responses to the stakeholder survey indicate the following resources and corresponding DOV merit consideration for inclusion on the CV survey:

- River beaches (riverside habitat)
- Native and non-native fish (endangered fish species)
- Vegetation and wildlife (riverside habitat)
- Recreation and tourism
- Cultural sites and Native Americans (cultural values)
- Hydropower
- Air quality/visibility (air emissions)
- Greenhouse gas emissions
- Human health (air emissions)
- "Ways of life" for farmers and ranchers tied to a particular distribution of hydropower (sustainable rural communities and social inequalities),
- Climate change (air emissions)
- Governance (and existing agreements)

Though rated as important by stakeholder survey respondents, water quality was removed from the list because the DEIS indicates that water quality will not be impacted by the GCD operational change under consideration. All of the DOV that were identified by respondents to the stakeholder survey were identified in at least one other source of evidence, suggesting that (1) the list of values that have been identified is relatively comprehensive, and (2) the values are of relevance to the GCD case and the operational decision at hand: the "no-change alternative," or the "preferred alternative" as described in the DEIS.

2.5 Conclusion

Provision of useful and valid information on the effects of operational changes on non-use values within a complex CHANS requires that a complete array of potentially affected values (DOV) be considered. This section of the report has outlined how we implemented a systematic approach to the identification and characterization DOV that is both comprehensive and replicable. Table 2.3 summarizes the results of our analysis by listing the DOV that were identified, the source(s) of identification, and the source of our characterization. If other researchers were to implement our protocol, we are confident that they would develop a similar list of DOV.

Table 2.3: Dimensions of Value by Source of Identification and Characterization

Dimension of Value	Source(s) of Identification	Source(s) of Characterization
River Beaches	Literature review, public hearings, stakeholder interviews	DEIS
Native and Non-Native Fish	Literature review, public hearings, stakeholder interviews	DEIS
Vegetation and Wildlife	Literature review, public hearings, stakeholder interviews	DEIS
Recreation and Tourism	Literature review, public hearings, stakeholder interviews	DEIS
Cultural Sites and Native Americans	Literature review, public hearings, stakeholder interviews	DEIS
Hydropower	Literature review, public hearings, stakeholder interviews	DEIS
Air Quality and Visibility	Literature review, public hearings, stakeholder interviews	DEIS
Greenhouse gas emissions	Literature review, public hearings, stakeholder interviews	DEIS
Health Effects of Air Pollution	Literature review, stakeholder interviews	Literature review
Farmers, Ranchers, and Associated Rural Communities	Literature review, public hearings, stakeholder interviews	Literature review
Climate Change Impacts of Hydropower	Literature review, stakeholder interviews	Literature review
Ancillary Benefits of Hydropower	Literature review	Literature review
Governance	Public hearings, stakeholder interviews	Literature review

The first 7 DOV in Table 2.3 were identified and characterized in the DEIS. At minimum, based on the analysis of the DEIS, the analytical literature review, the coding of Congressional hearings on hydropower and dams, and the stakeholder interviews, all of these values should be represented in a CV exercise that is designed to measure relative preferences for and valuations of the "no-change alternative" and the "preferred alternative" as described in the DEIS for operating the GCD. The additional DOV that we identified through this protocol required validation and testing before they could be included in a CV exercise. Are these additional DOV salient to the public? Does the addition of these DOV lengthen or complicate a CV survey to the point where survey respondents can no longer understand or meaningfully respond to the exercise? Section 3 addresses these critical questions using data from a representative nationwide survey of U.S. residents.

3. Validation of Non-Market Value Dimensions

As described above in Table 2.3, we identified a set of non-use social, environmental and cultural dimensions of value that are potentially linked to operational changes in the GCD. These DOV were captured in theoretical (Loomis, 2014) and substantive analytical literature reviews (Lowry et al., 2016), experimental surveys (Jones et al., 2016), analyses of Congressional hearings, and in our survey of stakeholders. What remains unclear is whether the public at-large perceives this set of DOV, as linked to expected changes in the operation of the GCD, to be salient. For that reason, we first seek to empirically validate that a representative cross-section of the public care about these DOV and the associated changes in resources, and that they find the descriptions comprehensible. We accomplish this using a nationally-representative sample of U.S. residents in a nationwide *value dimension validation survey* (validation survey, hereafter). Results from the validation survey are used to inform the final set of DOV that are included in the nationwide random sample survey, from which (in Section 4 of this report) we estimate *net* household willingness to pay (WTP) for changing GCD operations. Furthermore, the validation survey is used to: (i) test the CV payment design and structure, and; (ii) evaluate respondents' ability to process the information presented in the survey on dimensions of value and proposed changes to GCD operations.

3.1 Sample and Data

We presented the candidate DOV to respondents in a nationally-representative internet-based survey on management of GCD, fielded by the University of Oklahoma's Center for Energy, Security and Society. Survey respondents were randomly assigned to receive one of seven split-sample, experimental information treatments. Survey Sampling International (Fairfield, CT) recruited adult U.S. respondents (≥ age 18) to take the survey online and the final sample had 3,002 responses. Our respondents were recruited to achieve national representativeness for key demographic characteristics (see Appendix 3 for a demographic comparison of survey respondents to the U.S. Census). The survey was fielded from May

18-21, 2016 and took respondents an average of 27 minutes to complete. Respondents were weighted to match 2015 U.S. Census estimates for gender, region, age, and race/ethnicity.[7] Past research has demonstrated that applications of internet surveys to non-market valuation exercises produces results consistent with mail, telephone, and face-to-face interviews (Lindhjem & Navrud, 2011; Berrens et al., 2003 and 2004). Note that we do not intend to estimate national parameters from this sample. Instead, these data are used to inform the design and implementation of the probabilistic, nationally representative survey described in Section 4 of this report.

3.1.1 Value dimension treatments

As shown in Table 3.1, we used seven experimental treatments to assess the salience of candidate DOV. Treatment #1, anchored to the DOV that were included in the DEIS, served as the baseline reference point as this is the relevant policy document currently under consideration for management of GCD over the next 20 years. Treatments #2-#6 independently represented candidate DOV that were not included in the DEIS, but that were identified in the value identification protocol: air pollution and human health (#2), rural community effects (#3), climate change (#4), ancillary benefits of hydropower (#5), and governance (#6). Treatment #7 combined, in one treatment, all of the individual value dimensions, creating a treatment inclusive of the full set of the DOV identified in Section 2 of this report.

[7] The Office of the Vice President for Research at the University of Oklahoma funded the design and implementation of the validation survey. The survey was implemented under a design protocol that was approved by the OU Institutional Review Board.

Table 3.1: Dimensions of Value Surrounding GCD Operations

Dimension (Treatment)	Concept	Sample Size
1. Draft EIS (baseline)	Used attributes and projected changes from Alt. D (preferred alt.) and Alt. A (no change) in December 2015 GCD DEIS	441
2. Adds health and air pollution effects to #1	Adds information and potential effects of changed operations on air pollution and human health	406
3. Adds rural Western community effects to #1	Adds information and potential effects of changed operations on farmers, ranchers, and associated rural Western communities	393
4. Adds climate change effects to #1	Adds information and potential effects of changed operations on climate change	394
5. Adds ancillary benefits effects to #1	Adds information and potential effects of changed operations on ancillary benefits of hydropower	432
6. Adds governance effects to #1	Adds information on governance and the decision making process for changing operations	452
7. Combines #1-#6	Combines information and potential effects from all treatments with base DEIS	484

Note: this table presents names, brief descriptions, and sample sizes associated with the seven informational treatments employed in the validation survey. Each respondent was randomly assigned to only one informational treatment (i.e., split-sample treatments).

Treatment groups differed in terms of the information presented on resources potentially impacted by alternative GCD operations. A baseline set of information derived from the DEIS was presented in all treatments and then additional information as described in Table 3.1 was presented in addition to the baseline. This allowed independent identification of the effects of each dimension of value in treatments #2-#6 on respondents' preferences for GCD operations. Two scenarios were described in each treatment: (i) a change in GCD operations and; (ii) a continuation of current operations (described in detail below). Impacts to resources in the region of changing or continuing operations were described and respondents were then asked which option they would vote for in an advisory referendum at no cost. Then, if they chose to vote for one of the options, they were asked whether they would be willing to pay to obtain that option at a randomly assigned payment level. The primary contrast of interest is between the baseline DEIS (treatment #1) and the inclusive value domain (treatment #7). Specifically, do votes for changing operations at no cost, and WTP for changing operations, in comparison to continuing current operations, substantively differ between #1 and #7? If so, the findings would indicate that value dimensions omitted from the DEIS are an important component of non-use values for re-purposing the GCD.

3.1.2 The survey instrument

Respondents were randomly assigned to one of seven treatments at the beginning of the validation survey. For all treatments, the survey began with a description of the region around the Glen Canyon Dam, including the Colorado River immediately below the dam, Grand Canyon National Park (nine miles downstream from GCD), Lake Powell (the reservoir created by GCD), and the seven U.S. states that receive supplies of electricity from GCD hydropower (Arizona, Colorado, Nebraska, Nevada, New Mexico, Utah, and Wyoming). Maps were presented showing the geography of the region and location of the dam relative to other landmarks (see Appendix 1).

Information on GCD was provided and respondents were told that government officials are currently considering two options—called "Option A" and "Option B"—to manage operations of the dam over the next 20 years. For ease of exposition in this report, "Option A" will refer to a change in dam operations while "Option B" is a continuation of current operations. In the actual survey, the options were randomized for each respondent so that they were unaware whether A or B represented changing or continuing dam operations. This was done to prevent status quo bias (Kahneman et al., 1991) and order effects (Krosnick & Alwin, 1987).

Survey Option A, what we term "changing operations," was based on Alternative D in the DEIS; designated the "preferred alternative" by the U.S. Department of the Interior (DOI). This option, if implemented, would result in patterns of GCD water releases that further moderate flows of the Colorado River. Additionally, Option A included expansion of so-called "high-flow experiments" that increase sediment flows, as well as new fish management tools, and new riparian vegetation treatments. This option is condition-dependent, meaning that GCD managers are allowed to experiment and test various flow regimes in response to learning. Triggers and objectives of success of Alternative D are defined in section 2.2.4 of the DEIS (DEIS, 2015, pgs. 2-48 to 2-52). In general, Option A, if implemented, is projected to slightly improve environmental conditions (i.e., endangered fish, native vegetation, wildlife, etc.) in the Colorado River downstream from GCD and reduce erosion of river beaches and cultural sites. This could come at the expense of reduced hydropower output and the potential for reduced river and lake recreation.

Option B, what we term "continuing current operations," was based on Alternative A in the DEIS; the "no-action alternative" (DEIS, 2015, pgs. 2-8 to 2-19). This represents a situation in which the DOI would not modify existing decisions related to operations. GCD would continue to be managed according to the 1996 Record of Decision and other small changes implemented by the DOI in 2007 and 2011, including limited high-flow experiments. Importantly, Option B represented no change from how GCD is currently managed today. Relative to Option A, Option B would preserve hydropower output and maintain visitor access to the river, but at the expense of not acting to improve downstream environmental conditions.

Before describing the impacts of resources, in order to remind respondents to consider only non-market, non-use impacts in their assessments of the options, we provided the following instruction:

> *Each option may have both market effects (e.g., on general levels of employment, prices, and income) and non-market effects (on things that are not bought and sold in the market, such as effects on the environment, specific communities, and particular ways of life) in the Region. Below we describe non-market effects of each option, and ask that you consider only these non-market effects as you answer the following questions.*

All respondents (no matter their treatment group) were then presented with descriptions of resources in the region around GCD that are impacted by operations of the dam (See Appendix 2). These descriptions were based on the scientific consensus as presented in the DEIS. Resources specifically included were: (i) river beaches; (ii) native and non-native fish; (iii) recreation and tourism; (iv) vegetation and wildlife; (v) cultural sites and Native Americans; (vi) hydropower and; (vii) air quality and visibility. The impact of each option was stated below the text description of each resource. For example, for the hydropower resource, the impacts of Option A (corresponding to changing operations here, though randomized in the survey) and Option B (continuing operations here) were:

Impact of Option A:

- *Reduced production of hydropower.*
- *Increased reliance on electricity produced by fossil fuels in the Region.*

Impact of Option B:

- *No change in the production of hydropower.*
- *No change in the production of electricity from fossil fuels in the Region.*

For respondents randomly selected to receive an informational treatment, we presented an additional page of treatment-specific resource(s), including the impacts of each option. For example, respondents randomly assigned to treatment #2 (air pollution and health) received an additional page of information on the how hydropower produced at GCD has helped improve the health of residents in the region through cleaner air. Option A would lead to more air pollution, potentially negatively impacting health in the region, while Option B would cause no change in air pollution and thus would have no effects on health. Informational treatments were provided *in addition to* the baseline set of resource descriptions that all respondents received.

