Measuring Nutrient Reduction Benefits for Policy Analysis Using Linked Non-Market Valuation and Environmental Assessment Models

Final Report on Stated Preference Surveys

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ABSTRACT

This document summarizes the economic modeling component of the project *Measuring Nutrient Reduction Benefits for Policy Analysis Using Linked Non-Market Valuation and Environmental Assessment Models*. The project's overall objective is to provide an integrated protocol that will assist state water quality managers in one aspect of their efforts to set numeric ambient nutrient pollution standards for surface water. The specific focus is on measuring the dollar-denominated benefits of nutrient reductions as they pertain to recreation and aesthetic services. To accomplish this task, a mechanism is needed that links measured nutrient pollution (e.g., ambient nitrogen, phosphorous) to a qualitative ranking of water quality, which can then be tied to an economic model of valuation. In this technical document we describe module 2 in our project, which centers on (a) designing and fielding a survey that uses stated preference methods to value water quality attributes, and (b) estimating economic models that take as inputs the predictions from our water quality model (constructed in module 1) and produce willingness to pay estimates of quality changes. We provide detailed descriptions of how water quality was described to survey respondents, how we designed choice experiment and contingent valuation method questions, and how our Internet-based sample was drawn. We also provide a full analysis of the data and present the main models we use for policy analysis. A case study is also included that draws together all aspects of the project.

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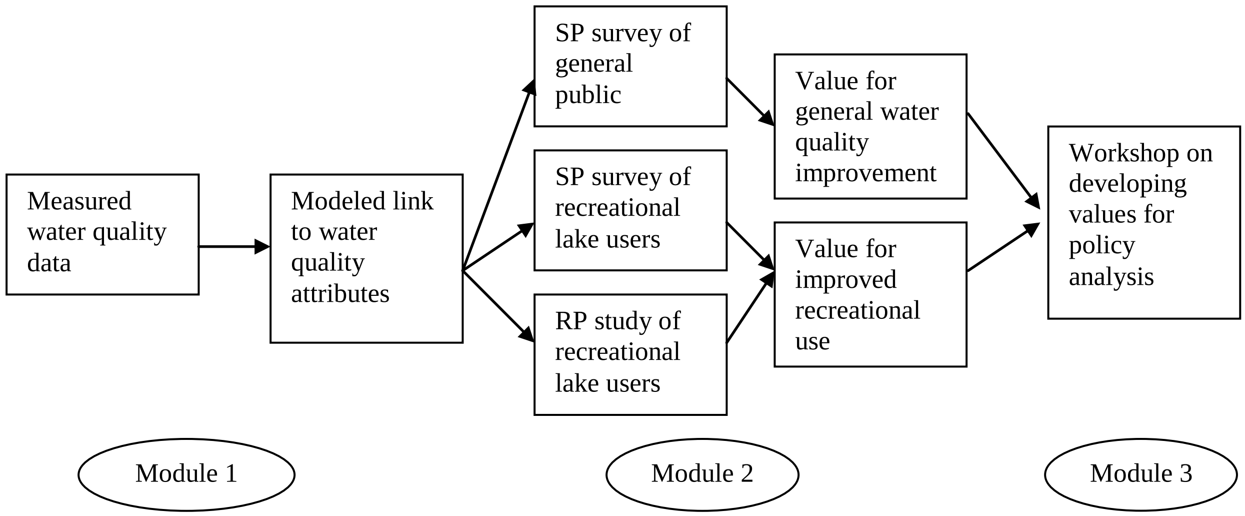
1. Introduction

In this report, we summarize work on the project *Measuring Nutrient Reduction Benefits for Policy Analysis Using Linked Non-Market Valuation and Environmental Assessment Models*. The project's overall objective is to provide an integrated protocol for use by state water quality managers in setting numeric ambient nutrient pollution standards for surface water. The specific focus is on measuring the dollar-denominated benefits of nutrient reductions as they pertain to recreation and aesthetic services. To provide benefit estimates, a mechanism is needed that links measured nutrient pollution (e.g., ambient nitrogen, phosphorous) to a qualitative ranking of water quality, which can then be tied to an economic model of valuation. Figure 1 provides an overview of the project. Our objective in this technical report is to describe the research centered on the second part of the project (module 2): construction of an economic model that predicts the dollar-denominated benefits of improvements in water quality based on a stated-preference (SP) survey. This report complements our earlier report, *An Interim Report on Water Quality Modeling* (Phaneuf et al., 2009), which describes module 1 of the project.

To provide context for this effort, we first describe the motivation for the project and its overall structure. In 2007 the U.S. Environmental Protection Agency's Office of Water (EPA-OW) solicited proposals for research that would "aid States in their attempts to estimate monetary benefits associated with nutrient reductions as they strive to adopt numeric nutrient criteria into their State water quality standards" (EPA-OW, 2007, p. 2). The solicitation was motivated by the desire among state and federal managers to establish numeric (as opposed to narrative) water quality criteria and the realization that the costs of obtaining such criteria are more readily measurable than the benefits.

Figure 1. Overview of Proposed Project Modules



The request for proposals goes on to state:

> However, State agencies charged with developing standards and facilitating their adoption into state regulations often lack the staff time and funding required to do a complete analysis of benefits. To assist State lawmakers and the general public in being better informed, State environmental agencies need to be able to accurately characterize the economic value of environmental benefits associated with achieving water quality standards for nutrients. A thorough assessment of these benefits associated with numeric nutrient standards *would apply a production function approach, documenting the direct linkage between excess nitrogen and phosphorus in the water and a loss of ecological goods and services provided to society*, and provide a monetary estimate of benefits from restoring these services. (EPA-OW, 2007, p. 3, emphasis added)

In response to this solicitation, we submitted a project focused on the Southeast of the United States (EPA eco-region IX) that had three main objectives:

i. Development of a eutrophication production function whereby quantitative measures of ambient nutrient levels can be mapped to qualitative indicators of water body quality as reflected by its trophic status.

ii. Development of a revealed preference (RP) and stated preference (SP) framework for nonmarket valuation of the benefits of nutrient reductions that (a) links to the eutrophication production function; (b) is general in that the software, data sources, and analytical techniques are transferable to other regions and scalable for any policy question; and (c) is location specific in that the parameters of the benefit function can be calibrated based on local conditions and the local policy question of interest.

iii. Transfer of knowledge on how the framework can be applied for regulatory analysis via (a) a training workshop targeted at state-level water quality regulators and analysts and (b) distribution of software, data sources, and educational materials necessary for implementing the framework.

EPA-OW selected our proposal for funding, and work began in April 2008. In this technical report, we summarize our research on the second of these objectives.

Our starting point is the output from module 1 (see Phaneuf et al., 2009 for a summary of the results from module 1). As part of module 1 of the project, we examined models that would provide a mapping between a specific southeastern lake's measured water quality (e.g., total nitrogen and phosphorous, chlorophyll a, turbidity) and a qualitative/descriptive categorization of its nutrient pollution status. Module 1 built on a series of expert elicitations to link trophic states with numerical water quality data (Kenney, 2007). Our task in module 2 is to construct an economic model that takes a change in a lake's qualitative ranking as its input and provides a measure of value associated with the change as its output. For this we use the tools of nonmarket valuation, which we introduce in Section 2. In Section 3, we describe the development of the survey vehicle we used to obtain the data needed to estimate our economic model, and in section

4 we provide a summary of the information obtained. Section 5 presents the analysis for the two types of SP questions contained in the survey. Section 6 presents a case study designed to highlight the use of both the economic and water quality models for policy purposes. Section 7 presents our final discussion and conclusions.

2. Principles of Economic Valuation

We are interested in the economic concept of value for measuring the benefits to society of improving ambient water quality. Using the economic concept of value, benefits arise from how change in water quality improves the well-being of individuals (and households). Individuals' well-being depends on their preferences (i.e., the collection of their likes, dislikes, and viewpoints) and the income and time they have to satisfy their wants and desires. For example, if water quality in a lake improves, the well-being of people who like to visit that lake will likely increase. Similarly, if environmental conditions in local lakes improve, people who care about the state of the environment will likely experience an increased sense of satisfaction. There are many other examples of specific ways that individuals' preferences determine the extent to which they benefit or suffer from changes in lake water quality, and the size of the implied well-being changes can vary immensely among different people. Our task is to find an observable metric that reflects how improvements in water quality at specific lake sites change the well-being of people living in the states where the improvements occur. This metric is what we then use to express the benefits of improvements in monetary terms.

Since well-being is a subjective and abstract concept, we need a proxy for well-being that has quantitative meaning. A useful concept is maximum *willingness to pay* (WTP), which is the highest amount of money a person is prepared to part with to secure some outcome (see Freeman, 2003, for an overview of the welfare economic concepts linking WTP to well-being). For example, we might be interested in a person's maximum WTP to secure a change in water quality at a lake near his home. Suppose she has an income of Y and is willing to pay at most \$$X$ for the improvement. From this trade-off, we know that the level of satisfaction the person perceives must be similar between the baseline condition with income Y and the improved quality condition with income $Y-$WTP. Thus, WTP measures the value of the change, expressed in terms of what an individual would be prepared to give up to obtain it. Since improvements in water quality tend to be non-rival (many people can enjoy them simultaneously), the total WTP across the population of people affected by the change is a dollar-denominated reflection of the value the population holds for the change. Estimating individual and population WTP values using survey and statistical techniques is the applied objective of our study. In some instances we are also interested in distinguishing between *use value* and *nonuse* value. The former arises from peoples' direct interactions with the environment. For example, use value for improved water quality can arise from the improved recreation experiences that better quality enables. Nonuse value refers to the component of WTP not based on direct interaction. For example, a person can value water quality in lakes simply because it is important to him, even if he never intends to visit a lake for recreation. Likewise, a person can value an improvement because she wants to assure that healthy ecosystems are available for future generations.

Revealed preference (RP) and stated preference (SP) are two possible strategies for estimating WTP for changes in environmental goods such as lake water quality. RP uses observations of people's actual behavior to infer their WTP for a change in an environmental good, and therefore tends to be appropriate for measuring use value. The primary RP approach for valuing water quality is the travel cost model. The premise of this model is that trips to a recreation site (e.g., a lake for swimming) are costly because people need to spend time traveling and, usually, some money to reach the destination. If water quality is important to these people, they may drive farther (effectively pay more) to reach a site with better quality. By doing so, they reveal their WTP for water quality in the form of higher travel costs. By observing the actual choices among a sample of recreation trip takers, it is possible to estimate a WTP function for water quality as it relates to recreation behavior.

The SP approach presents survey respondents with detailed information about a specific environmental good (e.g., lake water quality in their home state) and then solicits responses to hypothetical changes in aspects of the environmental good. SP methods are quite flexible in that they are able to measure both use and nonuse values. We used two SP methods in this study: contingent valuation (CV) and choice modeling (also called conjoint analysis). CV directly questions people about their WTP. For example, after being introduced to the environmental good and a proposed (but hypothetical) change in the good, a survey respondent faces a question of the form *"Would you be willing to pay $X to have this change?"* If the survey is properly designed a yes answer shows the person has WTP $\geq X$, while a no answer suggests WTP $\leq X$. A full sample of responses allows estimation of a WTP function that depends on characteristics of the survey respondents. Questions of this type usually measure WTP in a way that includes both use and nonuse values, in that people can answer yes for a variety of motives. Choice modeling takes a less direct approach to estimating a WTP function. Respondents face choice situations in which they are asked to select their preferred option from two or more hypothetical possibilities. Each possibility consists of a bundle of characteristic levels. For example, the choice situation may be *"Suppose you are considering a visit to a lake. Which of the following two lake types would you choose to visit?":*

- Lake A: quality level = medium, travel distance from home = 20 minutes
- Lake B: quality level = high, travel distance from home = 40 minutes

When the survey is properly designed, the trade-offs people report making among the different attributes in the experimental design allow estimation of the value of changes in one of the attributes, relative to another. In this example, we can measure the value of water quality as reflected in the additional travel time people are willing to undertake to obtain a desired level of quality. The SP scenario in this case is related to the actual use of lakes, and so it will capture only the use value associated with improved water quality.

The effectiveness of an SP approach to valuing environmental goods depends critically on the details of how the survey is designed. In the next section we discuss the design of the survey we used to carry out the SP analysis for this project, which constituted the main approach we applied. We note first, however, that there is a large literature that has applied SP methods of various types to value water quality. Two examples of recently published work in this area include Herriges et al. (2010) and Viscusi et al. (2008). These papers use contingent valuation and choice experiment approaches, respectively, to measure values for freshwater quality improvements. Our study builds from and extends analyses of this type by linking the outputs from our eutrophication model to the commodity design aspect of our survey. We provide specifics about this approach in the following sections.

3. Survey Development

A key goal of our project was to design and execute a major survey of southeastern households to measure values held by residents for lake water quality. In this section we describe the survey design process. Throughout the design process we made use of standard survey research techniques. During the initial and intermediate stages of development, we held focus groups at three different locations over the course of 5 months. These locations included Raleigh, NC, in December 2008; Richmond, VA, in February 2009; and Charlotte, NC, in April 2009. To further assess the survey draft, we conducted one-on-one cognitive interviews with outside volunteers in September and October 2009. The survey was designed to be self-administered through a web interface. Between October and December 2009, we reviewed and tested the web version of the survey. We also commissioned peer reviews of the instrument from Dr. Kevin Boyle of Virginia Tech University and Dr. John Whitehead of Appalachian State University. In February 2010 we executed an online pretest of the survey, which involved 100 respondents. In the subsections that follow we describe in detail the interrelated steps we used to design the final survey.

3.1 Survey Objective and Overall Structure

In a broad sense, the survey objective was to gather data that would allow us to connect the water quality model estimated in module 1 of the project (which links numerical water quality measurements to an index of eutrophication) to economic values. Recall that our modeling effort in module 1 provided a function that linked chemical indicators of water quality at particular lakes to the qualitative/descriptive categories shown in Table 1 (and used for Kenney 2007). The chemical indicators such as levels of nitrogen and phosphorous are policy variables because numeric quality criteria can be set based on their values. The economic

Table 1. Trophic Status/Eutrophication Categories

Level	Water Clarity	Color	Algae	Nutrient Levels	Oxygen	Odor	Aquatic Life
1	Excellent	None	Very little	Very low	Very high	No	Very healthy, abundant
2	Good	Little	Little	Low	High	Little	Healthy, abundant
3	Fair	Some	Moderate	Moderate	Moderate	Little	Somewhat healthy, abundant
4	Poor	Noticeable	High	High	Low	Noticeable	Unhealthy, scarce
5	Poor	Considerable	Very high	Very high	Low to no	Strong offensive	Unhealthy, scarce or none present

benefits of better water quality, however, are not easily linked to these chemical values. Instead, people's preferences are more likely to be based on descriptive indicators of water quality expressed in lay terms. Given this, our primary concern was to examine preferences for water quality using the definitions and descriptions shown in Table 1. For the SP part of the survey, the challenge was to describe the water quality attributes in Table 1 in a way that was meaningful to the public but that conveyed the scientific understanding of the terms in module 1 of the project.

Economic theory and past research suggest that water quality affects people's utility through a variety of pathways. Water quality has been linked to recreation choices (Phaneuf, 2002), the value of lakeshore property (Leggett and Bockstael, 2000), concern for ecosystem health (Farber and Griner, 2000), and the cost of the public drinking water supply (Olmstead, 2010). For the public, the aesthetic characteristics of the water body and the quality of aquatic habitat are the characteristics most directly affected by nutrient levels. Many of the lakes in the Southeast, especially the large reservoirs, provide important recreation opportunities. Based on the goals of the project, we decided to focus on measuring the value of water quality changes for individuals who use lakes for recreation and the value of changes in water quality in the state as a whole for the general public.

The most natural format for eliciting the value of changes in water quality for recreation visitors is to observe how water quality affects trip decisions. RP analysis uses data on actual trips taken, and modeling is therefore based only on existing water quality conditions. Thus, for the SP choice experiment, we decided to have respondents choose between alternative trips to lakes with different levels of water quality. To match the travel cost paradigm, the cost of a trip was expressed as the time it takes to get to the lake. The choice experiment questions focus on day trips. We selected day trips as the object of choice for three primary reasons. First, the travel cost model is best suited for day trips in which driving time is the main cost (Phaneuf and Smith, 2005). Second, as discussed in more detail below, choice questions based on day trips are easier for respondents because fewer trip characteristics need to be described. Finally, a day-trip model allowed us to focus on lakes within a small radius around the respondent's home. Although the day-trip format has advantages, the result is that our estimates will not reflect the value of improvements in water quality for overnight trips.

We selected a contingent valuation (CV) SP approach to elicit the value the general public places on water quality improvements in the state. The CV question was presented in the form of a referendum in which the benefits and costs of lower nutrient levels were presented. Given the two SP approaches used, we decided at the beginning of the process that the survey vehicle would contain four main sections, presented to respondents in the following order:

a) <u>Recent recreation experience</u>. Gather information on whether the respondent has participated in lake-based recreation in the past year. If yes, solicit information about typical activities and the actual lakes visited. If no, solicit information on the future likelihood of a visit to a lake.

b) Water quality communication. Present information to respondents on how nutrient pollution affects lake water quality. Discuss how water color and clarity, fish populations, algae blooms, and the presence of odors can be used to classify lakes. Define and present five qualitative lake quality categories based on these dimensions that matched the descriptions in Table 1.

c) Choice experiment questions. Present lake recreation choice tasks to the subset of respondents who had visited a lake in the recent past or plan to visit in the near future. Design the choice tasks to solicit the trade-offs people are willing to make between distance from the lake and the water quality level when choosing a lake to visit.

d) CV question: Present the full sample of respondents (both those who answered the choice experiment and those who did not) with a CV question that solicits WTP for a program that improves water quality levels at lakes in the respondent's state.

As we discuss in detail below, the recreation and choice experiment sections are intended to assess water quality benefits as related to the recreational use of lakes, while the CV section is designed to measure the broader value of water quality improvements around the state. Section 4 discusses the fielding of the survey. Appendix A contains the final instrument on which the online version was based. No socioeconomic information was directly collected, because information of this type is available from Knowledge Networks (the marketing company we used to field the survey) for all members of their panel, independent of specific surveys. Each section of the survey was developed in an iterative fashion using focus groups, cogitative interviews, peer feedback, and discussion among the project team. We discuss the development process in the following subsections.

3.2 Recreation Section

In the recreation literature, trip activity typically correlates with an individual's WTP for water quality (see Herriges et al., 2010, and the works cited therein, for evidence of this from the Iowa Lakes Project). Reports on lake-based recreation provide information on the frequency and types of trips respondents take. Our objective in gathering recreation trip information was to obtain a relatively complete accounting of individuals' lake recreation trips during the last 12 months, while minimizing the burden to respondents of providing this information. This is a common objective in survey research designed to support travel cost modeling; thus, we were able to call on substantial past experience in designing this section (see Parsons, 2003, for more detail on data collection for recreation demand models).

The typical strategy is to present a "choice set" – the collection of sites for which trip-taking records are desired – and ask people to indicate which sites they visited and how many trips were made. Ideally, the choice set contains all the lakes a respondent might visit. Our design was made difficult by the large geographical scope of our survey: respondents were drawn from 8 states, including North Carolina, South Carolina, Virginia, Georgia, Kentucky, Tennessee, Alabama, and Mississippi. Thus, the number of lake sites we might consider presenting to people was comparatively large. Given this, our specific tasks were to (1) design skip patterns that would allow people to move quickly through irrelevant sites and (2) design choice sets that contain the major lake sites in all the states, while keeping lake lists small enough to view on a single screen page.

We ultimately settled on a telescoping skip pattern, which proceeded as follows:

- People were asked if they had taken any day trips to lakes for recreation in the last 12 months. Our previous experience suggests that 12 months is long enough to distinguish between frequent lake visitors, occasional visitors, and nonvisitors but short enough that recall problems should not be a significant issue.

- Trip takers were presented with a list of states within our broad study area and asked to indicate which states they had visited for their lake trips.
- For each state visited, respondents were presented with a map dividing the state into specific regions (e.g., western North Carolina, central North Carolina, and eastern North Carolina) and were asked to indicate the region(s) in which the lake(s) they visited was located. This was done for each state sequentially.
- For each region/state combination in which a trip occurred, the respondent was presented with a list of lakes and asked to mark those they visited. An option to write in a lake name was provided for cases in which the lake was not listed. Once the lakes for the region/state were obtained, a new prompt asked for the count of trips to those lakes. This was done for each region/state combination sequentially.

This strategy for obtaining trip counts was tested mainly via cognitive interviews and the pretest of the survey. Interview respondents reported having little trouble reporting their activities in this manner, and the pretest data set had few item nonresponse instances for this set of questions.

We relied on three sources to design the lake choice sets for each state/region that would be presented to respondents. As part of previous research, co-PI Dr. Kenney assembled an inventory of lakes in North Carolina that formed the basis for that state's lake list. Her research also provided input into identifying the main recreation lakes in Virginia and South Carolina. For other states in the study area, our initial source of information was web sites maintained by state government agencies for tourism promotion and/or water management. Project team members with substantial experience with water issues in the Southeast reviewed these lists for completeness. These reviews produced ad hoc additions and clarifications on naming conventions. Finally, we used data from the 2008 National Survey of Recreation and the Environment (NSRE) to cross-check our lake lists. The NSRE is a large, country-wide survey of recreation behavior that includes a module summarizing freshwater recreation activity, including the names of particular destinations. We listed lakes in each state in our study area that respondents to the NSRE named as having visited and ranked these by the count of visits reported. We matched these data against our initial lake lists to be certain that we had not left out lakes that may be important recreation destinations. This effort led to the addition of a small number of lakes to our lists. Appendix B contains the final region/state-specific tables used to program the survey. Ultimately, our choice set included 1,117 named lakes across the states in our study region.

3.3 Water Quality Communication

As noted above, our survey plan involved using a choice experiment and CV to measure the trade-offs in time and money respondents would make for improved lake water quality. A critical component of any SP exercise is to define the environmental good in question and communicate how different quality levels of the environment might affect survey respondents. In our case, the environmental good is lake water quality, which is affected by nitrogen and phosphorous loadings. Recall that our water quality model links chemical and physical measures of water quality to the five-level eutrophication index presented in Table 1. The eutrophication index is based on seven traits of lakes that have ordinal, qualitative levels. For each value in the eutrophication index, the seven traits are set to levels consistent with what one would generally expect to find in lakes at that index value. The SP section uses five of the seven traits to elicit the public's preferences for improving water quality from one level to another by reducing eutrophication. We dropped the traits "nutrient levels" and "oxygen." The general public does not perceive nutrient and oxygen levels per se, but rather the effects of these levels on observable traits.

The water quality communication section of the survey begins with a short discussion of how excess nitrogen and phosphorous can affect water quality. The next few pages of the survey present the traits used to describe the level of eutrophication, with the objective of providing a survey-appropriate version of Table 1. Starting with Table 1, we needed a scheme for ranking the quality levels of different lakes that was accessible to survey respondents, based on perceptible features of the water bodies; scientifically accurate, appropriate for both the choice experiment and the CV question; and could be linked to the five levels shown in Table 1.