Following descriptions of how each resource in the region would be impacted by changing or continuing GCD operations (plus any added value dimensions from the informational treatments, if applicable), respondents were asked which option they would vote for in an advisory referendum if it cost them nothing – the $0 decision node:

Think about a situation in which you had an opportunity to vote for Option A or Option B in an advisory referendum. The option with the most support would be recommended to the government officials managing the Glen Canyon Dam. 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 A or Option B?
1 - Option A
2 - Option B
3 - I would choose note to vote for either option

Immediately following this question, respondents were told that the decision on how the dam should be operated could cost their household money through a combination of higher monthly electricity bills for households served by GCD and increased federal taxes on all U.S. residents. Costs to their household would begin in 2016 and would last for the following 20 years. Respondents were then presented with a single-bounded dichotomous choice (SBDC) valuation question and asked if they would be willing to pay the randomly assigned payment amount for their preferred option (i.e., the option they selected at the $0 decision node):

> *You selected ["Option A" or "Option B"]. Both options are costly to operate and will require continued financing. The following question asks whether you, as a taxpayer, would vote for this option in an advisory referendum. The option with the most support would be recommended to government officials managing the Glen Canyon Dam. As you think about your answer, keep in mind the amount of money you and your household would pay for the policy, how much you would be able to afford to pay, and the other things you could spend the money on instead.*
>
> *Would you vote for ["Option A" or "Option B"] if adoption of this option would cost your household [RANDOMIZE discrete payment: $1, $50, $150, $300, $600] in increased taxes every year for the next 20 years?*
> *0 - No*
> *1 - Yes*
> *2 - Not sure*

Voting results for the $0 decision node question and the SBDC valuation question are presented in Table 3.2 by treatment (see Appendix 4 for a full description of the valuation exercise). Across all experimental treatments, there was never a majority (or plurality) of votes supporting a change in dam operations. That is, when respondents were presented with two options, change or continue operations, and the effects of each option on the region around the GCD were described, we found consistent majorities supporting a continuation of current operations. This was true even in the baseline treatment #1 (DEIS); a close approximation of the changes and regional impacts described in the DEIS. Respondents rejected the preferred alternative (change in operations) as described in the DEIS. As dimensions of value were added, support for continuation increased, reaching 73% for the fully inclusive treatment #7 (DEIS + all treatments) compared to 19.4% support for change and 7.6% who would not vote.

Table 3.2: Baseline and Treatment Voting Results for GCD Operational Preferences

	DEIS (base)	Health and Air Pollution	Rural Communities	Climate Change	Ancillary Benefits	Governance	DEIS + All Treatments
Vote to Change Operations	**37.4%**	**25.3%**	**28.0%**	**28.9%**	**27.4%**	**43.0%**	**19.4%**
Would pay >$0 payment amount	*13.4%*	*12.7%*	*14.9%*	*15.5%*	*14.4%*	*20.5%*	*10.0%*
Would not pay >$0 payment amount	*24.0%*	*12.6%*	*13.0%*	*13.5%*	*13.0%*	*22.6%*	*9.4%*
Vote to Continue Operations	**53.7%**	**63.6%**	**61.5%**	**63.5%**	**65.1%**	**49.2%**	**73.0%**
Would pay >$0 payment amount	*23.6%*	*22.1%*	*22.8%*	*32.3%*	*30.5%*	*22.0%*	*36.3%*
Would not pay >$0 payment amount	*30.1%*	*41.5%*	*38.7%*	*31.2%*	*34.6%*	*27.2%*	*36.7%*
Would Not Vote	**9.0%**	**11.1%**	**10.5%**	**7.6%**	**7.5%**	**7.8%**	**7.6%**

Note: this table presents tabulated voting results by informational treatment. “Vote to Change Operations”, “Vote to Continue Operations”, and “Would Not Vote” presents the percentage of respondents who, at $0 cost, selected this as their preferred option for future GCD operations. These values may not sum to 100% due to rounding. “Would pay >$0 payment amount” is the percentage of respondents who indicated that they would be willing to pay their non-zero randomly assigned payment amount for their preferred option. “Would not pay >$0 payment amount” is the percentage of respondents who would not be willing to pay their randomly assigned non-zero payment amount for their preferred option.

Similar trends emerged in response to the SBDC elicitation exercise, as shown in the “would pay >$0” and “would not pay >$0” rows in Table 3.2. A greater percentage of respondents indicated that they would pay >$0 to continue operations rather than pay >$0 to change operations. The difference ranges from 7.9% (for the rural communities treatment) to 26.3% (DEIS + all treatments) in favor of paying a non-zero amount of money for continuation. In treatments where additional DOV were presented to survey respondents, support for paying for continuation of operations increased at the expense of paying for change. For the fully inclusive treatment (DEIS + all treatments), 36.3% of respondents supported continuation of current GCD operations and were willing to pay their randomly assigned payment amount to achieve it, compared to 10.0% of respondents who were willing to pay their payment amount for changing operations. These results suggest that the continuation of current dam operations is the preferred option, even if the respondents face a non-zero cost.

To re-cap, a validation survey instrument, using a consequential advisory referendum voting format, was fielded asking respondents to consider both the environmental downstream impacts of GCD (through river flows) and, through informational treatments, the regional impacts to communities, tribes, air sheds, energy grids, and climate change vis-à-vis potential changes in the sale and distribution of hydropower. Weighing these tradeoffs across two policy options currently being evaluated for how GCD could be managed, Option A and Option B, respondents were asked to choose in an advisory referendum format which option they prefer both at no cost and at a randomly assigned payment level. Based on this design, we learned the relative importance of value dimensions in shaping respondents' preferences for operational preferences. To further explore dam operations preferences across observable characteristics, we now turn to discrete choice regression models.

3.2 Empirical Model of Operational Preferences at No Cost

To investigate preferences for GCD operations across observable respondent characteristics and treatment groups, we use the following discrete choice model,

$$\boldsymbol{P}(\boldsymbol{Vote}_i = \mathbf{1}) = \boldsymbol{\varphi}(\boldsymbol{Group}_i'\boldsymbol{\alpha} + \boldsymbol{X}_i'\boldsymbol{\beta}) \qquad (\mathbf{3.1})$$

where $Vote$ is an indicator variable for whether respondent i voted to change GCD operations (=1) or continue current operations (=0) at no cost;[8] $Group$ is a vector of indicator variables for treatment group assignment; X is a vector of demographic, socioeconomic, and environmental belief characteristics (described in detail below); and $\varphi(\cdot)$ is the logistic CDF.[9] The estimated vector of α coefficients will tell us the independent effects of each treatment group on the probability of voting support for changing operations, after controlling for observable characteristics in X.

Covariates included in X were selected based on previous work on GCD operational preferences (Jones et al., 2016; Welsh et al., 1995). Table 3.3 presents definitions of each covariate and their respective sample summary statistics. In addition to standard covariates for demographics and socioeconomics, we included controls for political

[8] Those who chose the "would not vote" option were excluded from this analysis.
[9] Probit and linear probability models were also applied to equation (1) with similar results on signs and significance.

ideology (*Ideol*) and environmental beliefs (*Hydro, Nature*). We also account for whether a respondent was familiar with GCD prior to the survey (*Heard*) and whether they had visited the Grand Canyon (*VisitGC*). Of note, about one-third of the sample had previously heard of GCD and the majority of respondents believe that hydropower is important. 41% of the sample said they had visited the Grand Canyon in the past.

Table 3.3: Sample Summary Statistics

Variable	Description	Coding	*N*	Mean	Std. Dev.
Vote	Support for changing or continuing current GCD operations	1=change, 0=continue	2740	0.33	0.47
Heard	Respondent has heard of Glen Canyon Dam before survey	1=yes, 0=no	2989	0.32	0.47
VisitGC	Respondent has visited Grand Canyon before survey	1=yes, 0=no	2991	0.41	0.49
Consider	Believes officials will consider survey results	1=yes, 0=no	2977	0.55	0.50
Nature	View of nature	0-10 scale; 0=robust and not easily damaged, 10=fragile and easily damaged	2996	6.42	2.53
Hydro	Importance of hydropower	0-10 scale; 0=not at all important, 10=extremely important	2977	8.43	1.67
Ideol	Political ideology	1-7 scale; 0=strongly liberal, 10=strongly conservative	2991	3.95	1.68
Age	Age	continuous	3002	48.07	16.04
Gender	Gender	1=male, 0=female	3002	0.47	0.50
Income	Annual household income in 2015	continuous	2971	65676.54	47960.21

Note: this table presents summary statistics of means and standard deviations for covariates included in all regression models. Variable *Vote* is truncated to voting respondents only.

3.3 GCD Operational Preferences Regression Estimates

Logit regression estimates of respondent preferences for changing GCD operations at no cost among those who stated that they would vote in the referendum are presented in Table 3.4. Columns (1)-(3) add controls for treatment effect, demographics, and environmental beliefs, respectively. For the full model in column (3), expanded information on value dimensions in treatments #2-#7 (except for #6) significantly reduced the probability that a respondent would vote for changing dam operations; increasing the probability that they would vote for continuation of current operational patterns. The strongest effect is observed for treatment #7, which includes all value dimensions presented in the survey. Respondents in treatment #7 were 13.7% less likely ($p<0.001$) to vote to change operations compared to respondents in treatment #1 (DEIS) after controlling for many observable characteristics. In decreasing order of treatment impact, treatment #3 (rural communities) reduced support for changing operations by 8.6% ($p<0.01$), treatment #2 (health and air pollution) by 7.6% ($p<0.01$), treatment #4 (climate change) by 6.0% ($p<0.05$), and treatment #5 (ancillary benefits of hydropower) by 5.9% ($p<0.05$). When respondents were told that changing operations is the preferred option of the DOI (treatment #6, governance), this increased support for changing dam operations by 6.7% ($p<0.05$) relative to the baseline.

Table 3.4: Logit Regression Estimates of GCD Operational Preferences, Change or Continue (=1 if Preferred Change, and =0 if Preferred Continue)

	(1) Treatment Effect Only	(2) + Demographic Controls	(3) + Environmental Controls	(4) Vote vs. Not Vote
Treatment #2	-0.331**	-0.347**	-0.400**	-0.129
	(0.153)	(0.156)	(0.160)	(0.247)
Treatment #3	-0.413***	-0.407***	-0.452***	-0.030
	(0.155)	(0.158)	(0.162)	(0.254)
Treatment #4	-0.254*	-0.264*	-0.309*	0.040
	(0.152)	(0.155)	(0.160)	(0.260)
Treatment #5	-0.331**	-0.315**	-0.302*	0.270
	(0.149)	(0.152)	(0.155)	(0.267)
Treatment #6	0.323**	0.317**	0.314**	0.397
	(0.142)	(0.145)	(0.148)	(0.270)
Treatment #7	-0.750***	-0.767***	-0.774***	0.178
	(0.153)	(0.156)	(0.160)	(0.256)
Age	-	-0.017***	-0.013***	-0.009*
		(0.003)	(0.003)	(0.005)
Gender	-	0.130	0.101	0.299**
		(0.084)	(0.088)	(0.146)
Income (log)	-	-0.033	-0.065	0.389***
		(0.048)	(0.051)	(0.076)
Ideol	-	-0.046*	-0.041	-0.072*
		(0.025)	(0.026)	(0.044)
Heard	-	-	0.181*	0.521***
			(0.098)	(0.185)
VisitGC	-	-	0.010	0.221
			(0.095)	(0.160)
Consider	-	-	0.260***	0.389***
			(0.090)	(0.143)
Nature	-	-	0.023	-0.024
			(0.018)	(0.029)
Hydro	-	-	-0.207***	0.172***
			(0.027)	(0.037)
Constant	-0.472***	0.806	2.337***	-2.868***
	(0.103)	(0.552)	(0.638)	(0.923)
Pseudo R2	0.0182	0.0346	0.0559	0.0618
N	2740	2708	2647	2878

Note: this table presents results from four separate logit regressions. For columns (1)-(3) the dependent variable is an indicator for whether a respondent voted to change GCD operations (=1), or continue current operations (=0) at $0 cost. For column (4) the dependent variable is an indicator for whether a respondent voted for either change or continue GCD operations (=1), or would not vote for either option (=0) at $0 cost. Columns are increasing in the number of control covariates except for (4). Treatment effects are relative to the baseline treatment #1 (GCD DEIS). ***p<0.01; **p<0.05; *p<0.1.

Respondents of greater age (*Age*) were more likely to vote for continuation of current dam operations. Not surprisingly, preferences for continuation of current GCD operations increased with the level of respondent support for hydropower (*Hydro*). Conversely, those respondents who believe that government officials will consider the results of this survey when setting policy (*Consider*) and those who had heard of GCD prior to the survey (*Heard*), were more likely to vote for changing dam operations.

As a check on the validity of these results, we also ran a logit regression on an indicator variable for whether a respondent voted for *either* change or continuing operations (a voter), or would not vote in the advisory referendum (a non-voter), as shown in Table 3.4, column (4). If respondents were more or less likely to vote in one treatment, then this might suggest a problem with the treatment wording and hence call into question the validity of the results in columns (1)-(3). While there were some demographic and ideological differences between voters and non-voters, there were no differences across treatment groups. This is an important validity check on the information treatment-effect.

3.4 Payment Structure

As part of the validation survey, we also evaluated the performance of the payment structure presented to respondents. For WTP estimation purposes, it is important to have a distribution of payment levels over which Yes/No responses vary in such a way as to provide meaningful information on latent WTP. For example, if all respondents answer No to the highest payment level (e.g., $600) then that provides little useful information for estimating WTP. Determining an appropriate range of payment levels to include in a CV survey using the DC format is perhaps one of the most difficult yet most important tasks (Whitehead, 2006). Results from the validation survey aided us in this regard.

Validation survey respondents were randomly assigned a WTP payment level either from a discrete distribution ($1, $50, $150, $300, or $600) or a continuous uniform distribution ($1 to $600). Discrete payment levels are more common in the CV literature, but recent research suggests improved precision of WTP estimators when the distribution of bids is continuous (Lewbel et al., 2011). We found no statistical difference between WTP responses from discrete and continuous payment distributions (two-sided hypothesis test: $t = -0.6648, p = 0.5062$). Based on this finding, the potential for improved WTP precision, and the fact that the Cameron and James (1987) model that we use to estimate WTP assumes a continuous dependent variable led us to use the continuous uniform distribution in the nationwide random sample survey.

The distribution of WTP responses across the range of payment levels employed in the validation survey were also investigated. We found evidence of "fat tails" in the distribution, wherein we observed a yes-response rate of over 20% at the highest payments offered in the survey. At the highest payment amount of $600, 37% of voting respondents indicated their support for the advisory referendum. At $500, support for the advisory referendum was 42%. Fat tails are frequently observed in the CV literature and the commonly prescribed solution is to increase the highest payment level in order to drive the yes-responses down (Parsons & Myers, 2016). Following this recommendation, we doubled the highest payment amount to $1,200 in the nationwide random sample survey.

3.5 Respondents' Ability to Process the Information Presented in the Survey

A considerable amount of text is required to introduce the resources in the region around the GCD and identify the impact of both changing and continuing current GCD operations on these resources (see Appendix 2). This text can be rather complex, especially for a general population that is unfamiliar with some of the terminology that is often used when describing these resources or impacts. These features can cause survey fatigue and confusion, which adversely affect the quality of survey responses and the validity of stated preference models (e.g., Bradley & Daly, 1994; Swait & Adamowicz, 1996). Given this concern, the validation survey included two sets of questions that were designed to identify confusion and/or fatigue. The first set of questions appeared at the end of each resource/impact description. Each question read as follows:

> *When thinking about the information provided on this page, would you say that you...*
>
> - *Learned something new*
> - *Already knew the information*
> - *Don't understand the information*

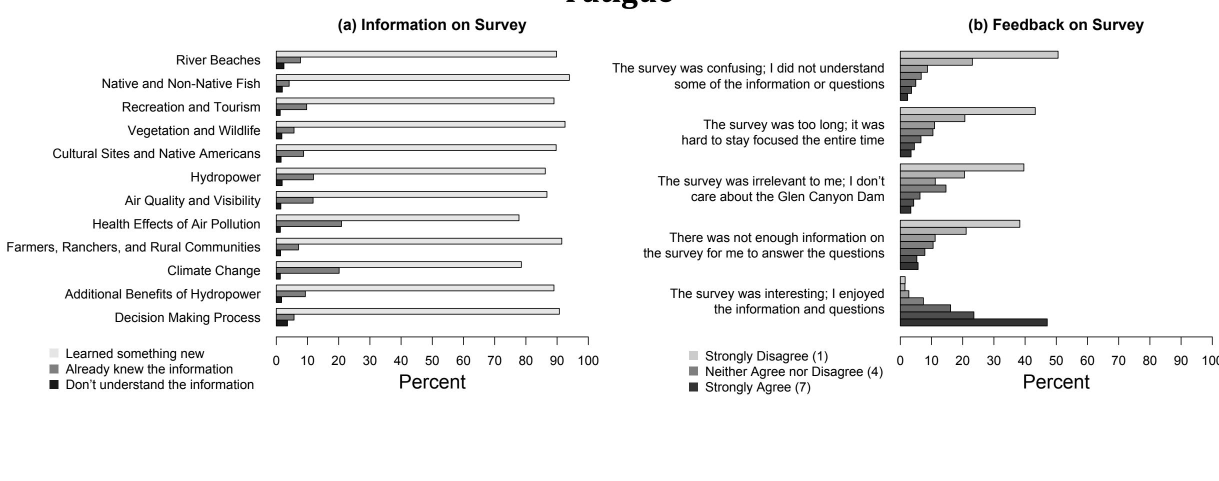
The second set of questions appeared in random order at the end of the survey. They read:

> *To conclude, we would like some feedback on this survey. Using a scale from one to seven, where one means strongly disagree and seven means strongly agree, please rate your agreement with the following statements.*

- *The survey was confusing; I did not understand some of the information or questions*
- *The survey was too long; it was hard to stay focused the entire time*
- *There was not enough information on the survey for me to answer the questions*
- *The survey was interesting; I enjoyed the information and questions*
- *The survey was irrelevant to me; I don't care about the Glen Canyon Dam*

The distributions of responses to these questions are shown in Figure 3.1. As shown in Figure 3.1(a), there is little evidence of confusion among survey respondents. At maximum, only 3.5% of respondents indicated that they did not understand the information that was presented on a given page; in most cases, the percentage was closer to 2% of respondents. Instead, the overwhelming majority of respondents (78% - 94%, depending on the resource) indicated that they learned something new when reading the information about the resources and impacts. This pattern suggests the opposite of survey fatigue; respondents were engaged and interested when reading the information provided on the survey.

Figure 3.1: Distributions of Responses to Questions About Confusion and Survey Fatigue



The distributions of responses shown in Figure 3.1(b) provide further support for these conclusions. Beginning with survey confusion, approximately 82% of respondents *disagreed* (3 or lower on the 7-point disagree-agree scale) with the statement that the survey was confusing, and 71% *disagreed* with the statement that there was not enough information on the survey to answer the question. In other words, survey confusion was not a problem for most respondents. The same is true of survey fatigue. Approximately 75% of respondents *disagreed* with the statement that the survey was too long, 71% *disagreed* with the statement that the survey was irrelevant, and 87% of the survey respondents *agreed* (5 or higher on the 7-point disagree-agree scale) with the statement that the survey was interesting. As a group, these findings provide strong evidence that the information provided in the validation survey did not cause survey fatigue and confusion. As a result, the same information was included on the nationwide random sample survey.

3.6 Implications of Validation Survey Findings

Taken altogether, results from the nationwide validation survey unambiguously demonstrate that in both non-regression (Table 3.2) and regression (Table 3.4) settings, both individually and as a full set, the candidate DOV significantly affect respondent support for future changes to GCD operations. In particular, respondents presented with randomly-assigned informational treatments on how changing or continuing GCD operations would affect rural ways-of-life, Native American tribes who depend on low-cost hydropower, air pollution and human health, climate change, and ancillary services of hydropower were less likely to support change and more likely to support continuation of current operations. On the other hand, understanding aspects of the regulatory process, and that the DOI had provisionally designated the change option as its "preferred alternative," increased support for changing operations. Overall, when presented with the full range of environmental, social, and cultural impacts that changing operations are predicted to have (treatment #7), a majority (73%) of respondents supported maintaining current GCD operations. We find that respondents in the full value dimension treatment (#7) are 13.7% more likely than respondents in the DEIS treatment (#1) to support continuation than change. This provides strong empirical evidence, consistent with Jones et al. (2016), that for a consequential advisory voting referendum, members of the public hold non-use preferences over a broad range of social, environmental, cultural, and governance DOV. As noted earlier, this is to be expected when the change occurs in a complex CHANS such as the GCD region.

There are two main implications of the validation survey for the nationwide random sample survey, where WTP was estimated for U.S. households. First, to various degrees, the six value dimensions considered in the survey (five individual plus one combined set) are materially significant for determining support for GCD operations. Focusing exclusively on changes in beaches and fish populations in the downstream stretch of the river when assessing the benefits of changing GCD operations leads to a biased estimate of public non-use values for the proposed change. Estimates of WTP are needed that are inclusive of the full range of relevant DOV. To this end, all DOV (treatments) were included in the nationwide random sample survey (Section 4).

Second, based on our findings it is evident that some members of the U.S. public hold non-use values for changing dam operations, while others hold non-use values for continuing current GCD operations. This kind of value difference across the public requires that *both sides of the analytical ledger* be accounted for in estimating net non-use values of the public. It is therefore not sufficient to simply include a broader set of value dimensions if the exercise is limited to valuing either change or continuation alone. Ignoring either side of the analytical ledger can lead to biased estimates of household WTP and misinformed policy (Carlson et al., 2016). This is consistent with the need for caution when employing contingent valuation in any policy domain (e.g., Carlson et al., 2016; Jones et al., 2016) where segments of the public have divergent preferences, for and against major policy changes, and when the good in question is "non-rejectable" (e.g., dams, nuclear waste facility siting, repurposing river systems, etc.). For decision-makers seeking to understand non-use values for changes in the operation of the GCD, estimates of WTP for a policy change, net WTP for continuation of the current policy is the relevant evidence for non-use values. Our nationwide random sample survey therefore allowed respondents to choose *and value* their preferred policy option, as done in the validation survey, consistent with this line of reasoning.

4. Elicitation of Non-Use Values for GCD Options

In previous sections of this report, we used a more comprehensive and replicable protocol to identify, characterize, and empirically validate a set of DOV that are potentially affected by re-purposing the GCD. The results from the validation exercise described in Section 3 indicate that members of the U.S. public hold significant non-use values for impacts of GCD on air pollution and health, climate change, rural communities, rural ways of life, Native American tribes, ancillary benefits of hydropower, and the processes by which the operations of the GCD are governed.

In this section of the report, we estimate preferences for re-purposing the GCD, as called for in the DEIS, as compared to preferences for maintaining current operational patterns. A nationwide random sample survey was conducted for this purpose and willingness to pay (WTP) for changing or continuing current GCD operations inclusive of the full range of identified DOV is estimated. Finally, a net WTP for continuing current GCD operations is calculated, providing a robust measure, inclusive of both sides of the analytical ledger, of the non-use social welfare impacts of the proposed re-purposing of GCD.

4.1 Sample and Data

The data for this analysis were collected from an online survey that was administered to a nationally representative random sample of 3,071 U.S. adults by the University of Oklahoma's Center for Energy, Security and Society (CES&S).[10] The survey was in the field from August 5-25, 2016. The median response time was 18 minutes. All surveys were conducted in English and the target population was non-institutionalized adults, age 18 and over, who reside in the U.S.

[10] Funding for the design and implementation of the survey was provided by the University of Oklahoma Office of Vice President for Research.