Table 2 displays our final definitions for the five categories of lake water quality, along with five perceptible traits that were used to describe each level. These traits are water color, water clarity, fish populations, algae presence, and odor presence. Note that each trait can take on three to five descriptive levels, so all trait levels do not vary over all categories. The categories A through E in Table 2 correspond to the levels 1 through 5 in Table 1. Note that the descriptions in Table 2 are abbreviated, and the survey instrument provides more explanation on each category and level (see Appendix A).

The process of moving from the conceptual objective to the final categorization shown in Table 2 involved several steps. The first was to establish whether water quality is likely to matter to people generally. This is important because one of the criticisms of SP survey techniques is that they create the preferences they are intended to measure. Focus groups are an important tool for examining the relevance of an issue as well as effective communication

Table 2. Abbreviated Water Quality Descriptions for the SP Survey[a]

CATEGORY	A	B	C	D	E
Color	Blue	Blue/brown	Brown/green	Brown/green	Green
Clarity	Can see 5 feet deep or more	Can see 2–5 feet deep	Can see 1–2 feet deep	Can see at most 1 foot deep	Can see at most 1 foot deep
Fish	Abundant game fish and a few rough fish	Many game fish and a few rough fish	Many rough fish and a few game fish	A few rough fish but no game fish	A few rough fish but no game fish
Algae blooms	Never occur	Small areas near shore; some years, 1–2 days	Small areas near shore; most years, 1 week	Large areas near shore; once a year, 2–3 weeks	Large, thick areas near shore; every year, most of summer
Odor	No unpleasant odors	1–2 days a year, faint odor	1–2 days a year, faint odor	3–4 days a year, noticeable odor	Several days a year, noticeable odor

[a] The survey instrument provided the respondents with more details on each category and level. Categories A to E correspond to levels 1 to 5 in Table 1.

approaches. The participant worksheets used for our three focus groups are included as Appendix C. Our first and second focus groups included tasks designed to establish whether water quality matters to people when considering lake recreation destinations. By prompting participants to list important features of lakes *before* mentioning the purpose of the focus group, we were able to examine the extent to which water quality indicators are salient in people's recreation choices. Along with obvious features such as distance from home, facilities, boat ramps, and swimming areas, a sampling of features people listed included the following:

- clean and neat generally—no litter near facilities, near-shore areas are debris free;
- pleasant scenery with healthy vegetation;
- quiet, a lack of crowds;
- water appears clean; no health worries about going in the water; and
- lack of pollution presence generally.

The focus group evidence suggests that water quality is a feature that is likely to matter to people in their recreation decisions. This provided assurance that water quality can be reasonably expected to enter preferences through recreation and that our choice experiment concept was valid.

The next step was to examine the ways that people judge the quality of lakes they might visit. Our hypothesis was that perceptible and intuitive features would be most relevant, rather than scientific measurements. In the first and second focus groups, we asked people to list features of lakes that they associate with cleaner and dirtier lake water. A sampling of clean-indicating responses included

- more fish and wildlife;
- clearer water; healthy looking color; and

- fresh and natural smells.

A sampling of dirty-indicating responses included

- stagnant water and rotting smells;
- surface scum, dead fish; and
- low water levels.

We used the responses from the focus groups, coupled with the descriptions from Table 1, to create descriptions of the five traits (color, clarity, fish populations, algae presence, odor presence) that we used to distinguish lakes of different quality. With the traits identified in the focus groups, input from Dr. Reckhow and Dr. Kenney, and the advice of outside water quality scientists were critical to our efforts to match our lay descriptions in Table 2 to the scientific understanding of the experts interviewed to create the water quality function in module 1.

In the survey instrument, each of the five traits is discussed separately. The survey instrument provided a short description of the trait, how it is affected by nitrogen and phosphorous, and the levels it could take. After each description, the respondent answered a question about the trait. The questions were intended to prompt the respondent to think about the trait and to break up the text in the survey, which helps keep respondents focused.

We first considered color. From Table 1, color ranged from none to considerable. The water quality scientists understood that the labels referred to the color associated with excess nutrients (primarily shades of green and brown). For the public, the actual color of water with varying levels of eutrophication needed to be described. In situations such as this, pictures and graphics provide an important complement to text in surveys. The NOAA panel[1] (NOAA, 1993)

[1] The National Oceanic and Atmospheric Administration (NOAA) panel was a panel of experts convened by the NOAA to review the use of CV surveys in natural resource damage assessments and to provide recommendations for best practice.

recommends including visual displays in addition to text, and in past studies we have always included pictures or graphs. Mathews et al. (2007) also emphasize the usefulness of visual aids in presenting information, both picture and graphs. Their discussion touches on the subjective judgment that must ultimately be employed in a decision about visual aids, and they stress the importance of pretesting to make sure that respondents do not misinterpret the visual aids.

We ultimately decided on four color levels: blue, blue/brown, brown/green, and green. In focus groups we started with five levels and provided participants with five photos of a single lake scene. The colors were digitally manipulated to show five color gradations with varying degrees of blue, brown, and green but were presented out of order. People were asked to identify the photo that best fit lakes in their area, and the subsequent discussion focused on rating which colors corresponded to the cleanest water. There was general consensus that blue was better and that gradations toward brown/green combinations indicated worse water quality. We settled on four levels of color (categories C and D both have brown/green color) because focus group respondents presented with five shades of color did not distinguish well between the middle brown/green categories. The survey instrument described the impact of nutrients on water color and presented photographs of the four levels (see Appendix A). The descriptions were somewhat complicated by the natural brown color of many Southeastern lakes. However, based on discussions with Dr. Kenney about how the water quality scientists she interviewed would have thought about color and the focus group results, the top category was designated as blue.

Like color, clarity is a visual trait of the water. In Table 1, clarity ranges from excellent to poor, with categories 4 and 5 both associated with poor clarity. For water clarity we decided on four levels: can see 5 or more feet, can see 2 to 5 feet, can see 1 to 2 feet, can see at most 1 foot. As in Table 1, the lowest two categories, D and E (levels 4 and 5 in Table 1), were both associated with the lowest level of clarity. The focus group discussion indicated that people were comfortable with this trait and understood what clarity meant. Again, the adjectives in Table 1 were translated into concrete descriptions with the help of water quality scientists to ensure that the levels used in the SP survey correctly matched with the scientists' understanding of the associated terms in Table 1. The main challenge was to suggest a tool people could use to visualize the differences mentally. Based on focus group discussions, the image of an angler's bait disappearing beneath the surface after some depth seemed the most effective.

Water color and clarity are visual traits that did not need to reference spatial or temporal dimensions to be effective, although, of course, they will vary depending on weather and other factors. The remaining three traits—aquatic life, algae and odor—were comparatively more complicated. In Table 1, aquatic life is described as ranging from "very healthy, abundant" to "unhealthy, scarce or none present." The focus group discussions suggested people were comfortable with the type and population of fish as an indicator of aquatic life. In the focus groups, anglers were familiar with the species of fish that thrive in lakes with better and worse water quality. Although nonanglers might have been less familiar with the names of the fish, they did understand that cleaner water supported greater species diversity, more highly valued fish species, and larger populations of fish. After testing descriptions of fish type and abundance in the focus groups, the participants could easily understand the distinction between game fish and rough fish. They also accepted that clean water was capable of supporting game fish populations (e.g., bass and crappies), while dirty water tended to be dominated by rough fish (e.g., carp). We, therefore, decided to describe fish habitat based on which types of species were most prevalent. The five levels we settled on include abundant game fish and few rough fish, many game fish and few rough fish, many rough fish and few game fish, and a few rough fish but no game fish. Based on focus groups and discussions with scientists, we used carp and bullhead catfish as examples of rough fish and bass, crappie, bluegill, and channel catfish as examples of game fish.

Describing the algae and odor trait levels posed special challenges because of the spatial and temporal variation in their outcomes. The algae levels in Table 1 range from "very little" to "very high." Again, scientists can interpret these terms based on their knowledge and the information provided to them in the expert elicitation. For the general public, more detailed descriptions were needed. In the focus groups, people were shown a photo of an algae bloom and asked to discuss whether they had seen such a phenomena. Participants generally knew that a bloom signaled something was not correct, but few had observed a major bloom covering large sections of a water body. Participants also appreciated that blooms were seasonal and temporary. However, because most of the focus group participants had never seen a large algae bloom in lakes where they visited, including the algae attribute caused some people to think that water quality was better than it actually was because of the lack of surface algae blooms. We addressed this problem in two ways. First, the final descriptions for the algae attribute described both spatial and temporal variation in algae. These dimensions were combined into five levels: blooms never occur, small areas of algae occur in some years and last a few days, small areas of algae occur in most years and last a few days, small areas of algae occur every year and last several days, large areas of algae occur every year and last several weeks. Even with spatial and temporal variation, some respondents had difficulty incorporating algae into their decisions, because they assumed they could take care of this problem by not visiting the lake when there were algae blooms. Our concern was that respondents would be distracted by the algae attribute. As discussed below, the odor attribute had similar problems. To test for the important of these two attributes, we designed two versions of the water quality descriptions—one that included algae and odor and one that did not. This allowed us to examine the extent to which responses differed across the two treatments.

As with algae, odor proved to be a difficult trait to describe accurately. In Table 1, the odor levels range from "no" to "strong, offensive." Although people appreciated that lakes can smell unpleasant, gaining consensus on how frequently this might occur in good versus bad quality lakes was more elusive. The focus group participants had never been at a lake that smelled anything close to "strong and offensive." Similar to the algae attribute, individuals tended to think water quality at lakes must be better than it actually is, because they had never experienced any problem with odor. We decided on five levels for this trait: strong unpleasant odor several times a year, noticeable unpleasant odor several times a year, noticeable unpleasant odor 2 to 3 times per year, faint unpleasant odor 1 to 2 times per year, no unpleasant odors.

In SP surveys, designing the attributes and levels for the attributes requires balancing the cognitive burden of the survey instrument against the information needed to make a decision. This balance was our primary concern in communicating the attributes described above. During the expert elicitation research, Dr. Kenney conducted long, detailed interviews with water quality experts who understood the subtleties of water quality science, including the nonlinear and correlated structure of eutrophication indicators. Although our descriptions for the lay public cannot convey the same subtleties, our focus group and pretest work and our discussions with water quality scientists suggest respondents were able to understand how attribute levels related to the water quality index in ways that scientific specialists would broadly agree with. Thus, we are confident that the descriptions shown in Table 2 provide a solid basis for our SP questions.

3.4 Question Design

The survey questions needed for our SP objectives fall into three categories: survey questions designed to explain and reinforce the water quality categorization used, the choice experiment questions, and the CV questions. A set of questions were designed to familiarize respondents with the water quality traits and their levels individually (see questions 10.1 to 10.5 in Appendix A). For each of the traits—color, clarity, fish population, algae, and odor—the survey provided explanations on how nutrient pollution can affect the levels of the trait in lakes across their region. For each trait, individual respondents were asked to review the levels and then indicate which level they thought most closely corresponded to the lakes in their area. Ultimately, peoples' answers to these questions were less important to our analysis, but by asking people to consider lakes in their area we encouraged them to read through and think about each trait and its possible levels. For water color and algae presence, photos were also included to provide visual cues (see questions 10.1 and 10.4). After reviewing the water quality traits individually, the next set of questions (questions 11, 12, and 13 in Appendix A) asked respondents to think about lakes in their home state using all five of the trait levels simultaneously. Respondents were presented with information similar to Table 2 and asked to select the lake category that they believed corresponds most closely to lakes in their home state. In this way people gained experience in thinking of lake quality as consisting of a related collection of perceptible indicators. To reinforce this, the next two questions asked respondents to consider the remaining categories and indicate which among them had the next best level of correspondence with lakes in their states. With the water quality communication section so completed, respondents who were lake recreators or potential lake recreators completed the choice experiment questions.

Choice Experiment Questions

The intent of our choice experiment was to examine trade-offs people make between water quality and other scarce resources, within the context of recreation behavior. To accomplish this, we presented people with sets of lakes that were differentiated by their water quality levels and other relevant attributes (such as travel time from home) and ask which they would prefer on a given trip-taking occasion. We had to make several decisions before arriving at the final form of the choice questions, an example of which is shown in Figure 2.

Figure 2. Example Choice Experiment Question

		LAKE 1	**LAKE 2**
WATER QUALITY	WATER QUALITY CATEGORY	**C**	**B**
	COLOR	Brown/green	Blue/brown
	CLARITY	Can see 1–2 feet deep	Can see 2–5 feet deep
	FISH	Many rough fish and a few game fish	Many game fish and a few rough fish
	ALGAE	Small areas near shore; most years, 1 week	Small areas near shore; some years, 1–2 days
	ODOR	Faint odor, 1–2 days a year	Faint odor, 1–2 days a year
ONE-WAY DISTANCE FROM YOUR HOME		[30-minute drive]	[90-minute drive]
Which lake would you choose? *(check one box)*		□ **LAKE 1**	□ **LAKE 2**

These included the plausibility of the trade-offs we wanted to model, the subset of people who would answer the questions, the specific form of the choice scenario, the role of different activity options, the collection of attributes that would characterize the lakes, and the role of an opt-out or "no trip" option.

As Figure 2 shows, our choice experiment focuses on trade-offs between water quality and travel time in the selection of lake destinations. We used the first focus group to scope out the extent to which this is a trade-off people accept as realistic, and consider in their actual decisions. Our discussion indicated that people understand that better water quality can result in a better visit experience, but that the activity that is planned would condition the extent to which water quality matters. Our summary of the open discussion in the first two focus groups suggests participants would be willing to drive 30 to 60 more minutes to reach a destination with appreciably better quality, particularly if it were for swimming or angling or if a child would be in contact with the water. During our second focus group, we also examined how people would respond to explicit trade-offs between travel time and water quality as defined for the survey, presented within a format as in Figure 2. The discussion indicated that people had little trouble accepting the notion that such trade-offs were possible, and participants again reported a willingness to travel further to obtain better quality. From our focus group work we are confident that the trade-offs we are modeling are grounded in reality and that people accept the notion that such trade-offs may be relevant. We also learned that the extent to which people think about the distance/water quality trade-off may depend in part on the activity that is planned and the composition of the group.

Because our survey used a general population sample, we needed to take steps to ensure that only people for whom lake recreation was relevant would answer the choice experiment questions. We used answers to the recreation experience question (question 1) to screen individuals. If respondents indicated they had not visited a lake for recreation in the last 12 months, they were asked if they thought it was likely that they would visit one in the coming 12 months (see question 2). If respondents visited a lake or indicated that they might in the future, they were tracked to the choice experiment section. At that point they were presented with a scenario that begins:

> *Imagine the following situation. Sometime next summer, the weather forecast for the weekend looks good so you begin thinking about a day trip to enjoy your favorite lake recreation activity.*

Because the focus group evidence suggested activity and group composition may matter in how people make trade-offs, respondents were then asked to indicate what their main activity would be, whether they would travel alone or in a group, and whether the group would include children. Survey questions 14 and 15 (see Appendix A) show the specific wording we used and the options that people could choose from. Answers to these two questions allow us to condition our analysis on what people imagine to be the intent of their recreation trips. Based on the focus groups, we knew that respondents would probably imagine the activity they would do on their lake trip. We decided to have people state their activity and group composition, because it did not seem realistic to assign these features to their trip. In addition, explicitly asking activity and group composition would allow us to better control the variability in answers.

Presenting different lakes for survey respondents to choose from required decisions on what attributes of the lakes to present and vary. Choice experiments can generally be divided into two types: branded and generic. A branded approach in our context would be to name *specific* lakes near a respondent's home (e.g., Falls Lake and Jordan Lake for residents of central

North Carolina) and present real or designed quality levels at the lakes for people to select among. This approach has clear disadvantages for our purposes, in that people's choices will reflect their unobserved (to us) attitudes toward the lakes, thereby invalidating our measurement strategy. A generic approach, by contrast, presents people with unnamed options that are distinguished only by the attributes included in the experiment. Though this is a more abstract concept for the individual, it allows us to measure the trade-offs we are interested in while hopefully avoiding confounding individuals' attitudes about or experience with specific lakes. To characterize the generic lakes we elected to use only two attributes: the water quality category (consisting of the bundle of traits and their levels) and the travel distance to the lake. We could have included other attributes such as the presence of facilities, a swimming area, and parking lots, but this would have complicated the design and increased the amount of information people would need to process. Because these attributes are largely orthogonal to our objectives, we left them as implicit rather than explicit variables. Each choice question was introduced as follows:

> *Imagine that your two options are Lake 1 and Lake 2. The only differences between these two lakes are shown in the table below. Otherwise, they are exactly the same in every other way.*

Thus, we invited people to form their own images of what the lakes would be like outside of the designed attributes but asked that they not differentiate their images between the two options. Our probing during focus groups indicated that people were comfortable with this level of abstraction.

The final decision regarding the design of the choice experiment questions had to do with the use of an opt-out option, in which the person can decide not to choose one of the options. In general, the decision to include an opt-out option depends on whether the respondents could realistically opt-out of the choice in the real world and the goals of the study (see Hensher, Rose and Greene, 2006, or Holmes and Adamowicz, 2003). For example, in this study, respondents could decide they did not want to take a trip given the choices available to them. If respondents can realistically decide not to choose any of the alternatives, including an opt-out alternative provides respondents with a more realistic choice situation. In addition, if the goal of the study is to predict demand, omitting the opt-out option will likely bias the predictions. Holmes and Adamowicz (2003) favor the inclusion of an opt-out option. However, an opt-out option reduces the amount of information gathered, because the person does not provide a ranking of the designed options if they select no trip. To balance these two features, we used a two-step approach in which respondents first indicated which was preferred between the two generic lakes and then was given the option of visiting neither if the attribute levels were not to their liking.

Contingent Valuation Questions

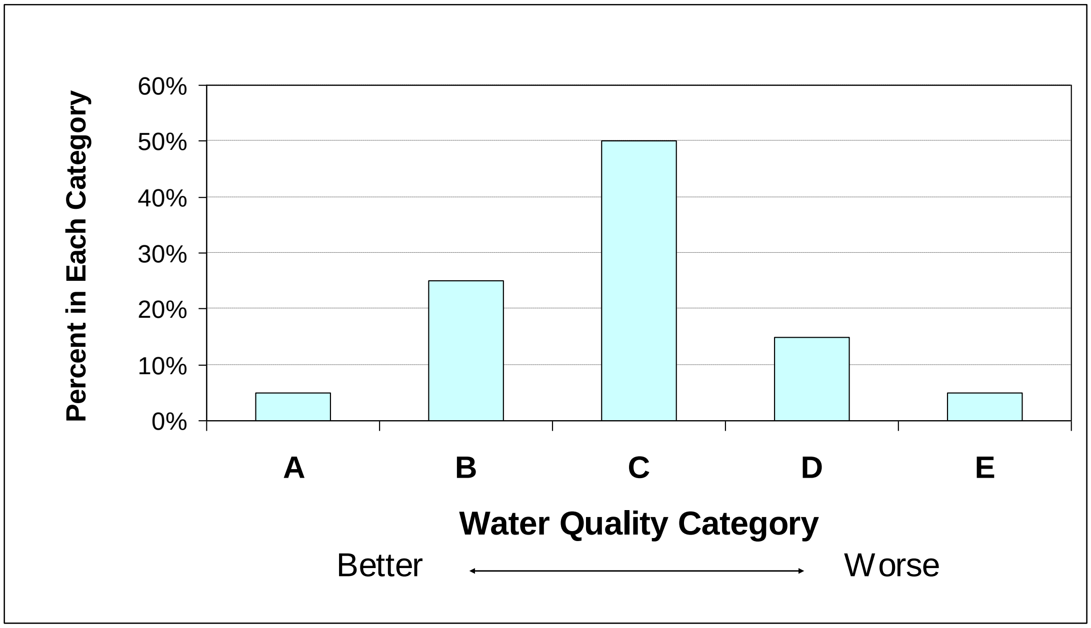
Though the primary intent of the survey is to assess the value of lake water quality as it relates to recreation, we decided to add a more general valuation vehicle for two reasons. First, we expected that at most half of the respondents in a general population survey would be lake recreators or potential lake recreators. Given this we wanted an auxiliary vehicle that was general enough for all respondents to answer. Second, there may be instances when the value of a broader policy intervention—for example, at the level of the entire state—may be useful for state water quality managers. For these two reasons we decided to include a CV exercise that would examine respondents' general (as opposed to recreation-specific) WTP for broad-scope policies that would improve lake water quality across their entire state. Designing the CV section of the survey required a definition of the commodity to be valued, a strategy for explaining baseline and improved levels of the commodity, a specific policy project that would provide the improvement, a payment vehicle, and an elicitation method.

Our goal in defining the commodity for the CV exercise was to describe water quality using the five categories discussed above, but in a way that would be broader than the single-lake/single-trip focus used in the choice experiment. We settled on an approach in which the overall commodity would be the distribution of lakes across the five categories in the respondent's home state. Thus, our valuation task was to measure people's WTP to shift the distribution of lake water quality from baseline conditions to some hypothetical improvement. This required that we communicate a baseline condition and how a policy might change things. We used both textual and graphical descriptions to accomplish this. As is recommended (Mathews et al., 2007), we pretested the graphic carefully to make sure that respondents understood the graph. In particular, the CV section began with a written description as follows:

> *Information about water quality at public lakes is often collected and reported by state agencies. This information can be used to show the percentage of lakes in HOME STATE that are in each of the five water quality categories.*
>
> - *30% (3 out of every 10 lakes) are in one of the best two categories (**A** or **B**)*
> - *50% (5 out of every 10 1akes) are in the middle category (**C**)*
> - *20% (2 out of every 10 lakes) are in one of the lower quality categories (**D** or **E**).*

A graphic as shown in Figure 3 was also provided to give a visual image of the baseline conditions.