GfK Custom Research (formerly Knowledge Networks) recruited participants for the survey. GfK used random-digit dialing (RDD) and address-based sampling (ABS) methods to recruit panelists to take this online survey. If non-internet households were selected for participation, GfK provided a web-enabled computer and free Internet service so those households could participate in the online survey. The resulting panel (called KnowledgePanel) is therefore a random sample of the general population. For this study, 6,419 panelists were drawn at random from the KnowledgePanel; 3,473 responded to the invitation, yielding a completion rate (COMR) of 54.1%.[11] The recruitment rate (RECR) for this study was 12.8% and the profile rate (PROR) was 64.7%, therefore the cumulative response rate (APPOR CUMRR1) was 4.5%.[12] Of the 3,473 participants who responded to the invitation, 249 were marked as ineligible because they did not provide “active consent” (as per OU Institutional Research Board guidelines for research involving human participants) and 153 exited the survey prior to completion.[13]

Because participants were randomly selected from the U.S. population, the 3,071 respondents who completed a survey for this study closely mirror the general population of U.S. adults (see Appendix 3). Nevertheless, post-stratification weights were used to adjust for slight geo-demographic differences between the respondents and the target population (as defined by March 2015 CPS Supplement Data). The weights, which are calculated by way of an iterative proportional fitting (raking) procedure, adjust for gender, age, race/ethnicity, education, census region, household income, and metropolitan area. They are relatively small (0.2 to 3.3), so trimming was unnecessary.

As demonstrated in previous research, this combination of sample frame development and mode of data collection produces welfare estimates in stated-preference studies that are consistent with mail, telephone, and face-to-face surveys that are administered to a random sample of adults (e.g., Boyle et al., 2016; Lindhjem & Navrud, 2011; Berrens et al., 2004).

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[11] Unit non-response analysis revealed relatively few geo-demographic differences between sample members who *did* and *did not* respond to the invitation (See Appendix 5). The post-stratification weights adjust for these differences.

[12] CUMRR1 = RECR * PROR * COMR = 0.128 * 0.647 * 0.541 = 0.045

[13] Item non-response analysis was extremely low and analysis suggests that values were missing at random, so list-wise deletion of missing values is used in the analysis that follows.

Importantly, constructing an internet panel through ABS, as was done here, does not lead to biased welfare estimates in stated-preference surveys (Boyle et al., 2016). Moreover, this methodology is compliant with the "Standards and Guidelines for Statistical Surveys" by the Office of Management and Budget (OMB, 2006).

This section of the report focuses on the 1,016 respondents to the random sample survey who were randomly selected to receive information on the impacts of changing and continuing GCD operations as reported in DEIS plus the previously identified and validated social, cultural, and environmental DOV described above in Sections 2 and 3 of this report. The information presented to these respondents is nearly identical to treatment #7 from the validation survey (described in Section 3), except for a few minor wording and grammar adjustments. Dimensions of value specifically included are: (i) health effects of air pollution, (ii) ways of life for farmers, ranchers, and rural communities who receive low-cost GCD hydropower; (iii) climate change; (iv) ancillary benefits of hydropower to incorporate intermittent renewables into the energy grid, and; (v) the decision making process for how GCD is operated. Appendix 2 contains the actual value dimension language presented in the survey.

With the exception of the changes in the bid structure and range of bids described in the conclusion to Section 3,[14] the design of the random sample survey was identical to the design of the validation survey. To briefly summarize, it described impacts to resources in the region around GCD associated with two scenarios, randomly named Option A or Option B: (i) a change in GCD operations, and; (ii) a continuation of current GCD operations. The description of the impacts of Option A (a change to operations, here) and Option B (continuation of current operations, here) are presented in Table 4.1.

[14] As noted in Section 3, the findings of the value demonstration survey indicated that a continuous bid structure and a bid range from $1 to $1,200 would improve the survey performance.

Table 4.1: Descriptions of Impacts for Options A and B

Resources	*Impacts of Option A*	*Impacts of Option B*
River beaches	*• An increase in the number and size of beaches.*	*• A decrease in the number and size of beaches.*
Native and non-native fish	*• A small increase in native fish populations, including humpback chub.* *• Little or no change in non-native fish populations, including rainbow trout.*	*• Little or no change in native fish populations, including humpback chub.* *• Little or no change in non-native fish populations, including rainbow trout.*
Recreation and tourism	*• Reduced visitor access to portions of the river.* *• Reduced whitewater rafting and boating opportunities, but increased camping space along the river in the Grand Canyon.* *• Small decrease in boater access to Lake Powell.*	*• Little or no impact to visitor access to portions of the river.* *• Little or no impact to whitewater rafting and boating opportunities, but declines in camping space along the river in the Grand Canyon.* *• Little or no impact to boater access of Lake Powell.*
Vegetation and wildlife	*• Increase in native vegetation cover and increase in plant biodiversity.* *• Improved nearshore wildlife habitats for birds, mammals, and reptiles.*	*• Decrease in native vegetation cover and decreases in plant biodiversity.* *• No change for most wildlife habitats.*
Cultural sites and Native Americans	*• Lower risk of erosion to Native American traditional-use areas, sacred sites, and archeological sites.* *• Reduced tourism along the river will negatively impact Native American ways of life.*	*• Higher risk of erosion to some Native American traditional-use areas, sacred sites, and archeological sites.* *• No change to tourism along the river and no impact on Native American ways of life.*
Hydropower	*• Reduced production of hydropower.* *• Increased reliance on electricity produced by fossil fuels in the Region.*	*• No change in the production of hydropower.* *• No change in the production of electricity from fossil fuels in the Region.*
Air quality and visibility	*• Increase in the amount of air pollutants emitted into the atmosphere in the Region.* *• Slight reduction in visibility at the Grand Canyon.*	*• No change in the amount of air pollutants emitted into the atmosphere in the Region.* *• No change in visibility at the Grand Canyon.*
Health effects of air pollution	*• More air pollution, which might negatively impact the health of residents and families in the Region.*	*• No change in air pollution, so the health of residents and families in the Region will not be affected.*
Farmers, ranchers, and associated rural communities	*• Higher and more variable electricity prices will disrupt the conditions that have supported traditional ways of life in rural ranching and farming communities.* *• Some rural electric utilities and Native American tribes would lose a potential source of funding for local infrastructure investments.*	*• No change in the level or stability of electricity prices, which will continue to support traditional ways of life in rural ranching and farming communities.* *• Rural electric utilities and Native American tribes would see no electricity price increases, sustaining potential sources of funding for local infrastructure investments.*
Climate change	*• Small increase in the amount of greenhouse gases, including CO2, emitted into the atmosphere, which could increase the negative effects of climate change.*	*• No change in the amount of greenhouse gases, including CO2, emitted into the atmosphere, resulting in little or no impact on climate change.*
Additional benefits of hydropower	*• Reduce the flexibility of the Glen Canyon Dam to provide baseload and peaking power.* *• This will make it slightly more difficult and costly to integrate renewables such as wind and solar power into the western US energy grid.*	*• Maintain the flexibility of the Glen Canyon Dam to provide baseload and peaking power.* *• This will preserve the ability of the system to integrate renewables such as wind and solar power into the western US energy grid.*
Governance	*• This option has tentatively been designated the "preferred" policy alternative by the US Department of the Interior. This designation may change, however, upon conclusion of the process designed to solicit stakeholder views.* *• Some stakeholders are concerned that this option will disrupt longstanding agreements over how water and other resources are allocated.*	*• Currently, this option is <u>not</u> the "preferred" policy alternative by the US Department of the Interior. This designation may change, however, upon conclusion of the process designed to solicit stakeholder views.* *• Some stakeholders prefer this option because it maintains longstanding agreements over how water and other resources are allocated.*

After viewing Table 4.1, respondents were asked which option they would vote for in an advisory referendum setting both at no cost and at a randomly assigned payment level using a single-bound dichotomous choice (SBDC) format.[15] This design allowed us to determine, for each respondent, their preferred GCD management option (change or continue dam operations) and their WTP for their preferred option (WTP for changing or continuing GCD operations).[16] The question wording was:

Preferred Option at No Cost

Think about a situation in which you had an opportunity to vote for <u>Option A</u> or <u>Option B</u> in an advisory referendum. The option with the most support would be recommended to the government officials managing the Glen Canyon Dam. Keeping in mind all of the potential effects described for each option above, and if adoption of either option <u>would not cost you anything</u>, would you vote for <u>Option A</u> or <u>Option B</u>?

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

Preferred Option at Randomly Assigned Payment Level (WTP question)

You selected [<u>Option A</u> or <u>Option B</u>]. Both options are costly to operate and will require continued financing. The following question asks whether you, as a taxpayer, would vote for this option in an advisory referendum. The option with the most support would be recommended to government officials managing the Glen Canyon Dam. As you think about your answer, keep in mind the amount of money you and your household would pay for the policy, how much you would be able to afford to pay, and the other things you could spend the money on instead.

Would you vote for [preferred option at no cost: <u>Option A</u> or <u>Option B</u>] if adoption of this option would cost your household [random sample for uniform distribution: $1:$1,200] in increased taxes every year for the next 20 years?

0 - No
1 - Yes
2 - Not sure

---

[15] As in the value demonstration survey, respondents were reminded to consider only non-market effects – those not included in prices or wages – when making their decisions.

[16] Respondents selecting "I would choose not to vote for either option" in the preferred option at no cost question were not provided with the follow-up WTP question.

Table 4.2 shows the distribution of preferred options at no cost and the distribution of WTP responses conditional on the preferred option. A majority of respondents (65.4%) opposed changing GCD operations to improve within-reach downstream environmental outcomes when presented with the additional information on how such changes would have broader, outside-the-reach social, cultural, and environmental effects through changes in the production and distribution of hydropower. Only 17.4% of survey respondents preferred change to continuation.

Table 4.2: Voting Results for GCD Operational Preferences

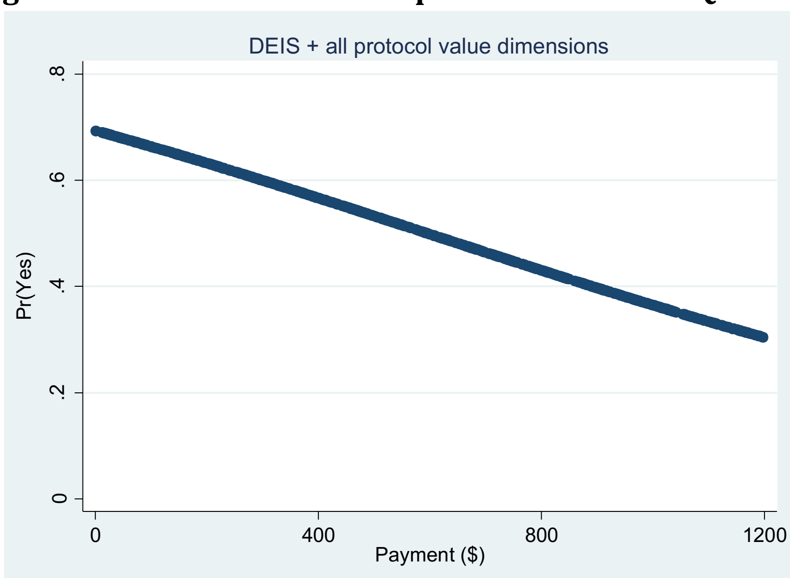
	Number of respondents	Percentage of sample
Vote to Change Operations	**175**	**17.4%**
Would pay >$0 payment amount	*54*	*5.2%*
Would not pay >$0 payment amount	*56*	*5.7%*
Not sure if would pay >$0 payment amount	*65*	*6.5%*
Vote to Continue Operations	**669**	**65.4%**
Would pay >$0 payment amount	*218*	*21.7%*
Would not pay >$0 payment amount	*217*	*20.4%*
Not sure if would pay >$0 payment amount	*234*	*23.4%*
Would Not Vote	**155**	**17.2%**

Note: this table presents tabulated voting results and survey-weighted sample percentages from the random sample survey. "Vote to Change Operations", "Vote to Continue Operations", and "Would Not Vote" presents the number and percentage of respondents who, at $0 cost, selected this as their preferred option for future GCD operations. These values may not sum to 100% due to rounding. "Would pay >$0 payment amount" is the number and percentage of respondents who indicated that they would be willing to pay a non-zero randomly assigned bid amount for their preferred option. "Would not pay >$0 payment amount" is the number and percentage of respondents who would not be willing to pay a randomly assigned non-zero bid amount for their preferred option. "Not sure if would pay >$0 payment amount" is the number and percentage of respondents who are not sure if they are willing to pay a randomly assigned non-zero bid amount for their preferred option.

Among those supporting continuation, 21.7% were also willing to pay a non-zero amount of money for continuation of current dam operations, compared to 5.2% who supported change and were willing to pay a positive amount. This suggests that non-use preferences for GCD operations are stronger for continuation than for change, and is consistent with the results of Jones et al. (2016), and with the results of the value demonstration survey described above in Section 3.