Figure 3. Graphical Description of Baseline Water Quality



After presenting the baseline, we described a generic program at the state level that would provide a general improvement in water quality across the state. Respondents were presented with the following program description:

Imagine that state agencies in charge of water resources in HOME STATE are considering a program to improve lake water quality. Because nitrogen and phosphorus come from many different man-made sources, there are many ways to control them. Under the program being considered, efforts to reduce nitrogen and phosphorus would be spread among many different groups. For example,

- *sewage treatment plants would have to install better treatment systems;*
- *residents using septic tanks would have to inspect these systems for leakage;*
- *towns and housing developments would have to install improved systems for managing water runoff from storms;*

- *farms would have to reduce fertilizer runoff from fields and improve the containment of animal waste.*

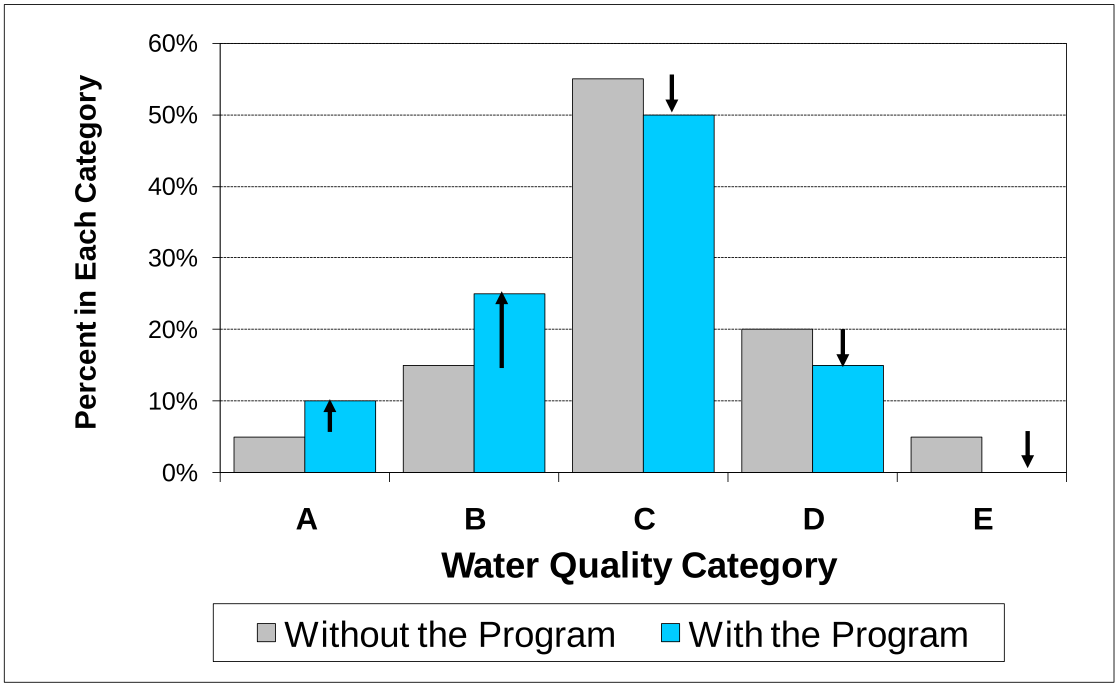
Our objective in describing the program this way was to allow the incidence of clean-up responsibility to be broadly distributed. Based on cognitive interviews and past experience, respondents are sometimes concerned about the perception of fairness or implicit property rights. With the program defined, respondents were then given textual and graphical information on how the program could be expected to improve water quality:

> *The diagram below compares projected lake conditions in HOME STATE <u>in 10 years</u>, with and without the program. The bars in grey show what lakes would be like without the program. If no action is taken to control nitrogen and phosphorus, only 20% (2 out of every 10 lakes) would be in one of the best two categories (**A** or **B**). The bars in blue show what lakes would be like with the program. 35% would be in one of the best two categories. The arrows show how the percent of lakes in the best two categories would increase, and the percent in the other categories would decrease.*

An example of visual display accompanying this text is shown below in Figure 4.

With the baseline conditions, program, and potential improvements so described, the next step was to describe how the program would affect the respondent financially, if it were to go forward. The payment vehicle, as it is referred to in the SP literature, describes how the respondent would pay for the program. Selecting an appropriate payment vehicle often poses a challenge. More specific payment vehicles make the whole scenario more realistic, but also increase the probability that respondents will vote based on their reaction to the payment vehicle rather than the scenario the researcher wants to value.

Figure 4.   Graphic Used to Show Change in Water Quality



Boyle (2003) reviews payment vehicles used in different studies, including income tax increases, general increases in the cost of living, increases in utility bills, or entrance fees and donations. In the survey, we presented a general set of actions that the state would take to improve water quality. Some of these actions might be financed by taxes, while others would be paid for by individuals or businesses through utility bills or increases in the costs of other goods. After pretesting, we selected a general payment vehicle that emphasized an overall increase in their cost of living. We felt this general payment vehicle best reflected the various avenues through which respondents would have to pay for the plan we described, and in pretests respondents seemed to accept the approach. We settled on the following phrasing:

> *The changes required by the program would have a cost for all HOME STATE households. Some of the basic things people spend money on would become more expensive. For example, for homeowners, water bills or costs for maintaining septic*

systems would go up. For renters, rent or utility bills would go up. Imagine that for households like yours, starting next year, the program would permanently increase your cost of living by $V per year, or $V/12 per month.

As we describe in the next subsection, *V* is one of several bid amounts presented to the survey respondents.

The final step is the wording for the actual choice question. Again, there are different ways to phrase the choice. The NOAA panel recommends phrasing the question as a referendum. Boyle (2003) discusses the research on decision rules, including results that suggest a risk of a referendum format is that it might induce respondents to vote as "good citizens" rather than reveal their individual, self-interested WTP. Against this is research (e.g., Carson and Groves, 2007) suggesting that incentive compatible decision rules such as referenda can help minimize hypothetical bias (the tendency to answer hypothetical questions differently than if it were a real choice). We decided to use a voting referendum, including the decision rule that the program will be adopted if a majority of the voters support it. As is often done in SP studies, we included text reminding people of their budget constraint ("cheap talk"), which is designed to counteract the problem of hypothetical bias. The cheap talk reminder noted that people sometimes answer hypothetical questions differently than real questions and asked respondents to avoid this phenomenon. We also emphasized the importance of the respondent's answer for policy makers to increase the saliency of the question. After presenting the amount by which a household's costs would increase if the program were in place, respondents were given the following hypothetical choice question:

Imagine that all HOME STATE residents were allowed to vote on the program. If a majority of voters support the program, it would be implemented next year. We would *like you to think carefully about how you would actually vote in this situation. In previous research we have found that people are often more willing to vote yes when payment is only imagined than when payment is real. Therefore, we urge you to respond as though costs for your household really would go up if the program were implemented. Knowing how different HOME STATE residents would vote on this program is very important for state government decision makers. So please take time to consider both the benefits of the program and the costs to your household. Ask yourself whether you believe the lake improvement program is worth $V each year to your household, since that is less money that you would have to spend on other things. There may be good reasons for you to vote for the program and good reasons to vote against it. Only you know what is best for you and your household.*

Respondents were then asked if they would vote for or against the program. Following this initial question, respondents were asked a follow-up question soliciting if they would pay a higher or lower amount, based on their response to the first question.

3.5 Experimental Design

With the choice experiment and CV question formats established, the next step was to create an experimental design for both the choice experiment and CV sections. For the choice experiment, creating an experimental design involved determining the different values that the travel distance attribute would take, generating the set of feasible choice combinations (e.g., the universe of questions with particular attribute-level combinations we might present), and settling on choice question sets that different versions of the survey would contain. For the CV exercise we needed to determine the set of bid amounts that respondents would face, the level and amount of variability in water quality outcomes that the hypothetical program would provide, whether we would use certainty scale follow-up questions, and the extent to which our elicitation would attempt to add extra bounding information via auxiliary dichotomous choice questions. The various dimensions of the design space led us to use six survey versions that varied in the choice experiment and/or CV parameters. In what follows we describe the details of our design.

Choice Experiment

As noted in the previous section, our choice experiment used only two attributes: water quality and travel time to reach the recreation site. Thus, for purposes of experimental design, the number of values that the water quality attribute could take on was predetermined. For the four levels of the travel time attribute, we used information from our own experience, summaries of the recreation data set that we have in hand, previous studies on the length of day trips, the focus groups, and advice from our peer reviewers. Our final design included four different amounts, all expressed as one-way travel time: 20 minutes, 40 minutes, 60 minutes, and 120 minutes. With five levels for the water quality attribute and four for the travel time, our full factorial included 20 choice elements. Thus, our design space was relatively small and our experimental design task comparably simple. We decide to present each respondent with six choice tasks, and by designing six conjoint versions that varied in the composition of choice tasks, we were able to present the full factorial (absent dominant choices) to our sample. Table 3 below displays the specific choice tasks contained in each of the six versions of the survey.

Contingent Valuation

The main challenges for the CV design were determining the bid amounts and the level of water quality that the program would deliver. For the bid amounts we used previous SP research on water quality valuation (in particular Banzhaf et al., 2006) and the results from our focus groups to arrive at four annual cost levels, which would be randomly varied across

Table 3. Conjoint Experimental Design[a]

	Version 1											
Task	1		2		3		4		5		6	
Lake	1	2	3	4	5	6	7	8	9	10	11	12
Attribute 1 – Water Quality	1	3	5	3	1	4	3	4	2	3	5	4
Attribute 2 – Distance	3	2	3	4	4	1	3	2	2	1	1	4
	Version 2											
Task	1		2		3		4		5		6	
Lake	1	2	3	4	5	6	7	8	9	10	11	12
Attribute 1 – Water Quality	5	4	1	5	2	3	2	1	5	4	1	5
Attribute 2 – Distance	2	4	3	1	4	1	2	4	3	4	3	2
	Version 3											
Task	1		2		3		4		5		6	
Lake	1	2	3	4	5	6	7	8	9	10	11	12
Attribute 1 – Water Quality	5	2	1	3	3	5	2	5	1	2	4	3
Attribute 2 – Distance	1	2	4	3	4	2	4	3	3	1	1	3
	Version 4											
Task	1		2		3		4		5		6	
Lake	1	2	3	4	5	6	7	8	9	10	11	12
Attribute 1 – Water Quality	4	3	1	2	5	3	2	5	4	3	1	2
Attribute 2 – Distance	1	4	4	3	1	2	4	1	1	2	3	2
	Version 5											
Task	1		2		3		4		5		6	
Lake	1	2	3	4	5	6	7	8	9	10	11	12
Attribute 1 – Water Quality	1	3	1	4	4	2	1	4	2	3	5	4
Attribute 2 – Distance	3	1	4	3	1	4	3	2	4	2	1	2
	Version 6											
Task	1		2		3		4		5		6	
Lake	1	2	3	4	5	6	7	8	9	10	11	12
Attribute 1 – Water Quality	1	4	5	2	4	2	2	5	4	1	2	3
Attribute 2 – Distance	3	1	1	3	1	2	4	2	2	4	4	3

[a] The survey contained six SP choice tasks. In the survey, task 1 is question 16, task 2 is question 18, task 3 is question 20, task 4 is question 21a, task 5 is question 23 and task 6 is question 24a. Appendix A contains the survey instrument. Each respondent was randomly assigned one of the six versions. Attribute levels 1 to 5 for the water quality level correspond to quality levels A to E. Likewise, attribute levels 1 to 4 for travel times correspond to times in minutes of 20, 40, 60, and 120.

respondents: $24, $120, $216, and $360. We also decided to use a double bounded dichotomous choice framework. In this framework, respondents are presented with a subsequent amount that is higher or lower, depending on the initial answer. Thus, each primary bid amount has two secondary bids associated with it:

- $24: yes → $120, no → $12
- $120: yes → $216, no → $24
- $216: yes → $360, no → $120
- $360: yes → $480, no → $216.

For the water quality improvement attribute, we decided on four different levels of improvement. The survey presented a baseline distribution (see Figure 2) and an improved distribution (see Figure 3). The baseline distribution was constant for all survey respondents, and we varied the improved conditions across the four CV versions. Table 4 shows the distributions (indexed I to IV) that were presented in each version.

3.6 Pretesting and Peer Review

The survey and experimental design described above pertain to the final version of the survey that we fielded in April 2010. As part of the development process, we conducted a pretest and peer review of the survey vehicle in February and March 2010. The pretest

Table 4. Distribution of Lake Water Quality Levels for the CV Question for Baseline and Four Versions

Water Quality Index Level	Baseline	I	II	III	IV
A	5%	10%	15%	10%	20%
B	25%	25%	35%	55%	45%
C	50%	50%	40%	30%	30%
D	15%	15%	10%	5%	5%
E	5%	0%	0%	0%	0%

used 100 respondents from the same web panel used for the final survey (see more details below), each of whom completed the survey as it existed at the time. Peer reviews were conducted by Dr. Kevin Boyle of Virginia Tech University and Dr. John Whitehead of Appalachian State University. The reports submitted by Dr. Boyle and Dr. Whitehead are included as Appendix D to this document.

By and large, the pretest confirmed that our survey development strategy was effective. Our named lake lists for the recreation section were reasonably complete, in that more than 80% of trips people reported making were to lakes included in the lists. Our conjoint section included four choice tasks, and the limited item nonresponse convinced us it made sense to expand this to six choice tasks in the final survey. Analysis of the pretest conjoint data produced sensible and stable parameter estimates that suggested good scenario buy-in among our respondents. Analysis of the CV data highlighted improvements that were needed in this section. In particular, we were not able to estimate price effects precisely because a large majority of people voted “yes” for the program. Also, the pretest did not contain enough variability in quality levels to find evidence of scope in people’s *WTP* for water quality. Based on these findings, we made adjustments to the experimental design for the CV section of the final survey. The peer reviewers’ comments echoed our findings from the pretest. Both reviewers made small suggestions on the conjoint section of the survey, and both provided useful feedback on how we could better develop the CV section.

4. Survey Execution and Data Summary

Knowledge Networks (KN) conducted the data collection for the survey. KN maintains a web-based panel of U.S. households that were originally recruited through random-digit dialing; more recently KN has begun using address-based sampling to recruit the panel (for more information on KN, see http://www.knowledgenetworks.com). If the household does not have a computer, KN provides the household with a computer and Internet access. If the household does have a computer, KN pays for Internet access. In return, the households agree to take a specific number of surveys. KN controls the number of survey invitations panel members receive. Samples for specific surveys are drawn from the panel using probability methods.

KN sent an invitation to take the survey to 1,873 panel members age 18 or older living in our target states. The final version of the survey went to the field on April 23, 2010, and data collection was closed on May 18, 2010. In total, 1,327 individuals completed the survey, resulting in a 70.8% completion rate. The full response rate for KN surveys is much lower when panel recruitment and attrition are factored in.

Table 5 displays the sample splits arising from our experimental and state selection design.[2] Our relevant population is residents of eight southeastern stages: Alabama, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia. The table shows that we obtained a larger number of observations from North Carolina, South Carolina, and Virginia, which we consider the core of our study area, because it is in these states that we expect our water quality model to provide the most reliable predictions. In addition, the North Carolina Water Resources Research Institute (WRRI) funded a co-project that provided

[2] The survey data and a Stata do-file that performs all of the summaries and modeling contained in this and the following section are available as a supplement to this report.

Table 5. Sample Distribution across Survey Versions

Observations by States	AL	GA	KY	MS	NC	SC	TN	VA
	102	102	113	97	366	211	119	217
Observations by Choice Experiment Version[a]	**V1**	**V2**	**V3**	**V4**	**V5**	**V6**		
	127	135	156	127	128	137		
Observations by CV Version[b]	**I**	**II**	**III**	**IV**				
	302	353	329	343				
Observations by Water Quality Description Treatment[c]	**WQ3**	**WQ5**						
	661	666						

[a] Choice experiment versions listed in Table 3.

[b] CV versions listed in Table 4.

[c] WQ3 used three attributes to describe water quality; WQ5 used five attributes to describe water quality.

additional resources for the North Carolina component of the sample. As described above, our choice experiment design included six versions of six choice tasks each. Sixty-one percent of the respondents were recreators or likely recreators, which provided 810 respondents in this subsample. Those who did complete this section were split approximately evenly among the six survey versions. The CV section used four different water quality levels, so this part of the survey had four variations. These are also approximately evenly divided among the full sample. Finally, as discussed in the previous section, we included a split sample design in the survey, which simplified the water quality communication section for half of the sample. Approximately half of the respondents who completed the choice experiment received descriptions of our water quality rating system that excluded the odor and algae attributes, while the remaining 666 people received the full description.

4.1 Sample Characteristics

Table 6 contains basic summary statistics for several of the socioeconomic variables available in our data set. Because the KN panel is designed to be nationally rather than state representative, these summaries are unlikely to match the distributions in individual states

Table 6. Summary Statistics for Socioeconomic Variables

Variable	Mean	Std. Dev.	Median	Min	Max
Household income ($1,000s)	57.04	40.07	50	5	175
Household size	2.61	1.41	2	1	10
Respondent age	48.76	15.88	50	18	94
Driving distance to nearest lake	38.59	36.66	30	0	240
Home-owning household	0.71	—	—	0	1
Respondent full-time work	0.56	—	—	0	1
Respondent retired	0.18	—	—	0	1
Respondent male	0.44	—	—	0	1
Respondent high school	0.26	—	—	0	1
Respondent some college	0.32	—	—	0	1
Respondent bachelor degree or higher	0.33	—	—	0	1
Respondent Hispanic or nonwhite	0.265	—	—	0	1

exactly. For example, according to U.S. Census figures the median household income in North Carolina is $46,500 annually, while the median for our survey respondents in North Carolina is $50,000. Likewise, 36% of our North Carolina sample respondents have at least a 4-year college degree, while the corresponding U.S. Census figure is 22%.

These figures suggest our sample is comparatively wealthier and more educated than the overall population in the states included in our sample. For the objectives of our study related to water recreation this is less of a concern than it may seem, because past research has shown that basic recreation behavior (as opposed to specialized/exotic activities) is not substantially influenced by income and education (see Phaneuf and Smith, 2005, for a discussion of income effects in recreation models).

4.2 Behavioral Summaries

Among our 1,327 respondents, 427 (32%) reported having made a recreation day trip (i.e., without an overnight stay) to a lake in the previous 12 months. The median person in this group visited two different lakes during the 12 months prior to the survey and completed four trips.

As is typical for recreation data, the distribution of trips is skewed by avid users so that the average number of trips per individual is 9.4. We solicited detailed information from the trip-taking individuals on their activities, group composition, and location choices. Table 7 contains a summary of the main activities that respondents participated in and a summary of their additional/auxiliary activities. The final row of Table 7 lists the percent of respondents who selected each activity for the SP questions. Activity choices are relevant in that the degree of contact with the water may condition people's attitudes toward water quality. Almost a third of the trip-taking people in our survey reported they went swimming during at least one of their trips. Swimming, fishing, and nature viewing were the most frequently reported main activities, through the table suggests there is considerable heterogeneity in activities. Nearly half of the respondents used trails near lakes for walking or running. Respondents generally visited lakes for recreation in the company of others. Only 6% of people completed a typical trip alone, while the remainder were equally split among those whose group contained only other adults and those whose group included a mix of adults and children.

Although our study focuses primarily on day trips, we did ask people to report the degree to which they participated in overnight visits to lakes. Approximately 18% of people in our

**Table 7.	Activity Summaries for Actual Trips and Activity Selected for SP Questions**

	Swimming	Fishing	Motor Boating	Non-motor Boating	Nature Viewing	Organized Event	Running or Walking
Main activity	14%	23%	11%	4%	17%	10%	17%
Additional activity	33%	36%	19%	9%	67%	25%	46%
Activity selected for SP questions	16%	23%	11%	4%	15%	10%	18%

sample took at least one overnight trip to a lake. Among them, the median number of trips is 2 and the average is 4.35. The latter is heavily skewed by a few avid trip takers who reported overnight trips in excess of 40 visits.

4.3 Water Quality Beliefs Summary

Table 8 presents a summary of how respondents in different states rated the water quality at lakes in their states. This table uses responses to question 11 (see Appendix A), which asked people to indicate the quality level they thought was most common for lakes in their state. Most of the answers clustered around levels B and C. There are some differences across the states. For example, 72% of people in Alabama thought lakes in their state fell in the A or B (the two best) range, while only 51% of people in Tennessee reported similar beliefs. In general, very few people thought lakes in their state fell into the worst category (level E).

Table 8. Summary of Beliefs about Lake Water Quality by State

	Water Quality Category					
State	**A**	**B**	**C**	**D**	**E**	**Sample Size**
AL	17%	54%	22%	5%	2%	102
GA	17%	38%	33%	8%	4%	102
KY	10%	52%	27%	8%	1%	113
MS	13%	43%	29%	8%	4%	97
NC	10%	47%	30%	9%	2%	366
SC	16%	44%	28%	9%	0%	211
TN	6%	45%	30%	8%	7%	119
VA	13%	47%	27%	10%	1%	217
All states	12%	46%	29%	9%	2%	1,327

5. Basic Analysis

In this section we present the results from several analyses using the conjoint and CV data. For each data type our strategy is to first present models that help us understand the variability in the data, provide some initial sense of water quality valuations, and allow us to make decisions on what our preferred policy-relevant models will look like. We then present what we consider our policy-relevant results, which we use for our case study in the following section.

5.1 Choice Experiment Analysis

We begin by looking at the conjoint data in detail. Recall that there were 810 respondents who qualified for the conjoint exercise – 427 people reported that they visited a lake for a day trip in the past 12 months and an additional 383 indicated they would likely visit a lake in the next 12 months. Each of the 810 respondents received six conjoint questions; some people did not complete all six questions, so our final sample size consists of 4,849 observations. The analysis in this subsection is based on these observations.

Recall that our choice experiment questions proceeded in two steps. First, people were asked to compare two lakes that differed only in the distance from home and water quality level. Second, they were asked to indicate if they would actually make a trip, if these were the only two options. We used this two-step approach to maximize the information gathered on preferences per question, while maintaining the realism implied by an opt-out choice. Among the 4,849 choices, 26% selected the "no trip" option (or the opt-out). Recall as well that people were asked to name the activity and group composition that would define their trip and thereby condition their answers to the first four choice tasks. The final row in Table 7 shows the distribution of activity choices people selected for the choice experiment. Thirty-nine percent of people selected the activities fishing or swimming that involve contact with the water, while 33% selected near-shore activities such as nature viewing or running/walking. In terms of group composition, 4% reported they would make the trip alone, 46% said they would be in the company of other adults, and 50% said they would be in a group that included children.

The economic model typically used to analyze choice experiment data of the type we collected is the random utility maximization (RUM) model. The underlying assumption in this model is that people make choices to maximize their utility (i.e., their well-being). In our choice tasks, we assume that respondents select the option that they believe would provide them with the highest satisfaction. We model this by specifying a respondent's conditional indirect utility function as

$$U_{ict} = V_{ict} + \varepsilon_{ict}, \quad i = 1,...,I, \quad t = 1,...,T, \quad c = 0,1,2, \tag{1}$$

where the utility available to respondent *i* on choice task *t* from selecting option *c* consists of two parts: an observable component V_{ict} and an unobservable component ε_{ict}. The former is a function of measured covariates and parameters to be estimated, such as the level of water quality and travel time for options 1 and 2 (the lake options), while the latter captures the component of the respondent's tastes that is not reflected by any measured variables. For example, in our application the baseline model is

$$\begin{aligned} V_{ict} &= \beta_1 \times time_{ict} + \beta_2 \times qual_{ict}, \quad c = 1,2 \\ V_{ict} &= \beta_0, \quad c = 0, \end{aligned} \tag{2}$$

where $time_{ict}$ and $qual_{ict}$ are the values of the travel time and water quality attributes from the conjoint design, and (β_0, β_1, β_2) are utility function parameters to be estimated. Note that $qual_{ict}$ is written as a continuous variable, although the actual quality levels in our survey are discrete. In our initial models we use the cardinal progression of water quality levels (A, B, , C, D, E) to code $qual_{ict}$ = 1 if lake option c had water quality A, $qual_{ict}$ = 2 if lake option c had water quality B, and so on out to $qual_{ict}$ = 5 if the lake option had water quality E. We subsequently explore models that use dummy variables for each of these discrete levels.