The distribution of predicted responses to the WTP question across payment levels is illustrated in Figure 4.1. The predicted probabilities of answering Yes, Pr(Yes), to the SBDC question are plotted on the y-axis. Pr(Yes) is declining in the payment amount, consistent with economic theory. Expansion of the highest payment level to $1,200 (from $600 in the value demonstration survey) has attenuated the fat tail, though not completely eliminated it. At $1,200, 30% of respondents indicated that they would pay the offered payment amount. Yes-response proportions above 20% are generally indicative of fat tails. To address the modest fat tails present in the data, in what follows we (i) focus on median WTP, which is robust to the fat tails problem (Ready & Hu, 1995), and; (ii) use certainty recoding to eliminate potential hypothetical bias. These are common approaches for mitigating the effect of fat tails on WTP estimates (Haab & McConnell, 2002).

Figure 4.1: Distribution of Responses to the WTP Question



Notes: This figure presents predicted probabilities of answering Yes to the WTP question across offered payment levels. Predictions are from a logit regression using the offered payment level as a covariate. Payments were randomly drawn from a [1, 1200] uniform distribution in increments of $1.

Following the WTP question, a debriefing question asked respondents who selected No to the WTP question the reason for their response. This question was aimed at identifying “protest responses” to the valuation question – respondents who objected to some component of the valuation exercise or even the valuation exercise itself. Table 4.3 presents the distribution of responses received from the protest debriefing question.

Table 4.3: Frequency Distribution of Reasons For Not Paying the Offered Payment Amount by GCD Operational Preference

		Change		Continue	
		Frequency	Percent	Frequency	Percent
1	I'm opposed to any additional tax or fee in general	5	9.26	44	21.05
2	Existing taxpayer money should be used	1	1.85	15	7.18
3	Government already wastes too much money	7	12.96	26	12.44
4	Collected money may not actually be used for the GCD as promised	3	5.56	8	3.83
5	Only users of the GCD hydropower should pay	10	18.52	43	20.57
6	I can't afford anything at this time	11	20.37	30	14.35
7	I would be willing to support such a tax if it was collected for less than 20 years	0	0	4	1.91
8	This policy is not worth it to me	5	9.26	17	8.13
9	I need more information before committing my money	10	18.52	11	5.26
10	I believe that the GCD should be removed and I oppose all policies that would continue to operate the dam	1	1.85	1	0.48
11	Other reason	1	1.85	10	4.78
	Total	*54*	*100.00*	*209*	*100.00*

Note: This table presents frequency distribution results from the protest debriefing question asked after the WTP question. Only respondents answering No to the WTP question received the protest question. The question asked was: "*We would like to know why you would not vote for the option you selected. Please select the most important reason*."

The three most common responses for why a respondent would not pay their offered payment amount, in no particular order, were "I'm opposed to any additional tax or fee in general" (continue only), "Only users of the GCD hydropower should pay", "I can't afford anything at this time", and "I need more information before committing my money" (change only).[17] Protest responses were identified as reasons 1, 2, 3, 4, 5, 7, 9, and 10, as shown in Table 4.3. This subset of reasons may indicate some form of protest to the valuation exercise, and—as in any attempt to estimate WTP—it is important to evaluate whether their inclusion will bias estimates of WTP (Strazzera et al., 2003).

[17] Only two respondents selected as their most important reason that "I believe that the GCD should be removed and I oppose all policies that would continue to operate the dam". Dam removal was therefore not an important factor for why respondents were opposed to paying the assigned payment amount for their preferred policy option.

Once we separately categorize the "Protest No" responses, there are four possible categories of responses to the WTP question: Yes, No, Protest No, and Not Sure. Table 4.4 presents the frequency distribution of these responses. Protest No responses comprise 21.26% and 22.86% of total responses for those preferring to change and continue dam operations, respectively.

Table 4.4: Frequency Distribution of Responses to the WTP Question by GCD Operational Preference

	Change		Continue	
	Frequency	Percent	Frequency	Percent
Yes	54	31.03	218	32.78
No	18	10.34	61	9.17
Protest no	37	21.26	152	22.86
Not sure	65	37.36	234	35.19
Total	*174*	*100.00*	*665*	*100.00*

Note: this table presents frequency distribution results of responses to the WTP question after flagging Protest No responses.

The literature is unclear on how Protest and "Not Sure" (NS) responses to the WTP question should be treated (Caudill et al., 2011; Champ et al., 2005). There are two commonly used approaches. One approach is to combine some combination of Protest, NS and No results together. Another approach is to drop NS and/or Protest responses from the sample and focus on Yes and No results. Which approach is taken is an empirical question to be addressed in a rigorous way. To evaluate these alternative approaches, we ran a multinomial logistic regression using the WTP vote categories (as shown in Table 4.4) as the dependent variable and the log of the payment amount received by the respondent as the single covariate (since we are interested in the variation of votes across payments). Following Martinez-Espiñeira et al. (2016), we performed pairwise likelihood-ratio (LR) tests for combining alternative categories of WTP responses. The null hypothesis of each LR test is that the alternatives can be collapsed.

From these tests, we found strong evidence to suggest that No and Protest No responses can be combined: $\boldsymbol{\chi^2_{change} = 0.001, p = 0.97}$; $\boldsymbol{\chi^2_{continue} = 0.02, p = 0.90}$, No and NS responses can be collapsed: $\boldsymbol{\chi^2_{change} = 0.13, p = 0.72}$; $\boldsymbol{\chi^2_{continue} = 0.69, p = 0.41}$, and Protest No and NS can be collapsed: $\boldsymbol{\chi^2_{change} = 0.27, p = 0.61}$; $\boldsymbol{\chi^2_{continue} = 1.79, p =}$

$\mathbf{0.18}$. Collapsing No, Protest No, and NS leaves two WTP response categories: Yes and Collapsed No/NS. Thus, in what follows, we focus on Yes and Collapsed No/NS (combined No, Protest No, and Not Sure) WTP question responses, hereafter referred to as Yes/No for simplicity.

4.2 Estimation of Willingness to Pay for Changing and Continuing GCD Operations

The underlying household WTP function was directly estimated following the conventional SBDC censoring threshold model of Cameron and James (1987). WTP is assumed to be an exponential function of a linear combination of covariates and an additive idiosyncratic error term,

$$\boldsymbol{WTP_i = e^{X_i'\beta+\varepsilon_i}} \qquad (\mathbf{4.1})$$

where $\boldsymbol{X}$ is a vector of covariates, $\boldsymbol{\beta}$ is the coefficient vector, and $\boldsymbol{\varepsilon}$ is a random error component with mean zero and variance $\boldsymbol{\sigma^2}$ for individual $\boldsymbol{i}$.

Since WTP responses are not directly observable to us, we used the results of latent WTP obtained from the SBDC elicitation exercise, where the probability of an individual responding Yes to an offered payment $\boldsymbol{Payment_i}$ is equivalent to the probability of the WTP function being greater than the offered payment. Following Haab & McConnell (2002; p.55), after standardizing, the probability of a Yes response is given by,

$$\mathbf{Pr}(\boldsymbol{WTP_i > Payment_i}) = \mathbf{Pr}(\boldsymbol{\theta_i > \delta\, ln(Payment_i) - X_i'\beta^*}) \qquad (\mathbf{4.2})$$

where $\boldsymbol{\theta = \varepsilon/\sigma}$, $\boldsymbol{\delta = 1/\sigma}$ is the estimated coefficient on the offered payment, and $\boldsymbol{\beta^* = \beta/\sigma}$. Assuming $\boldsymbol{\varepsilon}$ is normally or logistically distributed, it is possible to recover estimates of $\boldsymbol{\beta^*}$ and $\boldsymbol{-1/\sigma}$. Using these estimates and equation (4.3), median WTP can be estimated (Haab & McConnell, 2002; p.57),

$$\boldsymbol{MD(WTP) = e^{X_i'\beta}} \qquad (\mathbf{4.3})$$

Standard errors and p-values for estimated WTP are constructed using the delta method (Cameron, 1991).

Models of WTP include controls for issue awareness, attitudinal beliefs, and economic effects.[18] Table 4.5 presents definitions of each control covariate and sample summary statistics. To capture issue awareness (*Heard*), we used results from a question asking respondents if they had heard about GCD prior to taking the survey.[19] We included attitudinal controls for both sides of the analytical ledger (*Hydro* and *Nature*). Since one management option (the change option) constrains hydropower production, there might be heterogeneity in WTP responses based on support for hydropower as an energy source (*Hydro*). On the other side of the ledger, one management option (the continue option) results in greater improvements to downstream environmental conditions, which might be more appealing to respondents that care deeply about nature (*Nature*). Finally, from economic theory the level of household income (*Income*) and the value of the randomly assigned payment amount are believed to influence WTP voting outcomes (Whitehead, 1995).

[18] Controls for demographics (e.g., age, gender, race, region) are not included since our unweighted data are highly representative of the U.S. population (Appendix 3) and because all results are survey weighted, further increasing sample representativeness. More fundamentally, we find that the demographic story is strongest in the selection equation (i.e., the decision to change or continue) and plays a largely insignificant role in determining WTP response. Estimated WTP is more conservative in our sample without controls for demographics.

[19] The question about whether respondents had heard about the GCD (*Heard*) was asked prior to presentation of the survey items informing respondents about the GCD or providing the experimental information treatments.

Table 4.5: Random Sample Survey Summary Statistics

Variable	Description	Coding	*N*	Mean	Std. Dev.
Vote	Support for changing or continuing current GCD operations	1=change, 0=continue	844	0.21	0.41
Heard	Respondent has heard of Glen Canyon Dam before survey	1=yes, 0=no	1000	0.23	0.42
Nature	View of nature	0-10 scale; 0=robust and not easily damaged, 10=fragile and easily damaged	1001	5.96	2.56
Hydro	Importance of hydropower	0-10 scale; 0=not at all important, 10=extremely important	997	7.85	2.18
Income	Annual household income in 2015	1-19 scale; 1=<5000, 2=5000-7499, 3=7500-9999, 4=10,000-12,499, 5=12,500-14,999, 6=15,000-19,999, 7=20,000-24,999, 8=25,000-29,999, 9=30,000-34,999, 10=35,000-39,999, 11=40,000-49,999, 12=50,000-59,999, 13=60,000-74,999, 14=75,000-84,999, 15=85,000-99,999, 16=100,000-124,999, 17=125,000-149,999, 18=150,000-174,999, 19=≥175,000	1016	12.31	4.56

Note: this table presents random sample survey summary statistics of means and standard deviations for covariates included in all regression models. Variable ***Vote*** is truncated to voting respondents only.

4.2.1 Parametric Selection Models

Our survey design was such that only respondents who preferred to change GCD operations were offered the opportunity to pay for change, and likewise, only respondents who preferred to continue GCD operations were offered the opportunity to pay for continuation.[20] Thus, observed WTP responses for a given policy option are conditional upon a respondent selecting that policy option as their preferred option at no cost.

This nonrandom split at the first stage no-cost preference node may affect estimated WTP at the second stage due to a "selection effect." It is well established that results from nonrandom samples can be biased if not appropriately corrected (Heckman, 1979). In a CV setting, a selection effect, if present, could bias estimates of WTP from parametric models (Blomquist et al., 2011). Therefore, we estimated a two-step Heckman selection model in addition to the parametric WTP model in equation (4.3), following a long history in the CV

[20] Respondents indicating that they would neither vote for change nor continue are not asked to express their WTP.

literature of using Heckman models to correct for selection bias (e.g., Gervès-Pinquié et al., 2014; Strazzera et al., 2003; Kaoru, 1993). In the results section, we tested the significance of the selection effect.

4.2.2 Adjustments for Hypothetical Bias

WTP estimated from stated preference CV response data may contain a degree of potential hypothetical bias—people not treating the WTP question as a real money income tradeoff (Parsons & Myers, 2016). Hypothetical bias has been (and continues to be) an issue with CV data since its inception, but can be attenuated by using an advisory referendum format and adjusting responses to the WTP question using results from a follow-up certainty question (Little & Berrens, 2004). Immediately following our WTP question (framed as an advisory referendum) we asked respondents on a scale of 0 (not at all certain) to 10 (completely certain) how certain they are that they would actually vote for their preferred option if it cost their household the assigned payment amount:

> *On a scale from zero to ten, where zero means not at all certain and ten means completely certain, how certain are you that you [would not if WTP response NO; would if WTP response YES] vote for [preferred option at no cost: Option A or Option B] if it would cost your household [payment level from WTP question] in increased taxes every year for the next 20 years?*
> *0-Not at all certain*
> .
> .
> .
> *10-Completely certain*

The average respondent indicated a certainty level of 7.33 (std. dev. = 2.56). We used the results from this question to employ a numerical yes-response correction for potential hypothetical bias, following previous literature (Li et al., 2009; Champ & Bishop, 2001). Specifically, uncertain Yes responses (defined as Yes responses with certainty <10) are recoded to No responses according to the 10-point certainty scale. This is known as the asymmetric uncertainty model and leads to more conservative WTP estimates (Loomis & Ekstrand, 1998). As in Li et al. (2009), we used a recoding threshold of Yes=8 or higher. In the results section, we report 80% of recoded results alongside results that have not been recoded.