The operational assumption in RUM models is that the analyst knows the distribution from which ε_{ict} is drawn but does not know its exact value. Thus, before observing a choice, the analyst can only know the probability of seeing a particular outcome, conditional on parameter values. Because option c will be selected if its utility value is highest (i.e., if $U_{ict} \geq U_{ist}$ for all $s \neq c$), we can derive this probability (Pr) as

$$\begin{aligned} \Pr_{it}(c) &= \Pr\left[U_{ict} \geq U_{ist}, \forall s \neq c\right] \\ &= \Pr\left[V_{ict} + \varepsilon_{ict} \geq V_{ist} + \varepsilon_{ist}, \forall s \neq c\right] \\ &= \Pr\left[V_{ict} - V_{ist} \geq \varepsilon_{ist} - \varepsilon_{ict}, \forall s \neq c\right] \\ &= \Pr\left[\varepsilon_{ist} - \varepsilon_{ict} \leq V_{ict} - V_{ist}, \forall s \neq c\right]. \end{aligned} \tag{3}$$

Equation (3) shows that with knowledge of the distribution for ε_{ict}, we can write an expression for the probability of observing any choice outcome as a function of the covariates and parameters contained in V_{ict}. By matching these *ex ante* probability expressions to the *ex post* responses, we can estimate the parameters of the utility function by maximum likelihood, where the log-likelihood function is

$$LL(\beta) = \sum_{i=1}^{I} \sum_{t=1}^{T} \sum_{c=0}^{2} d_{ict} \ln \Pr_{ict}, \tag{4}$$

and d_{ict} in an indicator variables equal to one if option c was selected on choice task t, and zero otherwise. In writing equation (4), we have for simplicity assumed the T choices made by respondent i are independent, and in this section we do not exploit the additional information that is provided by the two-step choice solicitation. Specifically, we do not use the ranking information provided by the initial choice between the two designed options when the opt-out option is ultimately selected; instead we treat the outcome as arising from a single trinomial choice. We do this for simplicity and transparency in this section, and incorporate the richer ranking information when we present our final policy models. Nonetheless it is necessary to cluster the standard errors of estimates at the level of the respondent, which we do in all our model runs. If we assume that ε_{ict} is distributed type I Extreme Value, the familiar conditional logit model arises.

Estimates of β_0, β_1, and β_2 from equation (2) are useful for measuring the trade-offs people are willing to make between travel time and water quality. To see this, it is helpful to distinguish between marginal utilities and marginal values. In equation (2) β_1 is the marginal disutility of travel time, which implies that $-\beta_1$ is the marginal utility of time itself. The parameter β_2 is the marginal disutility utility of a one-unit increase in the water quality variable (recall that lower values correspond to better quality). Although the signs of these parameters do have qualitative meaning, they do not have a quantitative interpretation in isolation. However, we can use the two together to compute the marginal value of a change in water quality, expressed relative to time, by totally differentiating the conditional utility function with respect to *time* and *water*:

$$\Delta U_{ict} = \beta_1 \Delta time_{ict} + \beta_2 \Delta qual_{ict}. \qquad (5)$$

If we hold utility constant at a reference level so that $\Delta U_{ict} = 0$, then

$$\frac{\Delta qual_{ict}}{\Delta time_{ict}} = -\frac{\beta_2}{\beta_1}. \qquad (6)$$

Conditional on making a trip, this ratio tells us the rate at which people are willing to trade travel time for water quality, while holding fixed a reference level of well-being. Equation (6) is useful because it allows us to express the value of an improvement in the water quality index at a lake in terms of the extra travel time a person would accept to have the improvement.

Table 9. Conditional Logit Results by State, Parameter Estimates with Z-Statistics

	All	AL	GA	KY	MS	NC	SC	TN	VA
Opt-out	−3.855	−3.342	−3.519	−3.808	−3.742	−4.031	−3.953	−3.757	−4.113
	(−31.81)	(−7.15)	(−8.05)	(−9.86)	(−7.56)	(−17.34)	(−13.15)	(−9.53)	(−15.21)
Travel time	−0.008	−0.007	−0.008	−0.008	−0.008	−0.009	−0.010	−0.009	−0.009
	(−20.05)	(−4.66)	(−5.16)	(−5.98)	(−4.44)	(−10.34)	(−9.4)	(−6.55)	(−8.57)
Water quality	−0.824	−0.747	−0.736	−0.782	−0.784	−0.872	−0.829	−0.795	−0.899
	(−30.36)	(−6.75)	(−7.39)	(−9.12)	(−7.35)	(−17.78)	(−12.48)	(−8.99)	(−13.03)
Number of choices	4,849	390	396	391	317	1,389	816	448	702
Marginal value water quality improvement in hours (standard errors)[a]	1.625 (0.08)	1.807 (0.36)	1.607 (0.28)	1.693 (0.31)	1.584 (0.32)	1.694 (0.15)	1.402 (0.14)	1.516 (0.22)	1.753 (0.20)

[a] Standard errors computed using the delta method (Greene 2000).

In what follows we discuss estimates from several different models and subsets of the respondents, using the conditional logit assumption in all cases. We begin with the simple specification in equation (2). Table 9 contains estimates from this model for the entire sample, as well as estimates obtained for subsamples corresponding to each state in our study region. The table shows that the coefficient estimates are significant and intuitively signed across all the models. The negative coefficient on *Opt-out* shows that respondents on average found it preferable to select a trip option, rather than not participate in recreation on a given choice occasion. Since we asked people to image they were planning a trip this means the designed alternatives on average met minimum quality standard thresholds. The estimates also show that a lake site is less attractive if it is further away, or if its water quality index is higher. Said another way, the utility of a site can be made greater if the value of its water quality index is reduced (water quality is improved). In the full sample, the ratio of the water quality parameter to the travel time parameter ($-\beta_2/\beta_1$) is 1.625, which suggests that people value a one-unit improvement in the value of the quality index (e.g., from *qual* = 3 to *qual* = 2) the same way that

Table 10. Conditional Logit Results by Main Activity and Type of Group, Parameter Estimates with Z-Statistics

	Swim	Fish	Boating[a]	Walk	Nature Viewing	Trip with Children
Opt−out	−4.022	−4.222	−4.369	−3.599	−4.012	−3.787
	(−13.68)	(−15.53)	(−13.88)	(−12.51)	(−14.46)	(−22.75)
Travel time	−0.008	−0.008	−0.010	−0.010	−0.009	−0.008
	(−7.45)	(−9.52)	(−8.07)	(−9.52)	(−9.4)	(−14.29)
Water quality	−0.897	−0.980	−0.831	−0.735	−0.828	−0.811
	(−14.58)	(−14.31)	(−13.18)	(−12.33)	(−13.86)	(−21.17)
Number of choices	723	1026	658	858	916	2404
Marginal value water quality improvement in hours (std. error)[b]	1.876 (0.22)	2.013 (0.20)	1.364 (0.15)	1.287 (0.12)	1.557 (0.15)	1.699 (0.11)

[a] Includes both motor boating and nonmotor boating.
[b] Standard errors computed using the delta method (Greene 2000).

they value 1.625 hours of extra time. When we split the sample for the different states, we see that marginal values for water quality held by residents across the study region vary from a low of 1.40 hours for South Carolina to a high of 1.80 for Alabama. The standard errors on the state-level estimates generally suggest most are statistically equal to the full sample model at conventional significance levels.

Table 10 provides estimates by activity and group composition. These data allow us to examine the impact of activity (and whether the activity involves contact with the water) on the value of water quality. We ran separate models for the different activities and for those who said they would travel with children. Our estimates generally suggest that people who participate in swimming or fishing have a higher marginal value for water quality compared with those who participate in boating, walking, or nature viewing. Thus, there is some evidence of heterogeneity in water quality values arising from people’s activity preferences. Comparing the first column in Table 9 with the subsample who said they would travel with children, the results suggest that people whose group includes children do not seem to value water quality differently from the full sample.

Although these results provide insights into the data, they do not allow us to express the value of water quality in monetary terms at the level of the individual. For this we need to convert the time cost of travel a person must bear to reach the site into a monetary equivalent. A common way of computing the value of time (i.e., the opportunity cost of time) in environmental economics is to use a fraction of the average wage rate (see Phaneuf and Smith, 2005). A typical choice is to use 0.33 of the wage rate, so we computed the opportunity cost of time using oct_i = 0.33 × $income_i$/2,000, where 2,000 is the approximate number of work hours in a year (Ceserio, 1976). With this we create a new variable

$$price_{ict} = oct_i \times \frac{time_{ict}}{60} + \left(gas / mpg + dep \right) \times \frac{time_{ict}}{60} \times speed, \quad c = 1, 2, \tag{7}$$

where *gas* = 2.75 is the per-gallon price of gasoline, *mpg* = 20 is our average miles per gallon assumption, *dep* =0.20 is our assumption for vehicle depreciation per mile, we assume an average speed of 45 miles per hour to translate travel time into out-of-pocket travel costs. The time variable is divided by 60 to change the units of time into hours. We replace $time_{ict}$ in equation (2) with the new variable $price_{ict}$. The variables *gas*, *mpg*, *dep*, and *speed* are set to a single value for all respondents, the opportunity cost of time (*oct*) varies by respondent, and travel time (*time*) varies across respondents and alternatives. The transformation in (7) there will therefor affect parameter estimates.

The first column of Table 11 contains estimates for a simple model including only price and water quality. As with the simpler model with time as a covariate, both coefficient estimates are negative, so the qualitative interpretation from earlier is still valid. However, for this model the ratio of coefficients provides an estimate of the marginal value in dollars of a unit change in

Table 11. Conditional Logit Estimates Using Variable Price under Different Specifications with Z-Statistics

	Model I	Model II	Model III	Model IV
Opt out	−3.491	−3.498	−3.981	—
	(−27.2)	(−27.23)	(−25.01)	
Price	−0.017	−0.017	−0.017	−0.018
	(−15.18)	(−15.18)	(−14.93)	(−14.67)
Water	−0.765	−0.804	−1.173	—
	(−27.45)	(−25.57)	(−14.86)	
Water×WQ3	—	0.074	—	—
		(2.40)		
water squared	—	—	0.069	—
			(5.47)	
Qual A (δ_A)	—	—	—	2.816
				(24.94)
Qual B (δ_B)	—	—	—	2.071
				(19.75)
Qual C (δ_C)	—	—	—	1.063
				(12.34)
Qual D (δ_D)	—	—	—	0.208
				(2.33)
Qual E (δ_E)	—	—	—	−0.033
				(−0.37)

Marginal Value of Water Quality (dollars)

	Model I	Model II	Model II	Model III	Model III	Model IV
	All	WQ5[a]	WQ3[a]	Quality = B	Quality = C	Change from C to B
Marginal value water quality in $ (std. error)[b]	$44.84 (2.62)	$47.05 (2.84)	$42.71 (2.69)	$51.68 (3.16)	$31.73 (3.15)	$57.23 (4.43)

[a] WQ5 indicates respondents who received the survey version with five characteristics describing water quality. WQ3 denotes those who received the version with three characteristics.
[b] Standard errors computed using the delta method (Greene 2000).

water quality. We find that people are, on average, willing to pay almost $45 per lake visit for a one-unit improvement in water quality (i.e. to move to the next higher water quality category).

The additional models in Table 11 explore different ways of including the water quality variables in the specification, with an emphasis on exploring nonlinearity. Model II tests whether people who received the simpler description of the water quality with only three attributes respond differently to the quality level. The coefficient on the interaction term between water quality and a dummy variable indicating the person received the simpler water quality description (WQ3) is positive and significantly different from zero, suggesting there is a difference in response. People who received the simpler description of water quality placed a lower value on water quality improvements, though the estimates for marginal WTP suggest preferences are qualitatively similar. Model III explores the extent of nonlinearity in how people respond to water quality. We find a significant and positive coefficient on the *water squared* term, which implies that the marginal WTP for water quality increases as water quality improves. For example, the marginal WTP for a change when the baseline quality level is *water quality* = 2 (level B) is $51.68, and it falls to $31.73 when *water quality* = 3 (level C). This provides evidence that there is a nonlinear relationship between the level of water quality and the marginal WTP for a change in quality, though the curvature suggested by the coefficient estimates is counter intuitive. As we show below using a more flexible specification, this finding is an artifact of the quadratic functional form and not a perverse aspect of our data.

Model IV moves away from using the five levels of water quality in the design as a continuous variable and instead includes a dummy variable for the discrete quality levels so that

$$\begin{aligned} V_{ict} &= \beta_1 \times price_{ict} + \sum_{k=A}^{E} \delta_k d_{ict}^k, \quad c = 1,2 \\ V_{ict} &= 0, \quad c = 0, \end{aligned} \tag{8}$$

where d^k_{ict} = 1 if lake c has quality level k, for k = A, B, C, D, E, and zero otherwise, and δ_k is a quality level specific coefficient that will be estimated. Equation (8) is the most flexible way that we can characterize preferences for the different water quality levels, in that it allows the WTP for a change in the water quality index to increase or decrease throughout its range. Note that we have included dummy variables for all five quality levels for ease of interpretation, meaning we have normalized the constant term to zero for c=0. In equation (8) we expect $\delta_A >$ $\delta_B \ldots > \delta_E$, because water quality level A is the highest and E is the lowest. The parameter values in Table 11 follow this pattern, meaning that our estimates pass a scope test. More specifically, respondents have a clear preference ordering for better water quality; conditional on travel cost people prefer the destination with better water quality. Sensitivity to scope has emerged in the stated preference literature as an important indicator of validity (see Kling et al. 2012 for discussion). As such model IV provides strong evidence of the quality of our stated preference data. The estimates from this model imply the WTP predictions (standard error) for a one-unit change in quality starting from different baseline changes are

- Level E to Level D: $13.66 (4.68)
- Level D to level C: $48.50 (5.16)
- Level C to Level B: $57.22 (4.43)
- Level B to Level A: $42.25 (4.08)

The biggest gains are for movements from D to C and C to B. These results suggest a nonlinear relationship based on the notion that the gains from marginal improvements are small when water quality is quite low or quite high, relative to improvements that shift water quality from levels that limit activities (e.g., E or D) to levels that enable them (C and B).

These preliminary findings are suggestive of several trends in our choice experiment data. First, people are willing to trade off travel time for better water quality when making recreation destination decisions. It seems that improvements in water quality do have value and the value is captured by our model. Second, water quality values are likely to be heterogeneous across activity types; water-contact trips such as fishing and swimming are associated with higher values than near-shore experiences, such as using trails. Third, group composition does not seem to matter much for water quality values. Finally, the role that water quality plays in people's preference for recreation sites is nonlinear. We use these insights in constructing our policy-relevant model.

Policy Choice Experiment Model

Recall that the output from the models described in Phaneuf et al. (2009) consists of predictions for the discrete probability distribution of a lake's (or a collection of lakes') quality levels. Given this, it is useful to use estimates from the choice experiment models that include dummy variables for each of the discrete water quality levels. In addition, these estimates provide the most flexible representation of the nonlinearity in peoples' preferences. Table 12 provides estimates for two types of models: a single column that includes all the observations drawn for the study, and several columns that are state specific in that they only include observations drawn from the particular state. The parameter estimates shown in the "All" column in Table 12 differ slightly from those for the comparable model shown in Table 11 because we have now used the extra information that our two-step opt-out option provides. In particular, if a person selects lake 1 over lake 2 but then indicates she would not take a trip if the two designed lakes were her only options, we know that utility(no trip)>utility(lake 1)> utility(lake 2). We have used this extra ranking information in the construction of the likelihood function for all the models presented in Table 12, in order to maximize the information content that goes into constructing our policy-use models. The tradeoff is a slightly more complicated and less transparent likelihood function (Stata code for this model in included in the appendix).

We suggest using the models in Table 12 for policy purposes given that they are relatively parsimonious. Though it is possible to include more accounting for observable

Table 12. Conditional Logit Policy Estimates with Z-Statistics for Choice Experiment Data

Variable/ Parameter	All	AL	GA	KY	MS	NC	SC	TN	VA
Price (β_1)	**−0.016**	−0.015	−0.017	−0.011	−0.012	−0.016	−0.017	−0.018	−0.016
	(−16.19)	(−3.82)	(−3.06)	(−3.39)	(−3.28)	(−8.86)	(−7.27)	(−7.01)	(−7.24)
Qual A (δ_1)	**2.560**	2.204	2.472	2.409	2.081	2.716	2.514	2.625	2.954
	(24.82)	(5.63)	(6.56)	(7.20)	(5.40)	(13.50)	(9.70)	(8.28)	(11.91)
Qual B (δ_2)	**1.938**	1.749	1.915	1.501	1.667	2.088	1.946	2.084	2.109
	(20.56)	(4.95)	(5.40)	(4.19)	(4.69)	(11.98)	(8.38)	(7.13)	(8.96)
Qual C (δ_3)	**0.983**	0.811	1.173	0.886	1.020	0.988	1.022	0.898	1.060
	(12.48)	(2.83)	(4.67)	(2.89)	(3.57)	(6.38)	(5.38)	(3.39)	(5.70)
Qual D (δ_4)	**0.176**	−0.108	0.252	0.127	−0.015	0.249	0.231	0.141	0.259
	(2.21)	(−0.37)	(0.91)	(0.42)	(−0.05)	(1.63)	(1.18)	(0.52)	(1.36)
Qual E (δ_5)	**−0.109**	−0.097	0.002	0.025	−0.247	−0.830	−0.123	−0.052	−0.205
	(−1.37)	(−0.36)	(0.01)	(0.09)	(−0.68)	(−0.40)	(−0.63)	(0.18)	(−0.96)

heterogeneity (e.g., allowing the marginal utilities for water quality to differ with activity and group composition), our sense is that the specific recreation data needed to support policy modeling via our protocol typically do not allow analysts to divide aggregate lake visitation out by activity or group composition. Thus, it seems better to assess the average per-trip WTP using models that do not include heterogeneity. We stress that the model estimates in Table 12 are not biased by their absence of interaction effects – they simply fold any and all heterogeneity into a single (average) estimate.

We have provided state-specific estimates to allow for the possibility of using spatially explicit state-level estimates if this is deemed important. We stress, however, that the limited number of observations in any given state (aside from North Carolina, where additional resources were available to increase the state sample size) means there is a cost in lost precision of using the state-specific estimates. For this reason in what follows we focus our attention on the average estimates obtained using the full sample. The per-trip WTP estimates (standard error) of discrete one-unit changes in water quality are summarized as follows:

- Level E to Level D: $18.38 (4.34)
- Level D to level C: $52.05 (4.94)
- Level C to Level B: $61.55 (4.30)
- Level B to Level A: $40.16 (4.18)

The small differences from the similar estimates presented above arise due to the slightly different coefficient estimates arising from the full information likelihood function. While the point estimates differ somewhat, the standard errors suggest the differences are not statistically significant. As noted above, we view these are the preferred estimates given their full use of the information content in the data.

In our policy setting we will generally only know the probability that a lake is in a particular category. Computing per-trip WTP estimates in this case using the results in Table 12 is computationally straightforward. Denote the probability that the policy lake has baseline water quality level k by p_k, for k = A, B, … , E. Furthermore denote the probability that the policy lake has counterfactual water quality level k by p_k^c for k = A, B, … , E. The expected per-trip WTP for the counterfactual quality improvement is

$$E(WTP) = \frac{1}{-\beta_1}\left[(p_A^c - p_A)\delta_1 + (p_B^c - p_B)\delta_2 + ... + (p_E^c - p_E)\delta_5\right], \qquad (9)$$

where the parameter values are taken from the "All" column in Table 12. With the choice experiment estimates and predictions from the eutrophication production function, a mapping from a change in lake-level assessed water quality to the per-trip recreation benefits of the improvement is available. In Section 6 we provide a simple case study on using the models together.

Table 13. Percent Voting Yes by Cost in CV Question

	$24	$120	$216	$360
Percentage voting yes	73%	60%	50%	42%

5.2 Contingent Valuation Analysis

We now turn our attention to the CV data. Across the entire sample of 1,327 and all bid levels, 56% of people responded positively to the referendum question. Breaking this out by the four specific bid amounts as shown in Table 13 confirms that people were responsive to costs. In stated preference studies it is generally considered an indicator of validity when quality improvement programs are less attractive to respondents when they are more costly (see once again Kling et al. 2012). Thus the responsiveness to cost provides an additional indicator of the quality of our SP survey.

Breaking the response summary out by the four program levels is also useful. Recall that the distribution of water quality in the four scenarios was such that I<II<III<IV.[3] If there is sensitivity to scope, we would expect the proportion of yes responses to increase as we move from I to IV. Broadly speaking, we see this type of pattern in the responses, but the magnitudes are not as clear-cut as for the cost variable. We find that 55% of those who received version I or version II responded yes, whereas 58% responded yes for versions III and IV. We examine this concept of scope in more detail below.

Our survey asked people to report how certain they were about their answer to the referendum question. Forty percent reported they were “very certain,” 50% “somewhat certain”, and 10% “not certain at all”. Among the people who were uncertain about their answer, only 41% answered “yes” to the referendum, while among those who were very certain 58% answer

[3] The difference between III and IV is in the percent of lakes in the top two water quality categories.

"yes". These figures suggest uncertain respondents tended to vote "no" on the referendum, meaning our sample did not engage in the "yea saying" that has been identified as a potential threat to validity. Several studies have looked at the relationship between the respondent's self-reported degree of certainty about their answer and the potential for hypothetical bias (the difference between responses to a hypothetical scenario and a real choice). Champ et al. (1997) and Blumenschein et al. (2008) both found more evidence of hypothetical bias among uncertain respondents. Respondents who were certain of their responses showed little or no evidence of hypothetical bias. In the results presented below (see Table 14), we compare the results using the respondents' original votes and certainty-adjusted votes where "yes" votes by respondents who indicated they were "not certain at all" are recoded as "no" votes.

In the remainder of this subsection we consider parametric models using the CV data. Each person answered one CV question based on one of the quality change treatments shown in Table 4. The sample was divided approximately evenly across the four treatments. To explore these data we first look at models that examine the four program levels discretely, and then models that specify water quality as a continuous variable. The econometric structure is based on a utility difference (ΔU) framework. In answering the CV question, the model assumes people choose to vote for or against the program based on whether the program (including its annual cost) provides an increase or decrease in utility compared to conditions without the program. Given this, our baseline model is

$$\Delta U_i = \Delta V_i + \varepsilon_i = \gamma_1 bid_i + \alpha + \sum_{j=II}^{IV} \delta_j Z_{ij} + \beta X_i + \varepsilon_i, \quad i = 1, \ldots, N, \tag{10}$$

where bid_i is the annual cost for the program presented to respondent i, and the indicator variable Z_{ij} takes the value one if the respondent answered the survey version with program j, for $j = II, III, or IV$, and zero otherwise (program I is the omitted category, the effect of which is captured by the intercept term). The variable X_i represents a vector of individual characteristics that may also affect the change in utility. Together, these three components make up the systematic portion of the change in utility (ΔV). If we assume that the random component ε_i follows a standard logistic distribution, the probability of voting for the program is

$$\Pr(yes_i) = \left(1 + \exp(-\Delta V_i)\right)^{-1}, \tag{11}$$

which implies that the expected willingness to pay for program j by household i is

$$E(WTP_{ij}) = -\left(\alpha + \delta_j + \beta X_i\right) / \gamma_1. \tag{12}$$

These formulas arise from the logistic error and form of utility difference function, respectively. In particular, the term in parenthesis on the right side of (12) is the gross utility improvement generated by the program; scaling this by the marginal utility of income ($-\gamma_1$) converts this into the dollar equivalent of the utility change, which is the maximum willingness to pay to have the change. The left hand side is an expectation since the formula does not include the (zero mean) random variable ε_i.