4.3 Results: WTP Response Regressions & Median WTP Estimates

Regression estimates for the association between WTP voting outcome (Yes/No) and respondent characteristics are presented in Table 4.6 along with estimates of median WTP. As predicted by economic theory, all model results indicate a negative and significant relationship between the randomly offered payment amount and the probability that the respondent votes Yes in the advisory referendum, given by $-\mathbf{1}/\boldsymbol{\sigma}$.

Table 4.6: Logit Regressions of WTP Response (Yes=1 or No=0) For Changing or Continuing GCD Operations & Median WTP Estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Change				Continue			
	Payment Only	Payment Only (80%)	All Controls	All Controls (80%)	Payment Only	Payment Only (80%)	All Controls	All Controls (80%)
Heard	-	-	0.512	0.627	-	-	0.405*	0.795***
			(0.393)	(0.474)			(0.215)	(0.260)
Hydro	-	-	0.064	-0.045	-	-	0.060	0.281***
			(0.089)	(0.119)			(0.059)	(0.077)
Nature	-	-	-0.055	-0.015	-	-	0.055	0.065
			(0.082)	(0.118)			(0.037)	(0.049)
Income	-	-	-0.011	0.019	-	-	0.008	0.045
			(0.038)	(0.046)			(0.022)	(0.031)
Constant	1.565*	0.234	1.587	0.394	2.970***	2.288***	2.055**	-0.827
	(0.882)	(1.100)	(1.360)	(1.797)	(0.619)	(0.642)	(0.843)	(0.985)
$\boldsymbol{\sigma}$	2.544***	3.023*	2.327***	2.763*	1.655***	1.545***	1.605***	1.374***
	(0.948)	(1.638)	(0.849)	(1.533)	(0.278)	(0.256)	(0.265)	(0.212)
Pseudo R2	0.029	0.024	0.052	0.044	0.052	0.064	0.063	0.122
Log likelihood	-100.814	-68.922	-94.765	-65.043	-386.024	-275.898	-375.307	-254.728
N	174	174	170	170	665	665	655	655
Median WTP	\$9.32	\$0.35	\$10.14	\$0.43	\$89.13	\$22.43	\$87.40	\$20.19
	(7.88)	(1.04)	(8.02)	(1.23)	(21.55)	(9.57)	(21.36)	(8.20)

Note: this table presents results from eight separate logit regressions using data from the random sample survey. The dependent variable is an indicator of support for changing or continuing operations at the assigned payment amount (i.e., Yes =1 or No =0 response to WTP question). Survey weighted standard errors are in parentheses. Sigma ($\boldsymbol{\sigma}$) = $(-\mathbf{1}/\boldsymbol{payment})$, where $\boldsymbol{payment}$ is the estimated coefficient on the log payment amount. Median WTP = $\mathbf{exp}\,(-\bar{\boldsymbol{x}}\boldsymbol{\beta}/\boldsymbol{payment})$, where $\bar{\boldsymbol{x}}$ are the controls evaluated at their means and $\boldsymbol{\beta}$ is the vector of estimated coefficients. WTP estimates have been weighted by the proportion of respondents with a given operational preference. ***p<0.01; **p<0.05; *p<0.1.

In our preferred model that accounts for hypothetical bias, respondents preferring to continue dam operations (column 8) are more likely to vote Yes in the WTP question if they were aware of GCD prior to the survey and if they are supportive of hydropower in general. Put differently, respondents believing that hydropower is an important renewable resource are more likely to pay a positive amount of money to preserve current levels of hydropower produced by GCD. We found no heterogeneity in WTP responses based on views of nature or income levels. Aside from the payment amount, none of the control variables have explanatory power in models restricted to individuals preferring to change GCD operations.[21]

Nationally-representative household median WTP for changing or continuing GCD operations is presented in the last row of Table 4.6. Our preferred models include all controls and 80% recoding (columns 4 & 8), since they account for potential hypothetical bias and provide the most conservative WTP estimates. From these models, we estimate that the average US household has a median WTP for continuing GCD operations (among those who prefer this option) of $20.19, compared to a median WTP of $0.43 for change (among those who prefer changing dam operations).

We have argued throughout this report that the relevant WTP metric in contested policy domains where there are some members of the public supporting one policy option (e.g., changing dam operations) and other members of the public supporting a different policy option (e.g., continuation of the current pattern of dam operations) is a relative or *net* measure, inclusive of both sides of the analytical ledger. This is the concept of net WTP – capturing, in one number, WTP for re-purposing GCD inclusive of the willingness-to-pay for changing operations relative to that for continuing current operations. Net WTP can be greater than, less than, or equal to zero depending on the relative preferences on both sides of the ledger.

Our most conservative estimate of net WTP for continue is therefore $20.19 - $0.43 = $19.76, based on the results from Table 4.6. This value can be interpreted as follows: In a contested policy setting where some households prefer that policymakers change GCD operations and others prefer that they continue current policy, we find that expected WTP for continuation of current operations (relative to changing operations) is larger by $19.76. That is, if operators of GCD were to make no operational changes and maintain existing policy, U.S. households would be willing to pay on net $19.76 to obtain that outcome after

[21] We find no evidence of a statistically significant selection affect between respondents' preference for change or continue and their response to the WTP question based on results from Heckman selection models. Lack of a significant selection effect means that WTP estimates will not be biased due to nonrandom selection.

accounting for households willing to pay $0.43 to acquire the change as called for in Alternative D of the DEIS. Continuing current GCD operations therefore improves social welfare by a greater amount than does change.

4.4 Validity Checks

It is important to assess the validity of the survey from which these estimates of non-use value are derived. To evaluate the construct validity of the nationwide value estimation survey, defined as the extent to which CV estimates are accurate representations of respondents' true WTP (Mitchell & Carson, 1989), we evaluate the results of two extended models.[22] In the first, split-sample treatments are used to investigate responses to the WTP question across heterogeneous levels of information presented to respondents. Two additional split-samples were investigated for this purpose: (i) a replicate of the information presented in DEIS that ignores many previously identified social and cultural value dimensions (Treatment #1), and; (ii) information only on downstream environmental effects, omitting all of the added cultural, environmental and social DOV associated with reduced hydropower production (Treatment #2). Treatment effects on WTP responses are presented in Table 4.7. The base treatment category is Treatment #3, the previously investigated split-sample treatment inclusive of all DOV identified in Section 3 of this report plus the information in Treatment #1 (DOV included in the DEIS).

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[22] Validity checks explored here follow the spirit of Carson and Hanemann (2005) who state, "one of the standard ways to look at the reliability of a CV survey is to construct a regression model to predict differences in WTP as a function of other variables in the survey; such as income, past recreational use, and various attitude and knowledge questions concerning the good. An equation with reasonably explanatory power and coefficients with the expected signs provides evidence in support of the proposition that the survey has measured the intended construct" (p.897).

Table 4.7: Split-Sample Treatment Effects on WTP Response

	(1)	(2)	(3)	(4)
	Payment Only	Payment Only (80%)	All Controls	All Controls (80%)
Treatment #1	-0.458***	-0.459***	-0.481***	-0.472***
	(0.122)	(0.156)	(0.124)	(0.160)
Treatment #2	-0.432***	-0.202	-0.449***	-0.215
	(0.118)	(0.146)	(0.121)	(0.149)
Heard	-	-	0.499***	0.694***
			(0.112)	(0.138)
Nature	-	-	0.104***	0.147***
			(0.022)	(0.031)
Income	-	-	0.015	0.044***
			(0.012)	(0.016)
Constant	2.987***	2.066***	2.211***	0.617
	(0.303)	(0.330)	(0.363)	(0.421)
$\boldsymbol{\sigma}$	1.636***	1.625***	1.563***	1.528***
	(0.130)	(0.140)	(0.120)	(0.131)
Pseudo R2	0.069	0.076	0.088	0.109
Log likelihood	-1394.403	-981.530	-1349.442	-937.322
N	2573	2573	2544	2544

Note: this table presents results from four separate logit regressions using data from three split-sample treatments in the random sample survey. Treatment #1 presented information on value dimensions included in the GCD DEIS. Treatment #2 presented information on the downstream environmental impacts of GCD, ignoring all cultural and social value dimensions. Treatment #3 (the base category) contains all information in Treatment #1 plus other identified cultural and social value dimensions. The dependent variable is a Yes/No response indicator to the WTP question. Survey weighted standard errors are in parentheses. Sigma ($\boldsymbol{\sigma}$) = $(\boldsymbol{-1/payment})$, where $\boldsymbol{payment}$ is the estimated coefficient on the log payment amount. $^{***}p<0.01$; $^{**}p<0.05$; $^{*}p<0.1$.

Results in Table 4.7 are consistent with our theoretical expectations. For brevity, we focus on the results of our preferred model that includes all controls and accounts for potential hypothetical bias (column 4). When reduced information on social and cultural impacts of GCD operations are presented to respondents through indicator variables for Treatments #1 and #2, respondents are less likely to vote Yes in the WTP question, though only the coefficient on Treatment #1 is significant. These results are as expected since Treatments #1 and #2, compared Treatment #3, include fewer of the impacts on environmental, social, and cultural resources in the region around GCD. To the extent that individuals are concerned about these impacts (as evidenced from the no-cost voting results in Table 4.2), we would expect that the intensity of non-market preferences would be reduced as fewer of these DOV are included, as is observed in Table 4.7.

As predicted by economic theory, income is positively and significantly associated with WTP response; households with higher incomes are more likely to accept the assigned bid amount. Results in Table 4.6 also confirm that individuals who were familiar with GCD prior to the survey, and those who believe that nature is important to them, are significantly more likely to accept the offered bid to change dam operations. This is an important validity check because it tells us that WTP is positively associated with prior experiences and an attitudinal belief that is substantially impacted by GCD operations, both of which would be expected.

Overall, the results in Table 4.7 provide evidence in support of the proposition that the survey has measured the intended construct (Carson & Hanemann, 2005). The signs and magnitudes on the coefficients are consistent with what we would expect to observe if respondents were accurately representing their underlying preferences for operations of GCD.

A second informal construct is to investigate GCD operational preferences at no cost across observable respondent characteristics for Treatment #3—the treatment for which we previously estimated median WTP. We have strong reason to suspect that the respondents' decision to prefer changing or continuing dam operations is influenced by other attitudinal beliefs in the survey, particularly beliefs towards the environment and the welfare of specific groups of people. We seek to understand if preferences for change or continue are consistent with our theoretical expectations. Results of this exercise are presented in Table 4.8.

Table 4.8: Logit Regression Estimates of GCD Operational Preferences At No Cost (=1 if Preferred Change, =0 if Preferred Continue)

	Change vs. Continue
Income	-0.024
	(0.025)
Ideol	0.149*
	(0.077)
Heard	0.501**
	(0.255)
VisitGC	-0.194
	(0.244)
Own	-1.762**
	(0.881)
Consider	0.541**
	(0.215)
Hydro	-0.307***
	(0.071)
Veg_Wild	0.211**
	(0.101)
Beach	0.114
	(0.070)
Fish	-0.046
	(0.091)
NativeAm	0.160**
	(0.082)
Rec_Tour	0.010
	(0.064)
Air_Health	-0.142*
	(0.081)
Farm_Ranch	-0.296***
	(0.083)
Climate	-0.078
	(0.067)
Gov	0.156**
	(0.064)
Constant	-0.012
	(0.695)
Pseudo R2	0.138
Log likelihood	-316.210
N	754

Note: this table presents results from a logit regression using data from respondents in Treatment #3. The dependent variable =1 if the respondent preferred change at no cost, and =0 if they preferred continue. Survey weighted standard errors are in parentheses. $^{***}p<0.01$; $^{**}p<0.05$; $^{*}p<0.1$.