An alternative way of modeling the role of water quality is to use a continuous index defined as

$$qual_j = (1 \times p_j^A) + (2 \times p_j^B) + (3 \times p_j^C) + (4 \times p_j^D) + (5 \times p_j^E), \tag{13}$$

where p_j^q is the percentage of lakes in water quality category q (q=A,B,C,D,E) under scenario j, where j=0 is the baseline and $j=I,II,III,IV$ represents the four designed scenarios. According to our design the baseline index value is $qual_0$=3.05, while the improved index values are $qual_I$=2.70, $qual_{II}$=2.45, $qual_{III}$=2.30, and $qual_{IV}$=2.20. Using the continuous quality index our utility difference model becomes

$$\Delta U_i = \gamma_1 bid_i + \delta_1 \ln(\Delta qual_i + 1) + \delta_2 \ln(\Delta qual_i + 1) \times X_i + \alpha + \beta X_i + \varepsilon_i, \tag{14}$$

where $\Delta qual_i = qual_0 - qual_j$ is the improved quality level presented to respondent *i* and we have used a log transformation. For this model the expected WTP for a specific change in quality is

$$E(WTP_i) = -\left[\delta_1 \ln(\Delta qual + 1) + \delta_2 \ln(\Delta qual + 1) \times X_i + \gamma + \beta X_i\right] / \gamma_1. \qquad (15)$$

Table 14 presents coefficient estimates for six different dichotomous choice logit models. The first three columns correspond to the program dummy variable specification in equation (10) and the last three columns correspond to the continuous quality difference specification in (14). For each specification we present sensitivity analyses that show how the estimates change when we control in different ways for responses reported to have been "very uncertain". We compare results for three different ways of coding the dependent variable. In columns 1 and 4 we use respondents' original votes (labeled *vote*) without adjustment. In columns 2 and 5 we use a certainty-adjusted vote (labeled *vote recode*) in which respondents who indicted "not certain at all" where coded as "no" votes, regardless of the actual vote. In columns 3 and 6 we drop responses that indicated "not certain at all" (labeled *vote certain*), so that our analysis includes N=1,182 for these models.

In each of the models the coefficient on the bid level is negative and statistically significant at the p<0.01 level, confirming that higher costs reduce the utility of the program and the likelihood of a yes vote (as suggested by the summary statistics, this is an indicator of validity). The first three columns show that income is not a statistically significant determinant of people's vote; based on this and other statistical tests the income variable (including interactions) was dropped from the later three specifications. We also examined the effects of several other respondent- and household-specific characteristics on preferences for the program. We find that those who have used or expect to use lakes for recreation and those with post-secondary education are statistically more likely to vote in favor of the program. Other

Table 14. Logit Regression Analysis of CV Survey Responses (standard errors in parenthesis)

	Vote (1)	Vote recoded (2)	Vote certain (3)	Vote (4)	Vote recoded (5)	Vote certain (6)
Bid	-0.00391***	-0.00408***	-0.00423***	-0.00355***	-0.00389***	-0.00390***
	(0.000480)	(0.000484)	(0.000515)	(0.000460)	(0.000465)	(0.000494)
Program II	0.0239	0.0107	0.0232			
	(0.164)	(0.164)	(0.175)			
Program III	0.202	0.297*	0.326*			
	(0.168)	(0.168)	(0.180)			
Program IV	0.176	0.267	0.300*			
	(0.165)	(0.166)	(0.177)			
ln(Δ*qual*+1)				1.038***	0.636**	1.295***
				(0.250)	(0.248)	(0.272)
Income	-0.0126	-0.00676	-0.0143			
	(0.0136)	(0.0136)	(0.0143)			
College	0.290**	0.343***	0.326**			
	(0.130)	(0.130)	(0.138)			
triplastyr	0.596***	0.773***	0.642***			
	(0.139)	(0.139)	(0.149)			
tripnextyr	0.401***	0.531***	0.377**			
	(0.141)	(0.141)	(0.151)			
ln(Δ*qual*+1)×college				0.500**	0.601**	0.547**
				(0.244)	(0.243)	(0.261)
ln(Δ*qual*+1)×trplastyr				1.197***	1.495***	1.256***
				(0.276)	(0.276)	(0.297)
ln(Δ*qual*+1)×tipnextyr				0.785***	1.006***	0.714**
				(0.278)	(0.279)	(0.297)
constant	0.560***	0.219	0.612***			
	(0.182)	(0.182)	(0.197)			
Observations	1318	1318	1182	1318	1318	1182

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

characteristics, such as age, sex, race, and marital status were found to be individually and jointly statistically insignificant and were therefore excluded from the models that we present.

By varying the water quality program descriptions across respondents we are able to examine how differences in the size of water quality improvements affect responses. In columns 1 through 3 the water quality improvements are represented as program dummy variables, where program I is the omitted category in the regressions. Because water quality outcomes are better as we progress from program I to program IV the parameters on the dummy variables represent incremental increases in the utility of a yes vote. Although the estimates have the expected positive sign, we find statistical significance for only one parameter in the *vote recoded* model and two parameters in the *vote certain* model. We conclude from these positive estimates that scope effects are likely present, but that the variability in quality levels amongst the programs is too small to detect differences at the level of flexibility implied by the dummy variable model. While our design could have varied the differences among programs to a larger degree, and thereby increased the power to identify scope effects without functional form assumptions, we were constrained by the need to maintain credibility in the size of the programs' deviations from the baseline.

Given this our last three sets of estimates use the specification in equation (6), where the log transformation of the continuous quality attribute imposes a smooth diminishing marginal utility of the quality change. Columns 4 through 6 restrict the constant term and the level effects of the respondent characteristics to zero, because joint tests of these restrictions could not be rejected at the 0.10 significance level. An advantage of this outcome is that it constraints the utility change (and by extension, willingness to pay) to be zero when $\Delta qual$=0, as would be expected. In all three models the size of the water quality improvement has a positive and statistically significant effect (p<0.01) on the utility difference. In addition, the interaction terms show that higher education and revealed and intended recreation use augment the positive utility effects of an improvement.

The results from all six models can be used to predict average WTP for the water quality improvements. For example, using the formula in equation (12) and sample mean values for *college*, *trplastyr*, and *trpnextyr* we find the following:

- For model 1 the annual WTP for program II is $233, with a 95% confidence interval of ($176, $298).
- For models 2 and 3 the corresponding figures are $173 ($117, $230) and $229 ($173, $293), respectively.[4]

As expected, recoding all uncertain votes to "no" in model 2 leads to a lower mean WTP. Using the formula in equation (15) and the sample means for the interaction variables we find the following:

- For model 4 with $\Delta qual$=0.6, which is equivalent to program II, our mean WTP estimate is $241 per year, with a 95% confidence interval of ($210, $283).
- For models 5 and 6 the corresponding estimates are $195 ($168, $226) and $252 ($220, $296), respectively.

In addition to the results reported in Table 14, we estimated a number of other models. These models indicate that there was no difference in the responses to the two versions of the water quality descriptions (comparing the three-attribute and five-attribute versions). We also ran a Heckman sample selection model (Heckman 1979) using demographic data on Knowledge Networks panel members who were invited to take the survey and declined. Using this approach

[4] Confidence intervals were estimated using the Krinsky and Robb (1986) procedure.

we did not find a statistically significant sample selection bias.

Policy Contingent Valuation Model

As illustrated above the estimates in Table 14 allow us to compute the mean value (WTP) of a specified change in the water quality index using any of the six models. It is important to note that these values should not be compared with similar calculations from the choice experiment. There, the marginal value was for a single trip to a single lake, and the relevant time frame was a single-trip choice occasion. This estimate is for all the lakes in a state, and it is an annual value for the change. Viewed in this light, the two models arguably are consistent with the same underlying preferences and water quality values.

The CV model that we suggest for policy purposes is model 5 in table 14. This model uses the continuous index to measure changes in water quality. By recoding all uncertain responses as “no” votes, it also provides more conservative estimates of WTP than the other models. This model suggests that the benefits of statewide improvements accrue to all residents (perhaps reflecting some types of nonuse value), but that actual and potential recreation uses value the improvements more. This is an intuitive finding, and further supports the validity of our application.

6. Case Study

The objective of this project is to provide a protocol that can be used by state water quality managers to measure the dollar-denominated benefits of proposed numeric nutrient criteria. As described in the introduction, this task requires two types of models: one that can map measures of water quality obtained from a monitoring station network (e.g., total nitrogen, chlorophyll a) to a descriptive quality-level indicator, and one that can map changes in the descriptive quality indicator to dollar values. With the methods described in the water quality modeling technical document (Phaneuf et al., 2009) and the previous sections of this document, the tools that we need to define a protocol are now in place. In this section we demonstrate how these tools can be used by applying them to a case study. For discussion purposes, we define the main policy problem as lake specific. That is, a manager is charged with evaluating a numeric nutrient criterion for a particular lake, and she must assess the recreation benefits of changes from the status quo to the new criterion.

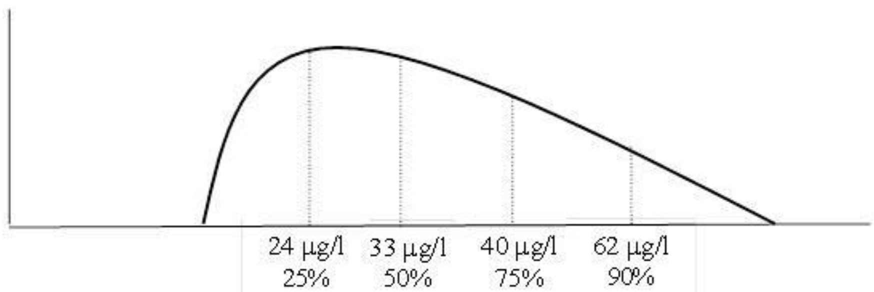
We use an application to valuing nutrient reductions in North Carolina's Falls Lake as our case study example. Nutrient targets for Falls Lake are currently under debate by the North Carolina Division of Water Quality; as a result, a large amount of monitoring station data are available. In particular, median (mean) measures of key nutrient parameters taken throughout 2006 are presented in Table 15. These summaries are based on 270 sampling events. Figure 5 describes in more detail the specific distribution of baseline readings for chlorophyll a.

North Carolina has discussed setting a nutrient criterion such that no more than 10% of chlorophyll a readings are over 40 μg/l. Figure 5 shows that under baseline conditions 10% of readings are over 62 μg/l. Thus, the policy objective that we evaluate in this case study is one that shifts the distribution of chlorophyll a so that the criterion is met (i.e., so that the 90th

Table 15. Median and (Mean) Values for Key Nutrient Parameters

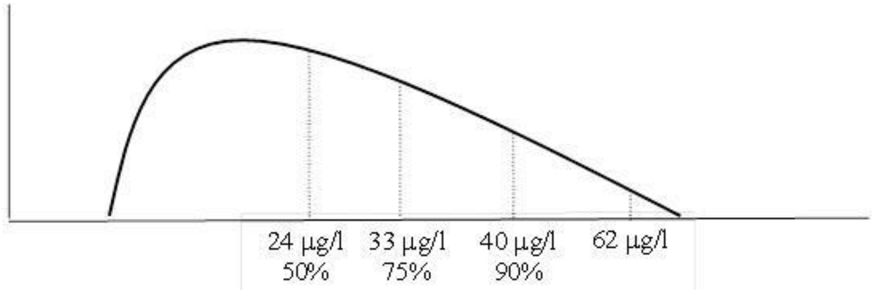
	2006 Baseline Medians and (Means)	Counterfactual Medians
Total nitrogen (TN)	0.76 (0.79) mg/l	0.70 mg/l
Total phosphorus (TP)	0.05 (0.07) mg/l	0.048 mg/l
Chlorophyll a (CLA)	33.00 (35.80) μg/l	24.00 μg/l
Secchi depth (S)	0.70 (0.70) m	0.74 m
Turbidity (T)	9.65 (14.06) NTU	9.05 NTU

Figure 5. Distribution of Chlorophyll a Readings from 2006



percentile of the chlorophyll a distribution is at most 40 μg/l). For this purpose, Figure 6 shows the assumed counterfactual distribution of chlorophyll a, which we have constructed by assuming a leftward shift in the percentile values. Based on this assumption for the counterfactual distribution, we consider the benefits of moving from the 2006 baseline median for chlorophyll a of 33 μg/l to a counterfactual chlorophyll a level of 24 μg/l. With the counterfactual standard for chlorophyll a set, it only remains to impute the implied values of the other nutrients in the counterfactual scenario. This is done using auxiliary regressions estimated using the monitoring network data that separately fit TN, TP, S, and T as a function of CHL. Table 15 presents the full set of nutrient measures for the counterfactual, based on the target for chlorophyll a and the imputed values for the other parameters. Note that these are fairly substantial changes in ambient water quality. In what follows we examine different benefit assessments arising from a change in the baseline to the counterfactual medians.

Figure 6. Distribution of Chlorophyll a Readings Under Counterfactual Assumptions



The first step is to use the tools developed in Phaneuf et al. (2009) to predict the water quality index that corresponds to the nutrient parameter medians. As described in Phaneuf et al. (2009), the actual water quality level in a lake will be influenced by many factors and will vary over time. Lakes with the same values for the nutrient measures listed in Table 16 could end up in different eutrophication categories. Our model first predicts the probability that a lake with a given set of nutrient measurements would be in a given eutrophication category (see Phaneuf et al., 2009 for details, and Kenney, 2007 for background). Using our preferred specification, Table 16 presents the predicted probabilities for each eutrophication category for our baseline and counterfactual scenarios. Based on the results in Table 16, we predict that the expected index level at baseline conditions is 3.45, suggesting that current water quality conditions in Falls Lake lie somewhere between levels C and D. The same prediction using the counterfactual nutrient concentrations results in an expected index level of 3.15. That is, the hypothetical policy intervention improves water quality so that Falls Lake approximately reaches level C.

The second step is to use the choice experiment model estimates to compute the per-trip WTP for the counterfactual improvement. We use equation (9) and the parameter estimates from the Table 12 "all" model so that

$$E(WTP) = \frac{1}{0.016}\begin{bmatrix} (p_A^c - p_A)\times 2.56 + (p_B^c - p_B)\times 1.93 \\ +(p_C^c - p_C)\times 0.98 + (p_D^c - p_D)\times 0.17 - (p_E^c - p_E)\times 0.11 \end{bmatrix}, \qquad (16)$$

Table 16. Predicted Baseline and Counterfactual Probabilities for Each Eutrophication Category

Eutrophication Category	Predicted Probability Under Baseline	Predicted Probability Under Counterfactual
Level 1 (Category A)	0.02	0.03
Level 2 (Category B)	0.06	0.12
Level 3 (Category C)	0.43	0.54
Level 4 (Category D)	0.46	0.30
Level 5 (Category E)	0.04	0.02

where the estimated baseline and counterfactual probabilities are computed from the water quality models and shown in Table 16. Using this formula we find an average per-trip WTP of $15.29.

Finally, to obtain an aggregate estimate of the recreation value of the Falls Lake improvement, we need estimates for the number of trips to the lake each year, a policy timeline, and an assumption for the discount rate. Based on the available data on visitation to Falls Lake (see NC DWQ, 2010), we conservatively assume there are 0.9 million trips to the lake each year and the annual benefits from the policy are $13.76 million. If we evaluate the benefits over 20 years and use a 5% discount rate, the present value of the stream of benefits is $171.52 million.

These values are based on several implicit assumptions. For example, the calculation assumes that the new quality level is reached immediately, when in fact it is likely to take several years before ambient conditions in the lake respond to current policy actions. To illustrate the importance of this complexity, consider a 20-year horizon in which water quality stays at baseline conditions for the first 5 years before obtaining the counterfactual level in the sixth year. In this case there are no program benefits in the first 5 years (because water quality has not improved). The annual benefits of $13.76 million per year accrue beginning in the sixth year, implying that the present value of benefits is now $108.81 million for the 20 years of the program.

As part of this project, we developed a spreadsheet tool that allows users to experiment with the protocol used to produce the estimates from this case study. This is available by navigating to http://www.epa.gov/nandppolicy/links.html, and clicking on the ‘grants’ folder once reaching this page. Appendix E contains the user manual that accompanies the spreadsheet tool and explains the equations and data behind the tool (see *User’s Manual for the Water Quality Spreadsheet* in Appendix E); the user manual is also posted at the web site.

7. Conclusion

The intent of our project has been to present a protocol for valuing the nonmarket benefits of numeric water quality criteria. For this purpose we have developed two sets of models: a water quality production function that maps changes in nutrient concentrations to changes in narrated water quality conditions and an economic model that maps changes in narrated conditions to dollar-denominated benefits. Methods related to the former are described in our earlier technical document (Phaneuf et al., 2009). In this document we have focused on describing the data collection and analysis used for the economic modeling.

In general, we find that our models based on the choice experiment and CV data produce intuitive and stable estimates of water quality benefits. Other summaries of behavior, attitudes, and beliefs among survey respondents provide further evidence that our descriptions of water quality in the survey were effective. From this we conclude that our estimates can be applied as one input into the process of evaluating proposed state-level numeric nutrient criteria. For this purpose we have also prepared a spreadsheet that integrates both aspects of our protocol (expert elicitation and the choice experiment analysis) into a non-technical tool that analysts can use. Appendix E to this report contains the user manual for the spreadsheet. The spreadsheet itself and an electronic version of the manual are available at www.epa.gov/nandppolicy/links.html (click on the 'grants' folder once reaching the page).

To close, we offer some caveats and limitations to the benefits estimates provided here. First, our choice experiment models by construction focus on a single aspect of the many ways that water quality improvements can provide economic benefits. Thus, the choice experiment estimates arising from our protocol are likely to be lower bounds in the sense that they do not include nonrecreation benefits of quality changes. Second, we have focused on keeping our economic models simple and transparent in order to make our protocol accessible to nonexperts. Thus, we do not include an endogenous trip-response margin or the effect on visits to substitute sites. In a technical sense this means our protocol computes the benefits of existing trips conditional on the existing allocation of trips to the set of available lakes in a region. If an ad hoc assumption about trip increases due to increases in water quality is not used, this too implies our estimates are likely to be lower bounds. Finally, in our case study we have focused on using the choice experiment model because it provides the most direct link to a well-defined policy objective and potential outcome. The improvement scenario used in the CV model makes the CV estimates most appropriate for a general assessment of statewide water quality standards, or an analysis of a large scale, regional policy intervention.

Limitations

To these caveats, we add a more formal listing of the specific limitations of this study, and those more generally associated with the tools we have applied here. First, in our case study we have relied on a trip choice conjoint experiment to measure the effects of water quality on preferences for lakes. As noted above this limits our focus to use value associated with nutrient pollution reductions. To the extent that there is nonuse value associated with these improvements, estimates from the choice experiment application may be a lower bound on total value. Policies designed to reduce nutrient pollution may also enhance water quality in other dimensions, such as bacteria levels associated with health risks. The economic value of this type of co-benefit is not explicitly included in our estimates. This again suggests our estimates represent lower bounds. Finally, our choice scenarios focus on day trip behavior, since overnight and longer trips tend to be different behavioral phenomena. We advise computing aggregate benefit estimates from this model using total day trip counts, meaning that the benefits to longer stay visitors of quality improvements may not be captured in the aggregate WTP predictions. The sum of these limitations arising from the structure of our preferred behavioral model suggests that the resultant WTP estimates are lower bounds on the value of quality improvements.

Second, we have relied heavily on stated preference techniques to estimate our benefit functions. Stated preference methods are somewhat controversial outside of the environmental economics community given concerns about hypothetical bias – i.e. the potential for respondents to answer questions differently than they would if they were facing a real choice. Our choice experiment estimates are at less risk of hypothetical bias than other types of SP questions, since we focus on a subsample of respondents who have actual experience with the type of choices we are presenting. We followed a careful and thorough approach to designing the study to minimize respondent confusion and we took steps, such as the inclusion of a "cheap talk" script, to reduce the potential for hypothetical bias. The risk of invalidity from hypothetical bias is therefore likely small, though (informal evidence aside) we are not able to provide formal tests to confirm its absence such as comparing the choices to real choices. Our CV estimates are comparatively more likely to be subject to hypothetical bias, in that the choice situation is less familiar to most respondents than a destination choice (and the value concept is less concrete than recreation services). As noted in the discussion of the CV results, our results conform to expectations and common assessments of validity that suggests we have a valid representation of preferences. In addition, our analysis of the uncertainty response indicators is designed to limit any overestimates of value due to hypothetical bias. However, we are not able to formally conclude that people would answer similarly in a real payment situation, since our design did not include this type of real payment treatment.

Third, there are potential limitations arising from our survey design choices. We view our description of the nutrient pollutions levels in Table 1 in non-technical language as a strength of the study. Nonetheless, compromises were necessary in a few instances. For the lay audience we needed to present the attribute levels and their correspondence with the quality categories linearly, though the actual ecosystem might display some non-linearity in how attribute levels relate to overall water quality. The natural brown color of many lakes in the southeastern US created challenges for communicating the color gradation between high and low quality lakes; we ultimately decided to associate brownish color with lesser quality levels, though in reality a brownish tint need not signal poor quality in other dimensions. In addition, our focus groups revealed that many people had not personally experienced large alga blooms or offensive odors at places they had visited. While focus group participants did indicate an understanding of the lower ranges of our quality spectrum, the fact that they had not visited destinations with such low quality may mean our estimates of preferences associated with the worst quality levels are less reliable than estimates for the middle of the quality range. Though we do not view any of these potential limitations as serious, we note that it is not possible to predict the direction of bias that they might cause.

Fourth, our experimental design for the contingent valuation study likely resulted in limited statistical power to detect scope effects among the different program quality levels. Use of a common baseline quality level for all treatments, and limiting the magnitude of quality improvements to physically feasible levels, meant we could not generate wide variability in the quality improvements offered by the different programs. We were therefore not able to estimate statistically significant scope affects with our most flexible model, though with some additional structure the evidence for scope effects is robust.

Fifth, our modeling choices necessarily imply some limitations in that the quantitative predictions depend on these choices (this is less so for qualitative predictions). For example, we have used a log specification in the contingent valuation model to impose intuitive, but non-testable, structure on the preference function. More importantly, our construction of the price of a visit to a lake in the choice experiment includes assumptions on the opportunity cost of time, travel speed, and out of pocket travel costs. Our choices for these parameters are consistent with what is used in the recreation demand literature, and are generally conservative (i.e. our assumptions imply lower travel costs than other studies that use, for example, the full wage rate as the opportunity cost of time). Our estimates of value are dependent on these choices and they would be different if we made alternative decisions. Given that our choices were conservative any errors arising from them likely imply predictions from the model are an under estimate of value – a direction consistent with the first limitation described above.

Sixth, the KN sample design is nationally representative, but this does not carry over to individual states. Thus, our sample of KN respondents from, say, North Carolina may not be representative of the population in that state. Our comparison of census and state sample averages for common household characteristics confirms that there are some differences between the target and sample populations. Though this is a point of concern, it is worth noting that our estimates suggest that household characteristics such as income, family size and status, and age are not strong predictors of the behavior we are studying.

Our final limitation concerns the transferability of our estimates. The protocol we have designed is intended for use by state water quality managers in the southeastern US. We note, however, that the water quality model was calibrated using North Carolina specific data. Likewise, the survey sample focused most heavily on the core study area of North Carolina, South Carolina, and Virginia. The accuracy of predictions from our protocol is likely to decrease with distance from the core study area, and the validity of our water quality modeling will be diminished when the policy lakes differ in hydrology from the North Carolina environment.

Closing Remark

To our list of caveats and limitations, we close by adding the obvious comment that any model is only as good as the data that are fed into it. Analyses of the type presented in our case study depend on having quality data on baseline conditions at a policy lake, a good prediction of the counterfactual scenario, information on aggregate visits to the policy lake, and a willingness to engage in sensitivity analysis to understand the uncertainties in the predictions. When properly deployed and interpreted in this way, our sense is that the protocol we have developed can serve as a valuable input into state-level water quality policy evaluation.

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Appendix A: Survey Instrument

[DISPLAY]

Thank you for agreeing to take this survey. It will ask you questions about lakes in the region where you live. By LAKES we mean standing bodies of freshwater (not saltwater) that are larger than private ponds. They include, for example, man-made lakes and reservoirs.

The first few questions ask about single-day trips you have taken to visit a lake. By single-day trips, we mean visits where you traveled at least 15 minutes from home, but did not spend the night away. This includes short trips within your community, and longer trips that may take several hours. It also includes trips when you went in the water, and trips when you stayed on shore or in a boat.

[RADIO]
[PROMPT IF SKIP]

1. During the past 12 months, did you take any single-day trips where the primary purpose was to spend time in or near a lake? (*check one*)

 ___ Yes [SKIP TO Q2]
 ___ No

1B. How likely is it that you will take a single-day trip in the next 12 months where the primary purpose will be to spend time in or near a lake? (*check one*)

 ___ Very likely [SKIP TO Q9]
 ___ Somewhat likely [SKIP TO Q9]
 ___ Not at all likely [SKIP TO Q9]

[RADIO]
[IF Q1=1]
[PROMPT IF SKIP]

2. On these single-day trips, what was your main recreation activity? (*check one*)

___ Swimming or playing in the water
___ Fishing
___ Motorized boating activities, such as waterskiing, jetskiing, or tubing
___ Non-motorized boating activities, such as sailing, canoeing, or kayaking
___ Viewing nature
___ Participating in an organized activity, such as a picnic or a competition.
___ Using walking trails or other near-shore facilities.
___ Other

[CHECK BOX]
[IF Q1=1]
[PROMPT IF SKIP]

3. On these single-day trips, what other recreation activities did you do? (*check all that apply*) [EXCLUDE CATEGORY SELECTED IN Q2. Show entire list if q2=refused]

___ Swimming or playing in the water
___ Fishing
___ Motorized boating activities, such as waterskiing, jetskiing, or tubing
___ Non-motorized boating activities, such as sailing, canoeing, or kayaking
___ Viewing nature
___ Participating in an organized activity, such as a picnic or a competition.
___ Using walking trails or other near-shore facilities
___ Other activity
___No other activity [SC]

____[RADIO]
[IF Q1=1]

4. On these single-day trips in the last 12 months, who normally went with you? (*check one*)

___ No one; I usually went alone.
___ 1 or more other adults, but no children
___ 1 or more other people, including children

[CHECK BOX]
[IF Q1=1]
[PROMPT IF SKIP]

5. In which state (or states) are the lakes you visited located? (*check all that apply*)

___ Alabama
___ Georgia
___ Kentucky
___ Mississippi
___ North Carolina
___ South Carolina
___ Tennessee
___ Virginia
___ None of the above [SC]

[FOR EACH STATE SELECTED IN Q5 SHOW STATE MAP AND ASK Q6]

[CHECK BOX]
[REPEAT Q6 FOR EACH STATE SELECTED IN Q5]
[PROMPT IF SKIP]

[INCLUDE STATE MAP (from *.png file) HERE]

6. In which part of [STATE] are the lakes you visited located? (*check all that apply*)

___ [REGION 1] [STATE]
___ [REGION 2] [STATE]
___ [REGION 3] [STATE]

[REGION NAMES IN state-region-lake.xls]

[FOR EACH REGION SELECTED IN Q6, ASK Q7 WITH CORRESPONDING LAKE LIST IN state-region-lake.xls]

[CHECK BOX]
[REPEAT Q7 FOR EACH REGION, STATE SELECTED IN Q6]
[PROMPT IF SKIP]

7. In the past 12 months, which of the following lakes in [REGION] [STATE] did you visit? (*check all that apply*)

If you can't find the name of a lake you visited, you can check "Other Lake Not Listed" at the end of the list.

[CENTRAL NC EXAMPLE]

_____ Bass Lake
_____ Bassemer City Lake
_____ Beaverdam Lake
_____ Belews Lake
_____ Big Lake
_____ Blewett Falls Lake
_____ Buckhorn Reservoir
_____ Burlington Reservoir
_____ Cane Creek Reservoir
_____ Carthage City Lake
_____ Clearwater Lake
_____ Corporation Lake
_____ Falls Lake
_____ Farmer Lake
_____ Graham-Meban Reservoir
_____ Hanging Rock Lake
_____ Harris Lake
_____ High Point Reservoir
_____ High Rock Lake
_____ Hyco Lake
_____ Jordan Lake
_____ Kannapolis Lake
_____ Kernersville Reservoir
_____ Kerr Lake
_____ Kerr Scott Reservoir
_____ Kings Mountain Reservoir
_____ Lake Adger
_____ Lake Benson
_____ Lake Brandt
_____ Lake Concord
_____ Lake Corriher
_____ Lake Crabtree
_____ Lake Devin
_____ Lake Fisher
_____ Lake Gaston
_____ Lake Hickory
_____ Lake Higgins
_____ Lake Hunt
_____ Lake Isaac Walton
_____ Lake Johnson
_____ Lake Lee
_____ Lake Lure
_____ Lake Mackintosh
_____ Lake Michie
_____ Lake Monroe
_____ Lake Montonia
_____ Lake Norman
_____ Lake Orange
_____ Lake Raleigh
_____ Lake Reese
_____ Lake Rogers
_____ Lake Roxboro
_____ Lake Summit
_____ Lake Thom-A-Lex
_____ Lake Wylie
_____ Lasater Lake
_____ Little River Dam
_____ Little River Reservoir
_____ Lake Wendell
_____ Lake Wheeler
_____ Lake Wright
_____ Long Lake
_____ Lookout Shoals Lake
_____ Lower Moccasin Lake
_____ Maiden Lake
_____ Mayo Reservoir
_____ McCrary Lake
_____ Mountain Island Lake
_____ Newton City Lake
_____ Pittsboro Lake
_____ Quaker Creek Reservoir
_____ Reedy Creek Lake
_____ Reidsville Lake
_____ Richland Lake
_____ Roberdel Lake
_____ Rock River Reservoir
_____ Rockingham City Lake
_____ Ross Lake
_____ Salem Lake
_____ Sandy Creek Reservoir
_____ Sycamore Lake
_____ Tuckertown Reservoir
_____ University Lake
_____ Upper Moccasin
_____ Wadesboro City Reservoir
_____ Water Lake
_____ Winston Lake

[Show in a separate row]

_____ **OTHER LAKE NOT LISTED ABOVE**

[IF "OTHER LAKE" IS SELECTED, ASK 7A:

7a. If you know the names of any of these other lakes you visited, or the names of their nearest towns, please enter them below:

Lake Name	Nearest Town

[NUMBER BOX 1-365]
[SHOW NUMBER BOX FOR EACH LAKE SELECTED Q7]
[PROMPT IF SKIP]

8. In the last 12 months, how many single-day trips did you take to each lake you visited? (*enter a number of trips next to each one*)

	Number of single day trips
[lake ***] in [region] [state name]	______
[lake ***] in [region] [state name]	______
[lake ***] in [region] [state name]	______

[SHOW A LIST OF THE LAKES CHECKED BY RESPONDENT IN Q7s, WITH A PLACE TO ENTER A NUMBER NEXT TO EACH ONE]

[RADIO]

9. Approximately how long does it take you to drive to the lake that is closest to your home? (*enter a number*)

___ minutes

9a. During the past 12 months, how many multiple-day trips (with at least one night away) did you take, where the primary purpose was to spend time on or a near a lake? (*enter a number*)

___ multiple-day trips

[DISPLAY]

Information about Nitrogen, Phosphorus, and Lake Water Quality

Please read the following information before answering the questions on the next screens:

Nitrogen and phosphorus are naturally occurring substances. They are essential nutrients for plant and animal growth, and for a healthy environment. But, when lakes receive too much nitrogen or phosphorus, they can also cause water quality problems.

The oversupply of nitrogen and phosphorus to lakes can come from several man-made sources, such as too much fertilizer applied to farmland or lawns, waste from animal farms, outflows from water treatment plants, leaking septic tanks, and even air pollution from cars, power plants, and farms.

When a lake receives too much nitrogen or phosphorus, changes may occur. These changes can make the water look (and sometimes smell) different. The changes can also make it harder for some animals and plants to live and grow. But, even in the worst cases it is very rare for these conditions to cause health problems for humans.

The next screens describe in more detail how lake waters can be affected by too much nitrogen or phosphorus.

[RADIO]
[ALIGN THE BUTTONS TO THE MIDDLE OF EACH IMAGE]

Lake water color

Too much nitrogen or phosphorus entering a lake can cause changes that give it more of a green color than it would otherwise have.

10-1. Which of the following colors is closest to what you see in most lakes in your area? (*check one*).

Blue

☐ 

Blue/Brown

☐ 

Brown/Green

☐ 

Green

☐ 

□ don’t know

[RADIO]

Water clarity

Too much nitrogen or phosphorus can cause changes that make lake water less clear. One way to measure water clarity is by how deep you can see into the water. For example, if you were fishing from a pier and dropped your line straight down into the water, how deep would your bait go before it disappeared from sight?

10-2. Which of the following categories best describes the water clarity you have seen in most lakes in your area? *(check one)*

___ You can see 5 feet or more deep into the water
___ You can see 2 to 5 feet deep into the water
___ You can see 1 to 2 feet deep into the water
___ You can see at most 1 foot deep into the water
___ don’t know

[RADIO]

Fish Habitat

Too much nitrogen or phosphorus can cause changes in a lake’s environment, which make it difficult for some fish to grow, reproduce, or survive. While some “rough fish” like carp and bullhead catfish are more able to tolerate these conditions, most “game fish” like bass, crappie, stripers, bluegill and channel catfish are less abundant in lakes with high nitrogen or phosphorus levels.

10-3. Which of the following fish types would you most expect to find in lakes in your area? *(check one)*

__ abundant game fish and a few rough fish
__ many game fish and a few rough fish
__ many rough fish and a few game fish
__ a few rough fish but no game fish
__ don’t know

[DISPLAY]
[IF WQVERSION=2]

Algae

Too much nitrogen and phosphorus can also cause algae to grow and multiply at a very fast rate, leading to algae "blooms" like the one shown in the picture below. These blooms mainly occur during the summer, when lake water is warmer, and especially in drier years. They are also more likely to occur in shallow water and in areas closer to where creeks or streams enter the lake.

[RADIO]
[IF WQVERSION=2]

10-4. Which of the following algae bloom conditions would you most expect to find in lakes in your area? *(check one)*

__ algae blooms never occur
__ small amounts of algae appear near shore in some years, and last 1 to 2 days
__ small amounts of algae appear near shore most years, and last for about 1 week
__ large amounts of algae (like in picture on previous screen) appear near shore about once a year and last for 2 to 3 weeks.
__ large amounts of thick algae appear near shore every year and last for most of the summer
__ don't know

[RADIO]
[IF WQVERSION=2]

Unpleasant Odor

Too much nitrogen or phosphorus can also cause changes that give lake water an unpleasant odor, like the smell of decaying leaves or plants. These odors often occur after algae blooms, as the algae die off.

10-5. Which of the following unpleasant odor conditions would you most expect to find in lakes in your area? *(check one)*

__ no unpleasant odors
__ 1 to 2 days a year, faint odor,
__ 3 to 4 days a year, noticeable odor,
__ several days a year, noticeable odor,
__ don’t know

[RADIO]
[PROMPT IF SKIP]

Depending on how much nitrogen and phosphorus they receive, lakes in [HOME STATE] generally fall into the 5 following categories. In your opinion, which lake category do you believe is most common in [HOME STATE]?

CATEGORY	**A**	**B**	**C**	**D**	**E**
COLOR	Blue	Blue/Brown	Brown/Green	Brown/Green	Green
CLARITY	Can see 5 feet deep or more	Can see 2-5 feet deep	Can see 1-2 feet deep	Can see at most 1 foot deep	Can see at most 1 foot deep
FISH	Abundant game fish and a few rough fish	Many game fish and a few rough fish	Many rough fish and a few game fish	A few rough fish but no game fish	A few rough fish but no game fish
ALGAE BLOOMS [show if WQVERSION=2]	Never occur	Small areas near shore; some years, 1-2 days	Small areas near shore; most years, 1 week	Large areas near shore; once a year, 2-3 weeks	Large, thick areas near shore; every year, most of summer
ODOR [show if WQVERSION=2]	No unpleasant odors	1-2 days a year, faint odor,	1-2 days a year, faint odor,	3-4 days a year, noticeable odor,	several days a year, noticeable odor,
	*	*	*	*	*

11-

[RADIO]

[REMOVE COLUMNS SELECTED FROM Q11]

12- Of the remaining 4 lake categories, which one do you believe is most common in [HOME STATE]? *(check one)*

CATEGORY	A	B	C	D	E
COLOR	Blue	Blue/Brown	Brown/Green	Brown/Green	Green
CLARITY	Can see 5 feet deep or more	Can see 2-5 feet deep	Can see 1-2 feet deep	Can see at most 1 foot deep	Can see at most 1 foot deep
FISH	Abundant game fish and a few rough fish	Many game fish and a few rough fish	Many rough fish and a few game fish	A few rough fish but no game fish	A few rough fish but no game fish
ALGAE BLOOMS [show if WQVERSION=2]	Never occur	Small areas near shore; some years, 1-2 days	Small areas near shore; most years, 1 week	Large areas near shore; once a year, 2-3 weeks	Large, thick areas near shore; every year, most of summer
ODOR [show if WQVERSION=2]	No unpleasant odors	1-2 days a year, faint odor,	1-2 days a year, faint odor,	3-4 days a year, noticeable odor,	several days a year, noticeable odor,
	*	*	*	*	*

[RADIO]
[REMOVE COLUMNS SELECTED FROM Q11 AND Q12]

13- Of the remaining 3 lake categories, which one do you believe is most common in [HOME STATE]? *(check one)*

CATEGORY	A	B	C	D	E
COLOR	Blue	Blue/Brown	Brown/Green	Brown/Green	Green
CLARITY	Can see 5 feet deep or more	Can see 2-5 feet deep	Can see 1-2 feet deep	Can see at most 1 foot deep	Can see at most 1 foot deep
FISH	Abundant game fish and a few rough fish	Many game fish and a few rough fish	Many rough fish and a few game fish	A few rough fish but no game fish	A few rough fish but no game fish
ALGAE BLOOMS [show if WQVERSION=2]	Never occur	Small areas near shore; some years, 1-2 days	Small areas near shore; most years, 1 week	Large areas near shore; once a year, 2-3 weeks	Large, thick areas near shore; every year, most of summer
ODOR [show if WQVERSION=2]	No unpleasant odors	1-2 days a year, faint odor,	1-2 days a year, faint odor,	3-4 days a year, noticeable odor,	several days a year, noticeable odor,
	*	*	*	*	*

[SKIP TO AFTER Q24 IF Q1B = Not at all likely]

[RADIO]

Imagine the following situation…

Sometime next summer, the weather forecast for the weekend looks good so you begin thinking about a day trip to enjoy your favorite lake recreation activity.

14- What main activity would that most likely be? *(check one)*

___ Swimming or playing in the water
___ Fishing
___ Motorized boating activities, such as waterskiing, jetskiing, or tubing
___ Non-motorized boating activities, such as sailing, canoeing, or kayaking
___ Viewing nature
___ Participating in an organized activity, such as a picnic or a competition.
___ Using walking trails or other near-shore facilities.
___ Other

[RADIO]

15- How many other people would most likely go with you?

___ No one; I would go alone.
___ 1 or more other adults, but no children
___ 1 or more other people, including children

[DISPLAY]

On each of the next few screens, you will be asked to compare two lakes and to select the one you would most likely visit.

In each case, please imagine that the two lakes are your only options for the day trip.

[FOR Q16, Q18, Q20, Q23, PLEASE SEE THE CONJOINT DESIGN FILE]
[RANDOMLY ASSIGN RESPONDENTS TO ONE OF 6 VERSIONS]
[DOV: CONJOINT=1-6]

[RADIO]
[PROMPT IF SKIP]

Imagine that your two options are Lake 1 and Lake 2. The only differences between these two lakes are shown in the table below. Otherwise, they are exactly the same in every other way.

16- Which lake would you be most likely to visit?
(*Please enter your choice at the bottom of the table*)

		LAKE 1	**LAKE 2**
WATER QUALITY	WATER QUALITY CATEGORY	**[C**	**[B**
	COLOR	Brown/Green	Blue/Brown
	CLARITY	Can see 1-2 feet deep	Can see 2-5 feet deep
	FISH	Many rough fish and a few game fish	Many game fish and a few rough fish
	ALGAE [show if wqversion=2]	Small areas near shore; most years, 1 week	Small areas near shore; some years, 1-2 days
	ODOR [show if wqversion=2]	Faint odor, 1-2 days a year]	Faint odor, 1-2 days a year]
ONE WAY DISTANCE FROM YOUR HOME		[30 minute drive]	[90 minute drive]
Which lake would you choose? *(check one box)*		☐ **LAKE 1**	☐ **LAKE 2**

[RADIO]
[SHOW TABLE AGAIN WITH ANSWER SELECTED AND GREYED OUT]
[PROMPT IF SKIP]

17- Your choice of Lake [LAKE NUMBER CHOSEN IN Q16] is shown above. If Lake 1 and Lake 2 were your only two options for the day trip, which of the following would you do? *(check one)*

____ Visit Lake [LAKE NUMBER CHOSEN IN Q16]
____ Not visit a lake on that day

[RADIO]
[PROMPT IF SKIP]

Now imagine instead that your only two options are Lake 3 and Lake 4. The only differences between these two lakes are shown in the table below. Otherwise, they are exactly the same in every other way.

18- Which lake would you be most likely to visit?
(*Please enter your choice at the bottom of the table*)

		LAKE 3	LAKE 4
WATER QUALITY	WATER QUALITY CATEGORY	[C	[D
	COLOR	Brown/Green	Brown/Green
	CLARITY	Can see 1-2 feet deep	Can see at most 1 foot deep
	FISH	Many rough fish and a few game fish	A few rough fish but no game fish
	ALGAE [show if wqversion=2]	Small areas near shore; most years, 1 week	Large areas near shore; once a year, 2-3 weeks
	ODOR [show if wqversion=2]	Faint odor, 1-2 days a year]	Noticeable odor, 3-4 days a year]
ONE WAY DISTANCE		[90 minute drive]	[15 minute drive]

FROM YOUR HOME		
Which lake would you choose? *(check one box)*	☐ **LAKE 3**	☐ **LAKE 4**

[RADIO]
[SHOW TABLE AGAIN WITH ANSWER SELECTED AND GREYED OUT]
[PROMPT IF SKIP]

19- Your choice of Lake [LAKE NUMBER CHOSEN IN Q18] is shown above. If Lake 3 and Lake 4 were your only two options for the day trip, which of the following would you do? *(check one)*

____ Visit Lake [LAKE NUMBER CHOSEN IN Q18]
____ Not visit a lake on that day

[RADIO]
[PROMPT IF SKIP]

Now imagine instead that your only two options are Lake 5 and Lake 6. The only differences between these two lakes are shown in the table below. Otherwise, they are exactly the same in every other way.

20- Which lake would you be most likely to visit?
(*Please enter your choice at the bottom of the table*)

		LAKE 5	LAKE 6
WATER QUALITY	WATER QUALITY CATEGORY	[C	[D
	COLOR	Brown/Green	Brown/Green
	CLARITY	Can see 1-2 feet deep	Can see at most 1 foot deep
	FISH	Many rough fish and a few game fish	A few rough fish but no game fish
	ALGAE [show if wqversion=2]	Small areas near shore; most years, 1 week	Large areas near shore; once a year, 2-3 weeks
	ODOR [show if wqversion=2]	Faint odor, 1-2 days a year]	Noticeable odor, 3-4 days a year]
ONE WAY DISTANCE FROM YOUR HOME		[90 minute drive]	[15 minute drive]
Which lake would you choose? *(check one box)*		☐ **LAKE 5**	☐ **LAKE 6**

[RADIO]
[SHOW TABLE AGAIN WITH ANSWER SELECTED AND GREYED OUT]
[PROMPT IF SKIP]

21- Your choice of Lake [LAKE NUMBER CHOSEN IN Q20] is shown above. If Lake 5 and Lake 6 were your only two options for the day trip, which of the following would you do? *(check one)*

____ Visit Lake [LAKE NUMBER CHOSEN IN Q20]
____ Not visit a lake on that day

[GRID]

Now imagine instead that your only two options are Lake 5 and Lake 6. The only differences between these two lakes are shown in the table below. Otherwise, they are exactly the same in every other way.

21a Which lake would you be most likely to visit?
(*Please enter your choice at the bottom of the table*)

		LAKE 7	LAKE 8
WATER QUALITY	WATER QUALITY CATEGORY	**[C**	**[D**
	COLOR	Brown/Green	Brown/Green
	CLARITY	Can see 1-2 feet deep	Can see at most 1 foot deep
	FISH	Many rough fish and a few game fish	A few rough fish but no game fish
	ALGAE [show if wqversion=2]	Small areas near shore; most years, 1 week	Large areas near shore; once a year, 2-3 weeks
	ODOR [show if wqversion=2]	Faint odor, 1-2 days a year]	Noticeable odor, 3-4 days a year]
ONE WAY DISTANCE FROM YOUR HOME		[90 minute drive]	[15 minute drive]
Which lake would you choose? *(check one box)*		□ **LAKE 7**	□ **LAKE 8**

[RADIO]
[SHOW TABLE AGAIN WITH ANSWER SELECTED AND GREYED OUT]
[PROMPT IF SKIP]

21b - Your choice of Lake [LAKE NUMBER CHOSEN IN Q21a] is shown above. If Lake 7 and Lake 8 were your only two options for the day trip, which of the following would you do? *(check one)*

_____ Visit Lake [LAKE NUMBER CHOSEN IN Q21a]
_____ Not visit a lake on that day

[GRID]

22- When choosing the lake you would most likely visit in the previous questions, how important were the following water quality attributes in your decision? (*Check one box for each attribute*)

	Not important	**A little bit important**	**Moderately important**	**Very important**
COLOR	☐	☐	☐	☐
CLARITY	☐	☐	☐	☐
FISH	☐	☐	☐	☐
ALGAE **[show if WQVERSION=2]**	☐	☐	☐	☐
ODOR **[show if WQVERSION=2]**	☐	☐	☐	☐
DISTANCE FROM HOME	☐	☐	☐	☐

[RADIO]
[PROMPT IF SKIP]

[IF AT LEAST 2 ITEMS SELECTED FROM 1-7 IN Q3, RANDOMLY SELECT ONE ACTIVITY]
[IF 1 ITEM SELECTED FROM 1-7 IN Q3, ASSIGN THE SELECTED ITEM AS ACTIVITY]
[IF "OTHER ACTIVITY" THE ONLY SELECTED ITEM IN Q3, "NO OTHER ACTIVITY", OR "REFUSED", ASSIGN "OTHER ACTIVITY/NO OTHER ACTIVITY/REFUSED" AS THE VALUE]

ACTIVITY:

___ Swimming or playing in the water
___ Fishing
___ Motorized boating activities, such as waterskiing, jetskiing, or tubing
___ Non-motorized boating activities, such as sailing, canoeing, or kayaking
___ Viewing nature
___ Participating in an organized activity, such as a picnic or a competition.
___ Using walking trails or other near-shore facilities
___ Other activity/no other activity/refused

[IF activity=1-7:]
Now imagine instead that your planned lake recreation activity for the day is [<u>activity</u>]. In this case, your only two options are Lake 9 and Lake 10

[IF activity=8:]
Now imagine instead that your only two options are Lake 9 and Lake 10.