Results are in line with our theoretical expectations. As a reminder, changing operations are expected to lead to improvements in downstream natural environment and reduce erosion to Native American cultural sites, but at the expense of reduced hydropower production. Consistent with these outcomes, we see from Table 4.8 that respondents who believe that vegetation and wildlife (*Veg_Wild*) and Native American cultural sites (*NativeAm*) are very important are significantly more likely to support change. More politically liberal respondents (*Ideol*), and those who view the government's decision making process for how GCD is operated (*Gov*) as important, are also more likely to prefer changing dam operations. Preferences for change are also greater for those who believe decision-makers will consider survey results in reaching a decision (*Consider*), and among those with prior familiarity with GCD (*Heard*).[23]

On the other side of the analytical ledger, continuing GCD operations will preserve renewable hydropower—and its ancillary benefits in shaping power generation (e.g., to accommodate intermittent renewables), minimizing social and cultural disruptions to farmers, ranchers, and rural communities, and will avoid increasing air pollution and carbon emissions, minimizing harmful health effects. Consistent with this outcome, results in Table 4.8 suggest that respondents who are supportive of hydropower (*Hydro*), concerned about the health effects of air pollution (*Air_Health*) and concerned about ways of life for rural farmers and ranchers (*Farm_Ranch*) are more likely to support continuation of current patterns of dam operations. The sign and significance of these covariates are as expected. Additionally, there is a self-interested aspect present in the results, where individuals owning property in the region around GCD (*Own*) are considerably more likely to support continuation of dam operations. These people are more likely to receive benefits of GCD hydropower at their property, and are therefore more likely to be personally affected by the economic viability of communities that receive low-cost hydropower.

Overall, the coefficient signs on the treatment effects and on relevant attitudinal beliefs explored in our validity tests are as expected and are consistent with our theoretical expectations. These results are consistent with the proposition that the survey has

[23] The result of the *Heard* variable is in the expected direction, because much of the recent press concerning GCD (and dams in general) has focused on how they can be repurposed to further improve the natural environment while better incorporating public opinion (e.g., Gies, 2015, December 8 for *The New York Times*).

measured the intended construct, providing evidence of the reliability of our CV survey and estimates of net WTP for preferred GCD operations.

5. Conclusions

This report has described an integrated research program that developed a replicable, multi-stage protocol for identification of dimensions of non-use value of relevance to changing GCD operations, designed and fielded two nation-wide non-use valuation surveys, and elicited and estimated *net* willingness-to-pay (WTP) for alternative options for management of the GCD from a random probability sample of U.S. residents. The components of the research program are described in detail in the prior sections of this report.

The results of our estimation of net WTP for alternative operations of the GCD, based on responses to a nationally-representative contingent valuation survey, indicate considerable net non-use value for preserving current GCD operations. Our preferred and most conservative estimates are that U.S. households have a median WTP of $20.19 per year, over 20 years, to maintain current GCD operations compared to a WTP for of $0.43 per year for the DEIS Alternative D. These results imply a net median household WTP for continuing current GCD operational patterns, in comparison with the change contemplated in Alternative D, of $19.76 per household year.

There are several implications of this finding. First, the potential social welfare gains of changing GCD operations as specified in Alternative D of the DEIS are outweighed by the potential welfare gains of maintaining current operations. Across all models and all specifications investigated for re-purposing GCD, we find no evidence that non-use values for changing dam operations could plausibly exceed those for continuing current operations. On the contrary, when presented with the relevant array of affected DOV, members of the U.S. public overwhelmingly reject changing dam operations in favor of continuation. This holds both when the options are presented at "no cost" and when they are presented in a referendum format at a randomly assigned cost of between $1 and $1,200.

Second, while our results find evidence of positive non-use values for changing GCD operations from a segment of the public, a substantially larger segment of the public holds non-use values for continuing current dam operations. Consistent with the findings in Carlson et al. (2016) and Jones et al. (2016), these findings make clear that for any CV exercise concerning a contested change in a CHANS, estimations of non-use values can only make sense when considered as a comparison of the alternatives under consideration—for the contemplated change in comparison with continuation of current policy. Focusing only on estimating non-use value for the change as if there were only an unchanging *status quo* for comparison, and implicitly assuming no non-use value for continuing current operations, will result in badly biased and misleading estimates of non-use value.

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Appendix 1: Description of the Study Area

The Region around the Glen Canyon Dam

To begin, we will describe the region around the Glen Canyon Dam. In the pages that follow, we call this the Region.

The Region consists of <u>three</u> sections:

Section 1: The area in and along the Colorado River at the bottom of the Grand Canyon and part of the Glen Canyon.

- This section of the Region is nearly 300 miles long and ends at Lake Mead near Las Vegas, Nevada.
- This section includes the Grand Canyon National Park.

Section 2: Lake Powell, the artificial lake created behind the Glen Canyon Dam.

- This section of the Region is nearly 254 square miles in size, about the same size as Chicago, Illinois.
- This section includes the Glen Canyon National Recreation Area.

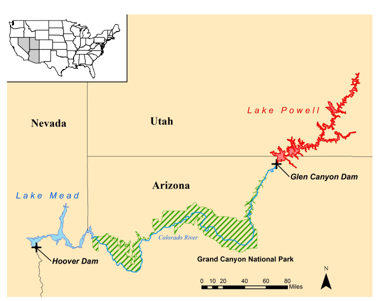
Section 3: The communities, households, and businesses that receive hydropower from the Glen Canyon Dam.

- Approximately 5.8 million customers receive part of their electricity from the Glen Canyon Dam.
- These customers live across seven states: Arizona, Colorado, Nebraska, Nevada, New Mexico, Utah, and Wyoming (in green on the map below).

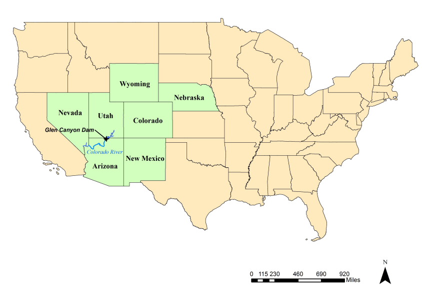
In addition to a number of large metropolitan areas, the Region also includes many Native American Tribal reservations and Pueblos, ranches, family farms, and rural communities. Many of the rural communities, Tribes and Pueblos receive hydropower from the Glen Canyon Dam.

Section 1

Section 2



Section 3



Glen Canyon Dam

- The Glen Canyon Dam is located on the Colorado River in Arizona.
    1. It is 10 miles upstream from the Grand Canyon National Park.

2. It was built in 1963 by the US government to provide water supplies and hydropower (electricity produced by running water through turbines in the dam).
3. It controls water flow through the Grand Canyon and a lower portion of the Glen Canyon.
4. In 2011, approximately 4.3 million people visited the Glen Canyon area.
5. Revenues from the sale of hydropower are used to repay costs of building and operating the dam.

- The amount of electric hydropower produced by the dam depends on the amount of water released; the more water released, the more electricity produced.
- Variations in the amount of water released through the dam and variations in the production and distribution of hydropower impact resources and communities within the Region.

Appendix 2: Description of Resources

On the next several pages, we will present you with some general information on the resources that are affected by the Glen Canyon Dam operations. At the end of each description, we will describe the likely impact of the two options under consideration on the resource <u>over the next 20 years</u>. Impacts of the two options are based on the best scientific consensus among resource managers and scientists who have studied the region around the Glen Canyon Dam. All described impacts are relative to the <u>current level</u> of resources in the Region.

River Beaches

- Deposits of sand and mud called beaches are scattered along the Colorado River. Most of the rest of the river bank consists of cliffs and steep slopes covered with rocks, boulders, sand, and desert vegetation.
    - Erosion and the blockage of new sediment caused by the Glen Canyon Dam decrease the number and size of beaches along the river below.
    - Controlled floods released from the Glen Canyon Dam can be used to rebuild the beaches.
- Some beaches are covered with vegetation.
    - Beaches with vegetation provide habitat for insects, small animals, and birds such as the Bald Eagle.
- Beaches are also used by river floaters (people rafting or boating down the river) for camping and recreation.
- Impact of Option A: An increase in the number and size of beaches.
- Impact of Option B: A decrease in the number and size of beaches.

Native and Non-Native Fish

- Operation of the Glen Canyon Dam affects both native and non-native fish downstream in the Colorado River.
- Five native fish species live in the Region.
    - Two of these native species, the humpback chub and razorback sucker, are considered endangered species.
    - Humpback chub are only found in the Colorado River and its tributaries.
- Non-native fish also live in the Region, including rainbow trout.
    - Rainbow trout were introduced for recreational fishing following construction of the Glen Canyon Dam.
    - People fish for these trout in the first 15 miles of river downstream from the dam.
- Impact of Option A:
    - A small increase in native fish populations, including humpback chub.
    - Little or no change in non-native fish populations, including rainbow trout.
- Impact of Option B:
    - Little or no change in native fish populations, including humpback chub.
    - Little or no change in non-native fish populations, including rainbow trout.

Recreation and Tourism

- The Colorado River and Lake Powell are a source of recreation for millions of tourists and outdoor enthusiasts each year.
- People go whitewater rafting and kayaking on sections of the river below the Glen Canyon Dam.
  - Daily fluctuations in river flows caused by water released from the dam affect downstream rafting, boating, and swimming.
  - During either low-water or high-water periods it becomes difficult and in some cases impossible to raft, boat, or swim in the river.
- Boating, swimming, and other water sports are popular on Lake Powell above the dam.
  - Recreation on Lake Powell can be affected by water levels dropping below the level at which ramps and marinas can function.
- People hike, bike, and camp along the river as well as on cliffs and other land in the Grand Canyon.
- Impact of Option A:
  - Reduced visitor access to portions of the river.
  - Reduced whitewater rafting and boating opportunities, but increased camping space along the river in the Grand Canyon.
  - Small decrease in boater access to Lake Powell.
- Impact of Option B:
  - Little or no impact to visitor access to portions of the river.
  - Little or no impact to whitewater rafting and boating opportunities, but declines in camping space along the river in the Grand Canyon.
  - Little or no impact to boater access to Lake Powell.

Vegetation and Wildlife

- The Colorado River supports a diverse wetland ecosystem with hundreds of species of plants and wildlife. Any changes to shoreline vegetation can affect wildlife habitat.
  - Currently, there are three endangered wildlife species on the river: the Kanab ambersnail (an air-breathing land snail), the Southwestern willow flycatcher (a small bird), and the Yuma clapper rail (a large-footed marsh bird).
- Most plant species depend on river water released from the Glen Canyon Dam.
  - Invasive plant species have expanded along the river, crowding out native plants.
  - Vegetation and plant biodiversity can be affected by dam operations through erosion during high flows, drowning, burial by new sediments, and reductions in soil moisture levels.
- Impact of Option A:
  - Increase in native vegetation cover and increase in plant biodiversity.
  - Improved nearshore wildlife habitats for birds, mammals, and reptiles.
- Impact of Option B:

- Decrease in native vegetation cover and decreases in plant biodiversity.
- No change for most wildlife habitats.

Cultural Sites and Native Americans

- Archeological sites and areas of cultural significance are located along the Colorado River.
  - These sites are associated with Native American cultures that have inhabited or used the Grand Canyon for thousands of years.
  - These sites include artifacts such as pots and tools and exist in places that may be damaged by erosion.
  - Erosion rates can be affected by water releases from the Glen Canyon Dam.
- Present-day Native Americans visit sacred sites and traditional-use areas along the river as part of their culture and way of life.
  - Plants, animals, and minerals used and held sacred by Native Americans are affected by erosion.
- Several Native American tribes in the Region rely heavily on tourism in and around the river and Lake Powell.
  - Tourism supports a way of life for Native Americans in the area.
- Impact of Option A:
  - Lower risk of erosion to Native American traditional-use areas, sacred sites, and archeological sites.
  - Reduced tourism along the river will negatively impact Native American ways of life.
- Impact of Option B:
  - Higher risk of erosion to some Native American traditional-use areas, sacred sites, and archeological sites.
  - No change to tourism along the river and no impact on Native American ways of life.

Hydropower

- Hydropower produced at the Glen Canyon Dam has reduced the need to rely on electricity produced at conventional power plants that use fossil fuels.
- Approximately 5.8 million customers in mainly rural areas and small communities in Arizona, Colorado, Nebraska, Nevada, New Mexico, Utah, and Wyoming rely on hydropower produced at the Glen Canyon Dam.
- Impact of Option A:
  - Reduced production of hydropower.
  - Increased reliance on electricity produced by fossil fuels in the Region.
- Impact of Option B:
  - No change in the production of hydropower.
  - No change in the production of electricity from fossil fuels in the Region.