The <u>only</u> differences between these two lakes are shown in the table below. Otherwise, they are exactly the same in every other way.

23- Which lake would you be most likely to visit?
(*Please enter your choice at the bottom of the table*)

		LAKE 9	**LAKE 10**
WATER QUALITY	WATER QUALITY CATEGORY		

		[C	[D
	COLOR	Brown/Green	Brown/Green
	CLARITY	Can see 1-2 feet deep	Can see at most 1 foot deep
	FISH	Many rough fish and a few game fish	A few rough fish but no game fish
	ALGAE [show if wqversion=2]	Small areas near shore; most years, 1 week	Large areas near shore; once a year, 2-3 weeks
	ODOR [show if wqversion=2]	Faint odor, 1-2 days a year]	Noticeable odor, 3-4 days a year]
ONE WAY DISTANCE FROM YOUR HOME		[90 minute drive]	[15 minute drive]
Which lake would you choose? *(check one box)*		☐ **LAKE 9**	☐ **LAKE 10**

[RADIO]
[SHOW TABLE AGAIN WITH ANSWER SELECTED AND GREYED OUT]
[PROMPT IF SKIP]

24 -Your choice of Lake [LAKE NUMBER CHOSEN IN Q23] is shown above. If Lake 9 and Lake 10 were your only two options for the day trip, which of the following would you do? *(check one)*

____ Visit Lake [LAKE NUMBER CHOSEN IN Q23]
____ Not visit a lake on that day

[DISPLAY]

[IF activity=1-7:]
Now imagine again that your planned lake recreation activity for the day is [<u>activity</u>]. In this case, your only two options are Lake 11 and Lake 12

[IF activity=8:]
Now imagine instead that your only two options are Lake 11 and Lake 12.

The only differences between these two lakes are shown in the table below. Otherwise, they are exactly the same in every other way.

24a- Which lake would you be most likely to visit?
(*Please enter your choice at the bottom of the table*)

		LAKE 11	LAKE 12
WATER QUALITY	WATER QUALITY CATEGORY	[C	[D
	COLOR	Brown/Green	Brown/Green
	CLARITY	Can see 1-2 feet deep	Can see at most 1 foot deep
	FISH	Many rough fish and a few game fish	A few rough fish but no game fish
	ALGAE [show if wqversion=2]	Small areas near shore; most years, 1 week	Large areas near shore; once a year, 2-3 weeks
	ODOR [show if wqversion=2]	Faint odor, 1-2 days a year]	Noticeable odor, 3-4 days a year]
ONE WAY DISTANCE FROM YOUR HOME		[90 minute drive]	[15 minute drive]
Which lake would you choose? *(check one box)*		☐ LAKE 11	☐ LAKE 12

[RADIO]
[SHOW TABLE AGAIN WITH ANSWER SELECTED AND GREYED OUT]
[PROMPT IF SKIP]

24b - Your choice of Lake [LAKE NUMBER CHOSEN IN Q24a] is shown above. If Lake 11and Lake 12 were your only two options for the day trip, which of the following would you do? *(check one)*

____ Visit Lake [LAKE NUMBER CHOSEN IN Q24a]
____ Not visit a lake on that day

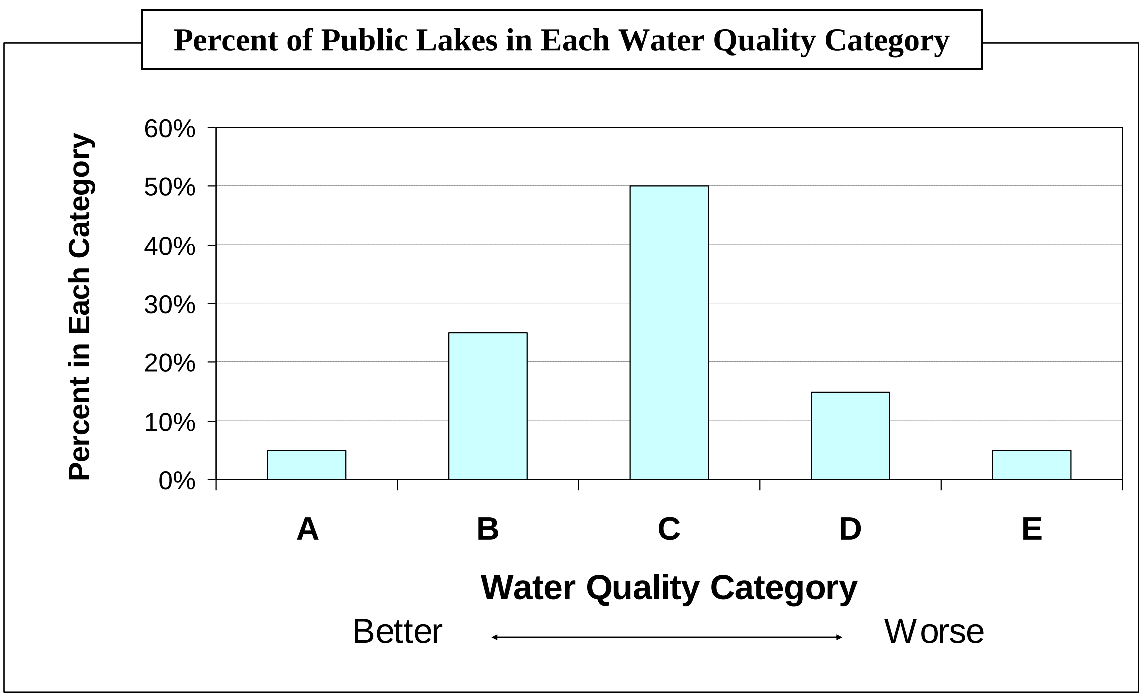
WATER QUALITY IN [HOME STATE] LAKES

Information about water quality at public lakes is often collected and reported by state agencies. This information can be used to show the percentage of lakes in [HOME STATE] that are in each of the five water quality categories.

- 30% (3 out of every 10 lakes) are in one of the best two categories (**A** or **B**)
- 50% (5 out of every 10 1akes) are in the middle category (**C)**
- 20% (2 out of every 10 lakes) are in one of the lower quality categories (**D** or **E**),

[DISPLAY]

The information on the previous screen can also be shown on a graph below:



[DISPLAY]

A PROGRAM TO IMPROVE LAKE WATER QUALITY

Imagine that state agencies in charge of water resources in [HOME STATE] are considering a program to improve lake water quality.

Because nitrogen and phosphorus come from many different man-made sources, there are many ways to control them. Under the program being considered, efforts to reduce nitrogen and phosphorus would be spread among many different groups.

For example,

- sewage treatment plants would have to install better treatment systems;
- residents using septic tanks would have to inspect these systems for leakage;
- towns and housing developments would have to install improved systems for managing water runoff from storms;
- farms would have to reduce fertilizer runoff from fields and improve the containment of animal waste.

[RADIO]

25- Have you ever heard or read about a program like this in [HOME STATE]? *(check one)*

_____ Yes
_____ No
_____ Not sure

[RANDOMLY ASSIGN AS VERSION A OR VERSION B]
[DOV: VERSION: 1=A 2=B]

[DISPLAY]

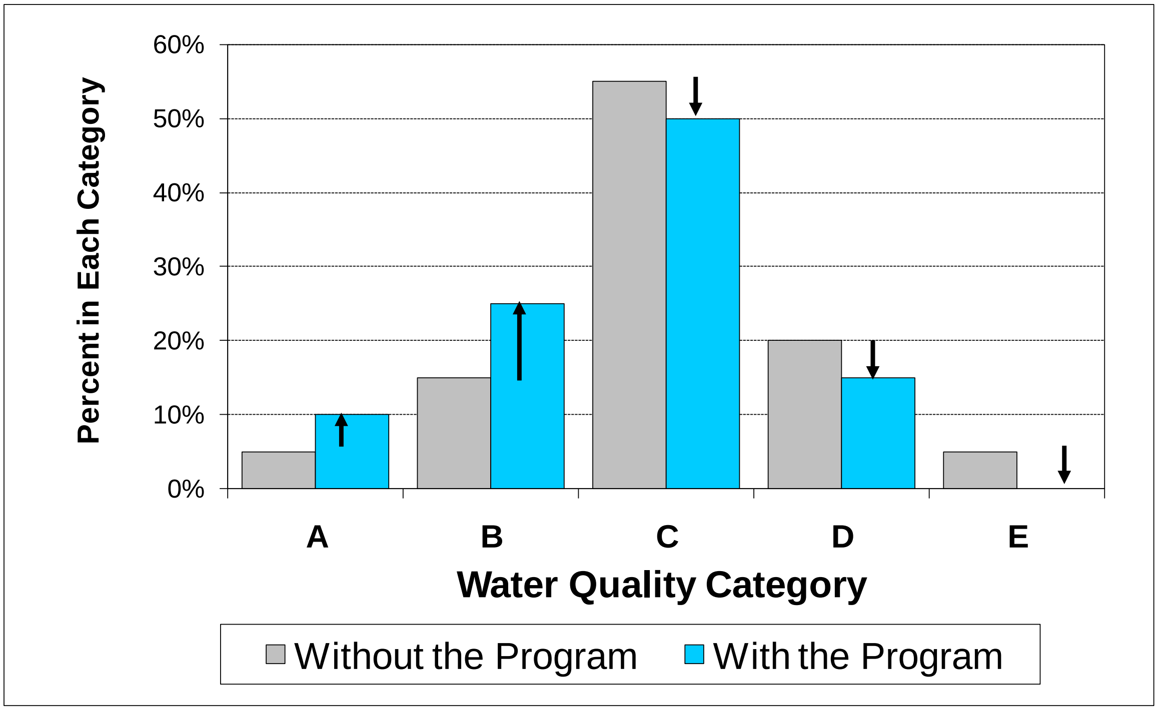
[VERSION A]

HOW WOULD THE PROGRAM IMPROVE LAKE WATER QUALITY IN [HOME STATE]?

The diagram below compares projected lake conditions in [HOME STATE] in 10 years, with and without the program.

The bars in grey show what lakes would be like *without the program*. If no action is taken to control nitrogen and phosphorus, only 20% (2 out of every 10 lakes) would be in one of the best two categories (**A** or **B**).

The bars in blue show what lakes would be like *with the program*. 35% would be in one of the best two categories. The arrows show how the percent of lakes in the best two categories would increase, and the percent in the other categories would decrease.


Percent in Each Category
60%
50%
40%
30%
20%
10%
0%
A
B
C
D
E
Water Quality Category
Without the Program
With the Program

[DISPLAY]

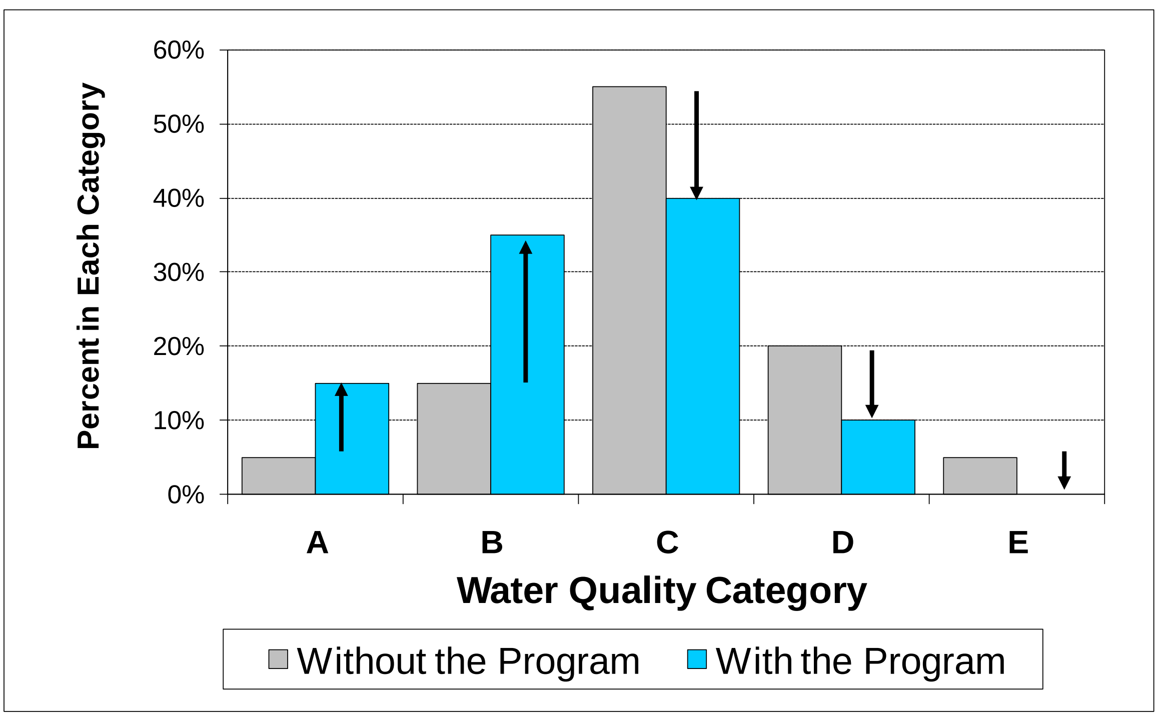
[VERSION B]

HOW WOULD THE PROGRAM IMPROVE LAKE WATER QUALITY IN [HOME STATE]?

The diagram below compares projected lake conditions in [HOME STATE] in 10 years, with and without the program.

The bars in grey show what lakes would be like *without the program*. If no action is taken to control nitrogen and phosphorus, only 20% (2 out of every 10 lakes) would be in one of the best two categories (**A** or **B**).

The bars in blue show what lakes would be like *with the program*. 50% would be in one of the best two categories. The arrows show how the percent of lakes in the best two categories would increase, and the percent in the other categories would decrease.



DISPLAY]

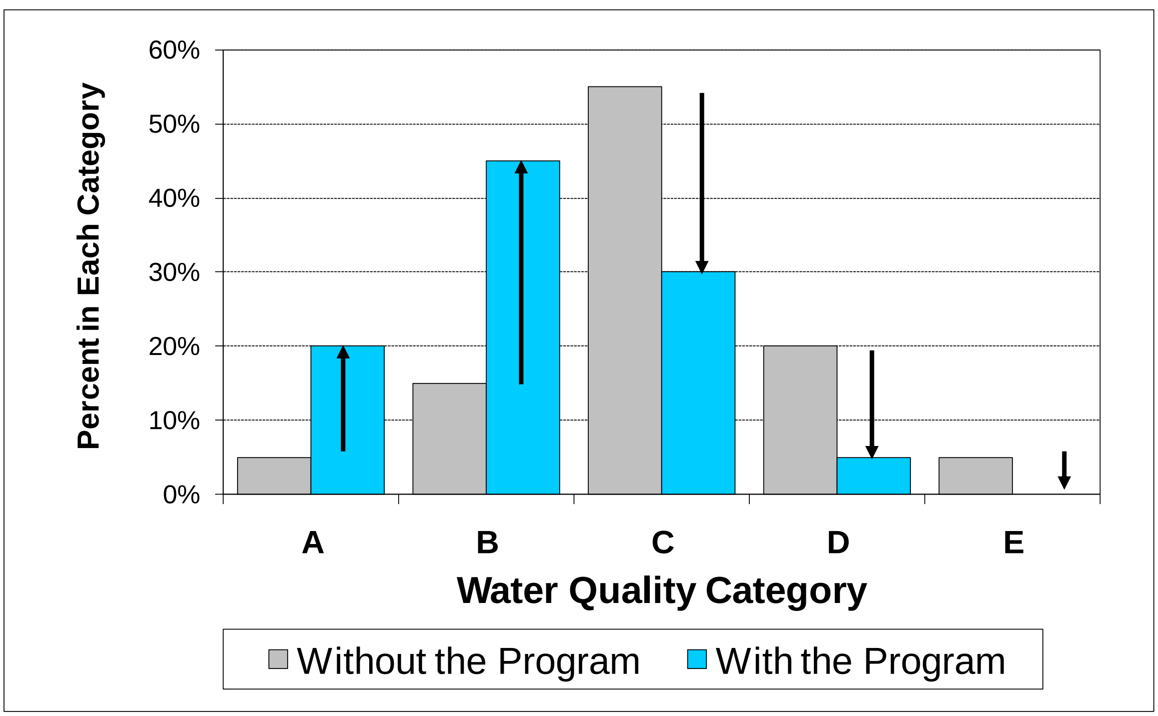
[VERSION C]

HOW WOULD THE PROGRAM IMPROVE LAKE WATER QUALITY IN [HOME STATE]?

The diagram below compares projected lake conditions in [HOME STATE] in 10 years, with and without the program.

The bars in grey show what lakes would be like *without the program*. If no action is taken to control nitrogen and phosphorus, only 20% (2 out of every 10 lakes) would be in one of the best two categories (**A** or **B**).

The bars in blue show what lakes would be like *with the program*. 65% would be in one of the best two categories. The arrows show how the percent of lakes in the best two categories would increase, and the percent in the other categories would decrease.



DISPLAY]

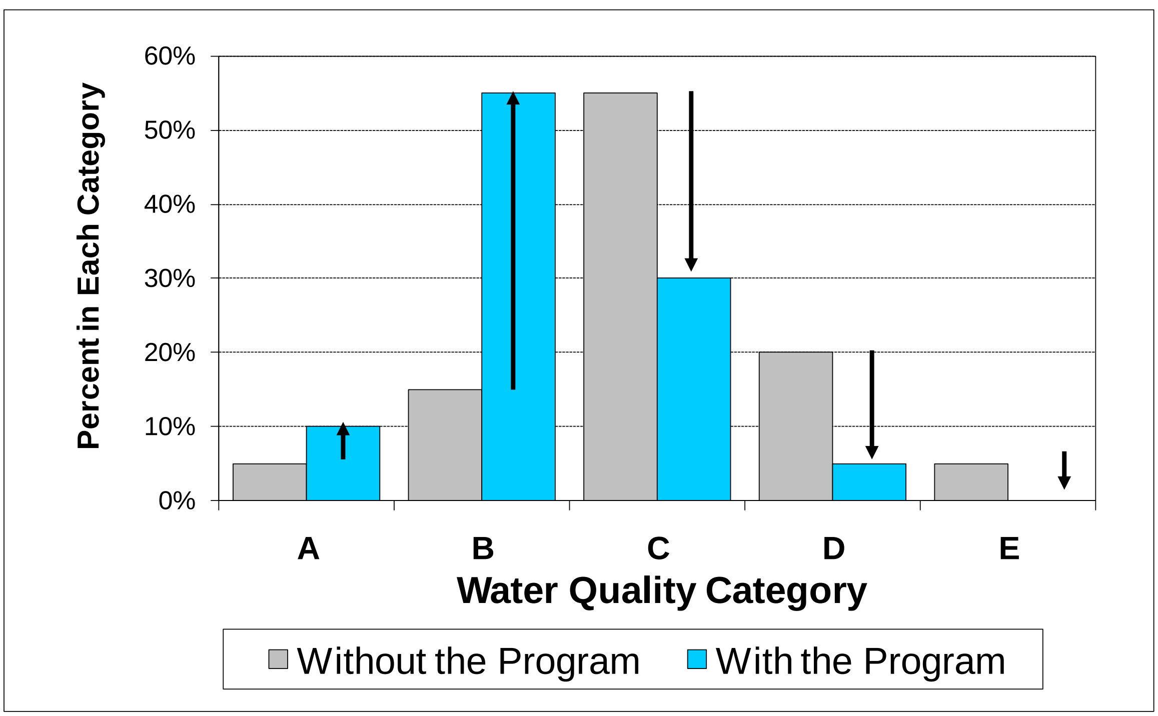
[VERSION D]

HOW WOULD THE PROGRAM IMPROVE LAKE WATER QUALITY IN [HOME STATE]?

The diagram below compares projected lake conditions in [HOME STATE] in 10 years, with and without the program.

The bars in grey show what lakes would be like *without the program*. If no action is taken to control nitrogen and phosphorus, only 20% (2 out of every 10 lakes) would be in one of the best two categories (**A** or **B**).

The bars in blue show what lakes would be like *with the program*. 65% would be in one of the best two categories. The arrows show how the percent of lakes in the best two categories would increase, and the percent in the other categories would decrease.



[RANDOMLY ASSIGN TO ONE OF FOUR V STARTING VALUES]
[SEE DESIGN FILE SHEET "VERSION SUMMARIES]
[DOV: 1=$24 2=$96 3=$144 4=$240]

[DISPLAY]

HOW MUCH WOULD THE PROGRAM COST HOUSEHOLDS LIKE YOURS?

The changes required by the program would have a cost for all [HOME STATE] households. Some of the basic things people spend money on would become more expensive. For example, for homeowners, water bills or costs for maintaining septic systems would go up. For renters, rent or utility bills would go up.

Imagine that for households like yours, starting next year, the program would permanently increase your cost of living by **$[V] per year**, or$[V/12] per month.

[RADIO]
[PROMPT IF SKIP]

WOULD YOU VOTE FOR OR AGAINST THIS PROGRAM?

Imagine that all [HOME STATE] residents were allowed to vote on the program. If a majority of voters support the program, it would be implemented next year.

We would like you to think carefully about how you would actually vote in this situation. In previous research we have found that people are often more willing to vote yes when payment is only imagined than when payment is real. Therefore, we urge you to respond as though costs for your household really would go up if the program were implemented. Knowing how different [HOME STATE] residents would vote on this program is very important for state government decision makers.

So please take time to consider both the benefits of the program and the costs to your household. Ask yourself whether you believe the lake improvement program is worth $[V] each year to your household, since that is less money that you would have to spend on other things. There may be good reasons for you to vote for the program and good reasons to vote against it. Only you know what is best for you and your household.

26- If the vote were held today, how would you vote? *(check one)*

__ vote FOR the program
__ vote AGAINST the program

26a How certain are you that would vote ["for" if Q26=1, "against" if Q26=2] the program?