Air Quality and Visibility

- By replacing fossil fuels, the hydropower produced at the Glen Canyon Dam has helped to reduce air pollution in the Region.

- Visibility over the Grand Canyon has also been improved by not having to use as many fossil fuels for energy production in the Region.
- Impact of Option A:
    - Increase in the amount of air pollutants emitted into the atmosphere in the Region.
    - Slight reduction in visibility at the Grand Canyon.
- Impact of Option B:
    - No change in the amount of air pollutants emitted into the atmosphere in the Region.
    - No change in visibility at the Grand Canyon.

Health Effects of Air Pollution

- By reducing air pollution, hydropower produced at the Glen Canyon Dam has also helped improve the health of residents and families in the area, who breathe cleaner air.
    - Cleaner air leads to fewer air pollution-related deaths, diseases, illnesses, and helps people live longer and healthier lives.
- Impact of Option A: More air pollution, which might negatively impact the health of residents and families in the Region.
- Impact of Option B: No change in air pollution, so the health of residents and families in the Region will not be affected.

Farmers, Ranchers, and Associated Rural Communities

- Traditional western ways of life for farmers, ranchers, and the rural communities where they live, have developed around a pattern of production and distribution of low-priced hydropower from the Glen Canyon Dam.
    - Hydropower production at the dam helps sustain the viability of rural communities and distinctive ways of life.
    - Consumption of hydropower from the Glen Canyon Dam enables farms and ranches in the Region to produce food that feeds people across the US.
- Revenue from hydropower produced by the Glen Canyon Dam supports local investments in rural infrastructure such as roads, schools, power lines, and electricity grids.
    - Some rural electric utilities, rural cooperatives, and Native American tribes generate financial revenues by selling their allotment of low-priced hydropower on the higher-priced "spot market".
- Impact of Option A:
    - Higher and more variable electricity prices will disrupt the conditions that have supported traditional ways of life in rural ranching and farming communities.
    - Some rural electric utilities and Native American tribes would lose a source of funding for local infrastructure investments.
- Impact of Option B:
    - No change in the level or stability of electricity prices, which will continue to support traditional ways of life in rural ranching and farming communities.

  - Rural electric utilities and Native American tribes would see no electricity price increases, sustaining potential sources of funding for local infrastructure investments.

Climate Change

- Using hydropower instead of fossil fuels has resulted in lower overall CO_2 (carbon dioxide) and greenhouse gas emissions that are linked to climate change.
- Scientists and government officials believe that hydropower is an important source of clean, renewable energy that can help reduce the contribution of the US to climate change.
- Impact of Option A:
  - Small increase in the amount of greenhouse gases, including CO_2, emitted into the atmosphere, which could increase the negative effects of climate change.
- Impact of Option B:
  - No change in the amount of greenhouse gases, including CO_2, emitted into the atmosphere, resulting in little or no impact on climate change.

Additional Benefits of Hydropower

- Having hydropower as part of the western US energy grid provides critical "baseload" electricity, meaning that dams, such as the Glen Canyon Dam, can consistently generate electricity needed to satisfy the minimum level of energy demand in the Region.
- The Glen Canyon Dam can also be "turned-up" very quickly to produce more electricity by releasing more water, providing a key source of "peaking power" in the western US for times when electricity demand is high – e.g., on a hot summer afternoon, in the evenings after people get home from work, etc.
- The dual ability of the Glen Canyon Dam to provide baseload <u>and</u> peaking power contributes to the stability and reliability of the western US energy grid.
  - This flexibility in the system makes it easier to integrate other intermittent renewables such as wind and solar power into the energy grid.
  - As more renewable wind and solar power are used in the western US, having flexibility in the energy grid such as that provided by the Glen Canyon Dam, will be increasingly important.
- Impact of Option A:
  - Reduce the flexibility of the Glen Canyon Dam to provide baseload and peaking power.
  - This will make it slightly more difficult and costly to integrate renewables such as wind and solar power into the western US energy grid.
- Impact of Option B:
  - Maintain the flexibility of the Glen Canyon Dam to provide baseload and peaking power.
  - This will preserve the ability of the system to integrate renewables such as wind and solar power into the western US energy grid.

Decision Making Process

- The US Department of Interior has the formal authority to make decisions regarding operation of the Glen Canyon Dam.
- Any decisions regarding the operation of the Glen Canyon Dam, which have the potential to affect and change a wide variety of resources, can only be made after completion of an extensive process intended to solicit and consider the views and preferences of all stakeholders.
    - This process is currently ongoing regarding the operational decision described earlier and the final decision will only be made upon its completion.
- Some stakeholders (e.g., rural utility cooperatives, ranching and farming communities, and Native American tribes) are concerned that their interests are not being adequately addressed through the process currently being conducted by the US Department of the Interior.
    - Some of these concerns stem from the potential for disrupting longstanding agreements, contracts, and expectations about how water and other resources are allocated and governed.
- Impact of Option A:
    - This option has tentatively been designated the "preferred" policy alternative by the US Department of the Interior. This designation may change, however, upon conclusion of the process designed to solicit stakeholder views.
    - Some stakeholders are concerned that this option will disrupt longstanding agreements over how water and other resources are allocated.
- Impact of Option B:
    - Currently, this option is <u>not</u> the "preferred" policy alternative by the US Department of the Interior. This designation may change, however, upon conclusion of the process designed to solicit stakeholder views.
    - Some stakeholders prefer this option because it maintains longstanding agreements, contracts, and expectations about how water and other resources are allocated.

Appendix 3: Demographic Comparison Across Samples

Table A3.1: Demographic Comparison Across Samples

Demographic	US Population (Age 18+)*	Value Definition Survey Respondents	Value Elicitation Survey Respondents
Age and Gender			
Age 18-29 Male	11.1	6.8	8.8
Age 18-29 Female	10.7	8.3	7.9
Age 30-44 Male	12.6	15.5	12.7
Age 30-44 Female	12.7	12.1	11.6
Age 45-59 Male	13.0	12.4	15.7
Age 45-59 Female	13.5	16.2	12.5
Age 60+ Male	11.9	12.5	15.4
Age 60+ Female	14.5	16.3	15.4
Race and Ethnicity			
White, Non-Hispanic	65.1	66.2	70.4
Black, Non-Hispanic	12.0	12.2	10.0
Other, Non-Hispanic	6.3	6.3	3.7
Hispanic	15.3	13.8	11.7
2+ Race, Non-Hispanic	1.3	1.5	4.2
Education			
Less than HS	13.2	1.2	8.7
HS	28.0	17.8	27.4
Some college	31.3	4.7	28.7
Bachelor or higher	27.5	76.3	35.3
Household Income			
$0–50,000	46.6	44.9	37.8
$50,000–100,000	29.8	35.2	32.3
$100,000–150,000	13.1	13.2	20.2
$150,000 and above	10.5	6.5	9.8
Census Region			
Northeast	18.0	18.8	19.8
Midwest	21.2	20.2	22.8
South	37.4	38.2	35.4
West	23.4	23.0	22.0

*Gender, age, ethnicity, race and census region based on the US Census Annual Estimates of Population (PEPASR). Household income based on American Community Survey (S1901). Education based on American Community Survey (S1501). All calculations based on are July 1, 2014, 50 states + Washington DC.

Appendix 4: Value Elicitation Exercise

Government officials are deciding how to operate the Glen Canyon Dam over the next 20 years. Officials are deciding between Option A and Option B. As a reminder, the options differ on when and how much water is released from the dam, the production and distribution of hydropower, operational flexibility given to managers, and the types and levels of downstream environmental programs implemented. The options also differ in their impacts on resources and communities in the Region.

Their decision on how the dam should be operated could cost your household money. These costs might include payment for personnel, equipment, and to monitor and evaluate the impacts of dam operations in the Region. These costs would be passed on to the public through a combination of:

- Higher monthly electricity bills for households in the seven states served by the Glen Canyon Dam, and;
- Increased federal taxes on all US residents.

Assume that the costs for your household (and similar households in your area) would begin in 2016 and would last for the next 20 years.

We would like to know how you would vote on an advisory referendum if all US residents were presented with two options – Option A and Option B – and asked to vote for the one they prefer. The option with the most support would be recommended to the government officials that manage the Glen Canyon Dam.

Government officials will consider many factors when deciding how to change dam operations. One factor they would like to consider is whether various options are personally worthwhile to people like you. We would like you to tell us which of these two options you would prefer.

Some people might vote for one option over another because:

- They support an option and the impacts of the option they support are worth what it would cost them to implement that option
- They oppose an option and the impacts of the option they oppose are worth what it would cost them to implement the other option

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 option is worthwhile at whatever level the final cost is determined to be. For this study, it is important that you tell us which option you prefer, based only on **your personal evaluation** of whether the effects of dam operations are worth the additional cost **to you**.

Think about a situation in which you had an opportunity to vote for Option A or Option B in an advisory referendum. The option with the most support would be recommended to the government officials managing the Glen Canyon Dam. 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 A or Option B?
1 - Option A
2 - Option B
3 - I would choose not to vote for either option

You selected [Option A/B]. Both options are costly to operate and will require continued financing. The following question asks whether you, as a taxpayer, would vote for this option in an advisory referendum. The option with the most support would be recommended to government officials managing the Glen Canyon Dam. As you think about your answer, keep in mind the amount of money you and your household would pay for the policy, how much you would be able to afford to pay, and the other things you could spend the money on instead.

Would you vote for [Option A/B] if adoption of this option would cost your household [$1:1200] in increased taxes every year for the next 20 years?
0 - No
1 - Yes
2 - Not sure

On a scale from zero to ten, where zero means *not at all certain* and ten means *completely certain*, how certain are you that you [would/would not] vote for [Option A/B] if it would cost your household [$1:1200] in increased taxes every year for the next 20 years?

We would like to know why you would not vote for the option you selected. Please select the most important reason.
1 - I'm opposed to any additional tax or fee in general
2 - Existing taxpayer money should be used
3 - Government already wastes too much money
4 - Collected money may not actually be used for the Glen Canyon Dam as promised
5 - Only users of the Glen Canyon Dam hydropower should pay
6 - I can't afford anything at this time
7 - I would be willing to support such a tax if it was collected for less than 20 years
8 - This policy is not worth it to me
9 - I need more information before committing my money
10 - I believe that the Glen Canyon Dam should be removed and I oppose all policies that would continue to operate the dam
11 - Other reason (please specify)

We would like to know why you are not sure if you would vote for the option you selected. Please select the most important reason.
1 - I'm opposed to any additional tax or fee in general
2 - Existing taxpayer money should be used

3 - Government already wastes too much money
4 - Collected money may not actually be used for the Glen Canyon Dam as promised
5 - Only users of the Glen Canyon Dam hydropower should pay
6 - I can't afford anything at this time
7 - I would be willing to support such a tax if it was collected for less than 20 years
8 - This policy is not worth it to me
9 - I need more information before committing my money
10 - I believe that the Glen Canyon Dam should be removed and I oppose all policies that would continue to operate the dam
11 - Other reason (please specify)

Appendix 5: Sample Non-Response

Table A5.1: Sample Non-Response

Variable	Respondents	Non-Respondents
Gender		
Male	52.6	45.8
Female	47.4	54.2
Age		
Age 18-29	16.7	24.4
Age 30-44	24.3	32.1
Age 45-59	28.2	23.7
Age 60+	30.8	19.8
Race and Ethnicity		
White, Non-Hispanic	70.4	54.4
Black, Non-Hispanic	10.0	15.1
Other, Non-Hispanic	3.7	4.6
Hispanic	11.7	20.1
2+ Race, Non-Hispanic	4.2	5.7
Education		
Less than HS	8.7	13.7
HS	27.4	27.9
Some college	28.7	30.3
Bachelor or higher	35.3	28.0
Household Income		
$0–50,000	37.8	44.5
$50,000–100,000	32.2	30.2
$100,000–150,000	20.2	16.8
$150,000 and above	9.8	8.5
Census Region		
Northeast	19.8	15.8
Midwest	22.8	20.8
South	35.4	38.3
West	22.0	25.2
Head of Household		
No	19.8	25.6
Yes	80.2	74.4
MSA		
Metro	85.1	85.7
Non-Metro	14.9	14.3
Employment Status		
Paid Employee	51.6	54.0
Self-Employed	7.3	7.3
Temporary Layoff	0.7	0.9
Looking for Work	5.8	9.0
Retired	20.4	11.5
Disabled	6.9	7.5
Not-Working (Other)	7.2	9.7
Total N	**3071**	**2995**