___very certain
___somewhat certain
___not certain at all.

[RADIO]
[IF Q26=1]
[PROMPT IF SKIP]
[IF Q26 = AGAINST, SKIP TO Q28]

27- Which of the following reasons best describe why you would vote FOR the program? *(check all that apply)*

__ the program is important and should be implemented, no matter how much it costs
__ the benefits of the program are worth the extra costs
__ I don't believe the costs to my household would actually be as much as $[V] per year
__ none of the above

[SKIP TO Q29]

[RADIO]
[IF Q26=2 OR SKIP]
[PROMPT IF SKIP]

28- Which of the following reasons best describe why you would vote AGAINST the program? *(check all that apply)*

__ improving lake water quality is not that important to me
__ improving lake water quality is important, but I don't believe the program would work as described
__ improving lake water quality is important, but $[V] per year is too expensive for my household
__ improving lake water quality is worth $[V] per year for my household, but it is too much to ask from some other households in [HOME STATE]
__ none of the above

[SKIP TO Q30]

[RADIO]
[IF Q26=1]
[PROMPT IF SKIP]

29- What if the costs of the program were higher? If improving lake quality as described before would increase the cost of living for households like yours by **$[V+] per year**, or $[V+/12] per month, how would you vote? *(check one)*

__ vote FOR the program
__ vote AGAINST the program

[RADIO]
[IF Q26=2 OR SKIP]
[PROMPT IF SKIP]

30- What if the costs of the program were lower? If improving lake quality as described before would increase the cost of living for households like yours by **$[V-] per year**, or $[V-/12] per month, how would you vote? *(check one)*

__ vote FOR the program
__ vote AGAINST the program

Appendix B: Lake Lists

AL Lakes

REGION 1 **Northern**	REGION 2 **Central**	REGION 3 **Southern**
Big Bear Reservoir	Aliceville Reservoir	Armstrong Lake
Brahan Spring Park	Bankhead Reservoir	Barbour County Lake
Brushy Lake in Bankhead National Forest	Bibb County Lake	Big Creek Lake
Cedar Creek Reservoir	Brantleyville Lake	Blue Lake
Cheaha Lake	Brent Lake	Blue Springs State Park Lake
Clay County Lakes	Chewacla State Park Lake	Chatom City Lake
Coleman Lake	Dallas County Lake	Chattahoochee Park Lake
Crooked Creek Watershed Lakes	Demopolis Lake	Claiborne Reservoir
DeKalb County Lake	East Lake	Coffee County Lake
Fayette County Lake	Gainesville Reservoir	Coffeeville Reservoir
Harris Lake (Lake Wedowee)	Goat Rock Reservoir	Columbia Reservoir
High Rock Lake	Harding Lake	Crenshaw County Lake
Highland Lake	Holt Reservoir	Dale County Lake (Ed Lisenby Lake)
Hillabee Reservoir	Jones Bluff Lake	Dannelly Reservoir
Inland Lake	LaFayette City Lake	Day Lake (Mobile Tricentennial Park)
Lake Catoma	Lake Howard	Eastgate Park Lake
Lake Chinnabee	Lake Jordan	Enterprise City Lake
Lake Guntersville	Lake Little Wills	Escambia County Lake (Leon Brooks Hines Lake)
Lake Neely Henry	Lake Louise	Fisher Lake
Lamar County Lake	Lake LU	Gantt Reservoir
Little Bear Reservoir	Lake Lurleen	Geneva County Lakes
Little River Lake (DeSoto State Park)	Lake Martin	Geneva State Forest Lake
Madison County Lake	Lake Nicol	Lake Eufaula
Marion County Lake	Lake Purdy	Lake Frank Jackson
McFarland Park Lake	Lake Virginia	Lake Jackson
Morgan Lake	Lay Lake	Lake Shelby
Pickwick Lake	Lee County Lake	Lake Thollocco
Sharon Johnson Park Lake	Logan Martin Lake	Little River State Forest Lake
Small Lake	Mitchell Lake	Monroe County Lake
Sportsman Lake	Montevallo Lakes	Omussee Park Lake
Swan Creek Management Area	Moon Lake	Pike County Lake
Sweetwater Lake	Notasulga City Lake	Point A Reservoir
Upper Bear Creek Reservoir	Oak Mountain State Park Lakes	Sherling Lake
Walker County Lake	Oliver Lake	St. Stephens Historic Park Lake
Weiss Lake	Opelika City Lake (Saugahatchee Lake)	Tensaw Lake
Wheeler Lake	Paul Grist State Park Lake	Washington County Lake (J. Emmett Wood Lake)
White Plains Reservoir	Payne Lake	
Wilson Lake	Perry Lakes	
	Smith Lake	
	Tuscaloosa Lake	
	Tuskegee City Lake	
	Warrior Reservoir	
	West Jefferson Lake	

Georgia Lakes

REGION 1 **Northern**	REGION 1 **Northern**	REGION 2 **Central**	REGION 3 **Southern**
Allatoona Reservoir	Stone Mountain Park Lakes	Altamaha Waterfowl Refuge Lakes	A.H. Stephens State Park Lakes
Antioch Lake	Sweetwater Creek State Park Lake	Bartletts Ferry Reservoir	Andrews Reservoir
Big Haynes Creek Reservoir	Talmadge 12 Oaks Lakes	Bennett Lake	Banks Lake
Black Rock Lake	Thomas County Pond	Big Lazer Creek Lake	Barnesville Reservoir
Blalock Reservoir	Tribble Mill Park Lakes	Boatright's Pond	Beaver Lake
Blue Ridge Reservoir	Tugalo Reservoir	Bradley Impoundment	Beaver Lodge Lake
Bull Sluice Lake	Twin Lakes	Callaway Gardens Lake	Bidds Sands Lake
Burton Reservoir	Unicoi Lake	Carver Park Lake	Black Shoals Lake
Carters Lake	Wade-Walker Park Lake	Chapman Lake	Blackshear Reservoir
Chapel Hill Park	Weiss Reservoir	Clarks Hill Lake (J. Strom Thurmond Lake)	Blythe Island Regional Park Lake
Chatuge Reservoir	Yargo Lake Reservoir	Cooper Creek Park Lake	Bobben Lake
Clayton County International Park Lake		Flatrock Park Lake	Bridge Lake
Collins Hill Park Lake		Fox Lake	Chehaw Reservoir
Commerce Watershed Lake		Franklin D. Roosevelt State Park Lakes	Cherokee Lake
Crow's Lake		George L. Smith Park Lake	Cooks Lake
Davidson Mountain Nature Preserve Lake		Goat Rock Reservoir	Duck Lake
Dog River Reservoir		Gordon Lakes	Fort Stewart Ponds
Evelyn S. Wade Park Lake		Haddens Lake	Fuller Lake
Exchange Park Lake		Hamburg State Park Lake	Gator Swamp Lake
Fort Mountain State Park Lake		Heads Creek Reservoir	Gordonia-Alatamaha State Park Lake
Fort Yargo State Park Lake		High Falls State Park Lake	Gordons Fish Pond
G.B.'s Lake		Houston Lake	Hidden Lakes
Glen Emerald Park Lake		Indian Springs State Park Lake	Horseshoe Lakes
Griffin City Reservoir		Jackson Reservoir	J F Gregory Lake
Hard Labor Creek State Park Lakes		John T Briscoe Reservoir	Lake Hugh M. Gillis
Hartwell Lake		Jordan Mill Pond	Lake Lewis
Heath Lake		Juliette Reservoir	Lake Lindsay Grace
Helton-Holland Park Lake		Lake Boline	Lake Mayer
Henderson Park Lake		Lake Conasauga	Lake Mayers
J. W. Smith Reservoir		Lake Heath	Lake Murphy
James "Sloppy" Floyd State Park Lake		Lake Meriwether	Lake Seminole
John Tanner State Park Lakes		Lake Olmstead	Lake Varner (Newton County Reservoir)
Kelly Cofer Park Lake		Lewis Lake	Lakeview Park Lake
Lake Acworth		Lower Raleigh Lake	Laura S. Walker State Park Lake
Lake Carlton		Magnolia Springs State Park Lake	Little Ocmulgee State Park Lake
Lake Carroll		Margery Lake	Louis Scott Stell Lake
Lake Horton Reservoir		Menonite Lake	Martin's Ponds
Lake Kedron		Merry Brothers Fish Ponds	McCant's Mill Pond
Lake Lanier		Miller Creek Lake	Ocmulgee Public Fishing Area Lake
Lake Marvin		Morgan Lake	Pamona Lake
Lake Trahlyta		Oconee Reservoir	Paradise Lake
Lake Winfield Scott		Oliver Reservoir	Patrick Lake
Long Branch Reservoir		Randy Poynter Reservoir	Pine Lake
Murphy Candler Park Lake		Richard B. Russell Reservoir	Ray's Mill Pond
Nottely Reservoir		Rush Creek Reservoir	Red Gate Plantation Lakes
Padgett Lake		Sandy Creek Reservoir	Reed Bingham State Park Lake
Paris Lake		Shepard Lake	S.C. Foster State Park Lake
Queen City Lake		Sinclair Reservoir	Steve Bell Lake
Rabun Reservoir		Still Branch Reservoir	Sunshine Lakes
Reservoir 51		Tallulah Falls Lake	Suwannee Canal Recreation Area Lakes
Rhodes Jordan Park Lake		Tobesofkee Creek Reservoir	Tacklebuster Lake
Rock Creek Lake		Town Creek Reservoir	Trestle Lake
Rock Eagle Lake		Trophy Trout Ranch	Walter F. George Lake
Lake Russell		Turner Lake	Willow Lake
Salacoa Creek Park Lake		Watershed Lake # 14	Woody Lake
Sears Lakes		Watershed Pond #1	
Seed Lake		West Point Lake	
Shamrock Reservoir		Whittakers Pond	
Sharpe's Creek Reservoir		Yonah Lake	

KY Lakes

REGION 1 **Western**	REGION 2 **Eastern**	REGION 2 **Eastern**
Audubon State Park Lake	4-H Club Lakes	Owsley Fork Reservoir
Barren River Lake	A.J. Jolly Lake	Paintsville Lake
Beaverdam Lake	Beaver Lake	Pan Bowl Lake
Bell Lake	Bert Combs Lake	Rebel Trace Lake
Bob Noble Park Lake	Beulah Lake	Reformatory Lake
Bottom Lake	Big Bone State Park Lake	Salem Lake
Briggs Lake	Boltz Lake	Smoky Valley/Carter Caves Lake
Buck Lake	Booker Reservoir	Sportsman's Lakes
Burnt Slough Lake	Buckhorn Lake	Springfield Reservoir
Butler Lake	Bullock Pen Lake	Spurlington Lake
Can Lake	Campbellsville City Lake	Stanford City Reservoir
Carpenter Lake	Campton Lake	Station Camp Creek
Castor Lake	Cannon Creek Lake	Sympson Lake
Crofton Public Lake	Carlisle Water Works Lakes	Taylorsville Lake
Cypress Lake	Carr Creek Lake	Watterson Lake
Dale Hollow Lake	Cave Run Lake	Wilgreen Lake (Taylor Fork)
Dixon City Lake	Cedar Creek Lake	Williamstown Lake
Energy Lake	Chenoa Lake	Willisburg Lake
Fish Lake	Clear Creek Lake	Wood Creek Lake
Goose Lake	Commerce Park Lake	Yatesville Lake
Green River Lake	Corbin City Reservoir	
Handicap Lake	Corinth Lake	
Happy Hollow Lake	Cranks Creek Lake	
Hematite Lake	Dewey Lake	
Honker Lake	Doe Run Lake	
Island Lake	Eagle Lake	
Jack's Lake	Elmer Davis Lake	
Kentucky Lake	Ernst Lake	
Kingfisher Lakes	Fagan Branch Lake	
Lake Barkley	Fishpond Lake	
Lake Beshear	Fishtrap Lake	
Lake Blythe	Flemingsburg Water Reservoir	
Lake Cumberland	Fox Valley Lake	
Lake George - Marion City Lake	General Butler State Park Lake	
Lake Luzerne	Grants Branch Lake	
Lake Malone	Grayson Lake	
Lake Morris	Greenbo Lake	
Lake Peewee	Greenbriar Reservoir	
Limestone Lake	Guist Creek Lake	
Little Turner Lake	Hambley Lake	
Loch Mary	Herrington Lake	
Mauzy Lake	Hoedown Island Lake	
Merlin Lake	Hubble-Logan Park Lake	
Metcalfe County Lake	Iroquois Park Lake	
Metropolis Lake	Jacobson Park Lake	
Mill Creek Lake	Jenkins Lake	
Mitchell Lake	Kincaid Lake	
Moffitt Lake	Kinniconick Creek	
Mortons Lake	Lake Carnico	
Musky Lake	Lake Jericho	
Nolin River Lake	Lake Linville	
Nortonville City Lake	Lake Mingo	
Pennyrile Lake	Lake Nevin	
Providence New City Lake	Lake Polliwog	
Rob's Lake	Lake Reba	
Rough River Lake	Laurel Creek Reservoir	
Shanty Hollow Lake	Laurel River Lake	
Shelby Lake	Liberty Reservoir	
South Lake	Lincoln Homestead Lake	
Spa Lake	Long Run Park	
Swan Lake	Marion County Lake	
Three Springs Lake	Martin County Reservoir	
Tom's Lake	Martins Fork Lake	
Turner Lake	Maysville/Mason County Rec. Lake	
Vastwood Park Lake	McDougal Lake	
Washburn Lake	McNeely Lake	
West Fork Drakes Reservoir	Olive Hill Reservoir	

MS Lakes

REGION 1 **Western**	REGION 2 **Eastern**	REGION 2 **Eastern**
Albermarle Lake	Aliceville Lake	Marathon Lake
Bee Lake	Arkabutla Lake	McAlpine Lake
Beulah Lake	Bay Springs Lake	Neshoba County Lake
Chotard Lake	Beaver Lake	Okatibbee Reservoir
Crystal Springs Lake	Big Lake	Oktibbeha County Lake
Desoto Lake	Bluff Lake	Pickwick Lake
Dump Lake	Bonita Reservoir	Pierce Lake
Eagle Lake	Burnside Lake	Pontotoc Lake
Fletcher Lake	Cane Lake	Puskus Lake
Flower Lake	Chewalla Lake	Rines Lake
Lake Bill Waller	Choctaw Lake	Roosevelt State Park
Lake Bolivar	Clarckco State Park Lake	Rose Hill Lake
Lake Charlie Capps	Columbus Lake	Sardis Lake
Lake Columbia	Cypress Lake	Sportsman Lake
Lake Dockery	Davis Lake	Tippah County Lake
Lake Ferguson	Dumas Lake	Tishkill Lake
Lake George	Elvis Presley Lake	Tishomingo State Park Lake
Lake Hazle	Enid Lake	Trace State Park Lake
Lake Jackson	Gieger Lake	Turkey Fork Reservoir
Lake Jeff Davis	Golden Memorial Park Lake	Veterans Lake
Lake Lee	Green Tree Lake	
Lake Lincoln	Greentree Reservoir	
Lake Mary	Grenada Lake	
Lake Mike Conner	Gulfport Lake	
Lake Tangipahoa	Horn Lake	
Lake Walthall	Horseshoe Lake	
Lake Washington	Hutson Lake	
Lake Whittington	Kemper County Lake	
Little Eagle Lake	Lake Bogue Homa	
Little Round Lake	Lake Claude Bennett	
Log Loader Lake	Lake Lamar Bruce	
Mayes Lake	Lake Lowndes	
Moon Lake	Lake Mary Crawford	
Parkers Lake	Lake Monroe	
Perry Martin Lake	Lake Perry	
Pipe Lake	Lake Ross Barnett	
Roebuck Lake	Lake Tiak-O' Khata	
Simpson County Lake	Lake Tom Bailey	
Six Mile Lake	Lakeland Park	
Thornburg Lake	Legion Lake	
Walnut Lake	Little Owl Lake	
Willow Lake	Loakfoma Lake	
Wolf Lake	Long Creek Reservoir	
	Lower Rines Lake	
	Luther Lake	

North Carolina Lakes

REGION 1 **Western**	REGION 2 **Central**	REGION 2 **Central**	REGION 2 **Central**	REGION 3 **Eastern**
Allen Creek Reservoir	Apex Reservoir	Kerr Scott Reservoir	Lake Wylie	Bonnie Doone Lake
Appalachia Lake	Back Creek Lake	Kings Mountain Reservoir	Lasater Lake	Glenville Lake
ASU Lake	Badin Lake	Lake Adger	Little River Reservoir	Hamlet City Lake
Bear Creek Lake	Bass Lake	Lake Benson	Long Lake	Holts Lake
Bee Tree Reservoir	Beaverdam Lake	Lake Brandt	Lookout Shoals Lake	Hope Mills Lake
Burnett Reservoir	Belews Lake	Lake Bunch	Lower Moccasin Lake	Kornbow Lake
Busbee Reservoir	Bassemer City Lake	Lake Burlington	Maiden Lake	Lake Ben Johnson
Calderwood Lake	Big Lake	Lake Butner	Mayo Reservoir	Lake Tabor
Cedar Cliff Lake	Blewett Falls Lake	Lake Concord	McCrary Lake	Lake Wilson
Chatuge Lake	Buckhorn Reservoir	Lake Corriher	Mountain Island Lake	Maxton Pond
Hiwassee Reservoir	Burlington Reservoir	Lake Crabtree	Newton City Lake	Mintz Pond
Kenilworth Lake	Cane Creek Reservoir	Lake Devin	Pittsboro Lake	Mott Lake
Lake Cheoah	Carthage City Lake	Lake Fisher	Quaker Creek Reservoir	Old Town Reservoir
Lake Emory	Clearwater Lake	Lake Gaston	Reedy Creek Lake	Pages Lake
Lake Fontana	Corporation Lake	Lake Hickory	Reidsville Lake	Roanoke Rapids Lake
Lake James	Falls Lake	Lake Higgins	Richland Lake	Tar River Reservoir
Lake Julian	Farmer Lake	Lake Hunt	Roberdel Lake	Toisnot Reservoir
Lake Junaluska	Graham-Mebane Lake	Lake Isaac Walton	Rock River Reservoir	White Millpond
Lake Logan	Hanging Rock Lake	Lake Johnson	Rockingham City Lake	Wiggins Mill Reservoir
Lake Rhodiss	Harris Lake	Lake Lee	Ross Lake	Alligator Lake
Lake Santeetlah	High Point Reservoir	Lake Lure	Salem Lake	Bay Tree Lake
Lake Sequoya	High Rock Lake	Lake Mackintosh	Sandy Creek Reservoir	Boiling Springs Lake
Lake Tahoma	Hyco Lake	Lake Michie	Sycamore Lake	Cabin Lake
Nantahala Lake	Jordan Lake	Lake Monroe	Tuckertown Reservoir	Catfish Lake
Thorpe Reservoir	Kannapolis Lake	Lake Montonia	University Lake	Ellis Lake
Waterville Reservoir	Kernersville Reservoir	Lake Norman	Upper Moccasin	Great Lake
Wolf Creek Reservoir	Kerr Lake	Lake Orange	Wadesboro City Reservoir	Greenfield Lake
		Lake Raleigh	Water Lake	Jones Lake
		Lake Reese	Winston Lake	Lake Mattamuskeet
		Lake Rogers		Lake Phelps
		Lake Roxboro		Lake Waccamaw
		Lake Summit		Lake Wackena
		Lake Thom-A-Lex		Limestone Lake
		Lake Tilery		Merchants Millpond
		Lake Townsend		Pungo Lake
		Lake Twitty		Salters Lake
		Lake Wendell		Singletary Lake
		Lake Wheeler		Swan Creek Lake
		Lake Wright		White Lake
		Lake Wylie		
		Lasater Lake		
		Little River Reservoir		
		Long Lake		
		Lookout Shoals Lake		
		Lower Moccasin Lake		
		Maiden Lake		
		Mayo Reservoir		
		McCrary Lake		
		Mountain Island Lake		
		Newton City Lake		
		Pittsboro Lake		
		Quaker Creek Reservoir		
		Reedy Creek Lake		
		Reidsville Lake		
		Richland Lake		
		Roberdel Lake		
		Rock River Reservoir		
		Rockingham City Lake		
		Ross Lake		
		Salem Lake		
		Sandy Creek Reservoir		
		Sycamore Lake		
		Tuckertown Reservoir		
		University Lake		
		Upper Moccasin		
		Wadesboro City Reservoir		
		Water Lake		
		Winston Lake		

South Carolina Lakes

REGION 1	REGION 2	REGION 3	REGION 3
Western	**Central**	**Eastern**	**Eastern**
Chattooga Lake	Anderson Reservoir	Alligator Lake	Mattassee Lake
Finleys Lake	Apalachee Lake	Amelia Lake	Mc Cray Lake
Friddle Lake	Belue Lake	Arrowhead Lake	Mirror Lake
Garren Lake	Broadway Lake	Ballon Lake	Mount Lake
Issaqueena Lake	Caldwell Lake	Barr Lake	Mullers Big Lake
Lake Becky	Cedar Creek Reservoir	Batesburg Reservoir	Old Womans Lake
Lake Cheohee	Cedar Pines Lake	Bay Lake	Peachtree Lake
Lake Jocassee	Chester Reservoir	Bens Lake	Pine Lake
Lake Keowee	Clark Hill Lake	Big Lake	Pitch Lodge Lake
Lake Lanier	Coneross Creek Reservoir	Booths Lake	Pitts Lake
Lake Oolenoy (Table Rock S	Conestee Lake	Burnt Gin Lake	Prestwood Lake
Lake Robinson	Crescent Lake	Cary Lake	Red Bluff Lake
Lake Russell	Elizabeth Lake	Cator Hall Lake	Rockyford Lake
Lake Strom Thurmond	Fishing Creek Reservoir	Clearwater Lake	Rogers Lake
Legion Lake	Great Falls Reservoir	Coleman Lake	Russ Lake
North Saluda Reservoir	Hammett Lake	Colonial Lake	Saylors Lake
Pinnacle Lake (Table Rock S	Hunts Lake	Cordes Lake	Semmes Lake
Silver Lake	J Strom Thurmond Lake	Cox Ferry Lake	Singleton Lake
Tall Pine Lakes	Lake Columbia	Cox Lake	Sister Lake
Tankersley Lake	Lake Craig	Crooked Lake	Spring Lake
Tugaloo Lake	Lake Cunningham	Crystal Lake	Sudlow Lake
White Water Lake	Lake Edwin Johnson	Crystal Springs Lake	Sunview Lake
	Lake Fairfield	Cypress Lake	Swan Lake
	Lake Frances	Dawhoo Lake	Thomas Lake
	Lake Greenwood	Dead River Lake	Timber Lake
	Lake Haigler	Dogwood Lake	Twin Lakes
	Lake Hartwell	Elliott Lake	Varn Lake
	Lake Huntington	Eureka Lake	Wee Tee Lake
	Lake Murray	Forest Lake	White Oak Slash Lake
	Lake Oliphant	Foul Craw Lake	Wildwood Lake
	Lake Patricia	Fountain Lake	Wilson Lake
	Lake Shamokin	Garrett Lake	Windsor Lake
	Lake Whelchel	Gilbert Lake	Wolf Lake
	Lake William C Bowen	Goose Creek Reservoir	
	Lake Wylie	Graves Lake	
	Lake York	Honey Lake	
	Lakeside Lake	Horseshoe Lake	
	Lancaster Reservoir	Huttos Lake	
	Lick Fork Lake	Johnson Lake	
	Lyman Lake	Kathwood Lakes	
	Monticello Reservoir	Kendall Lake	
	Mountain Lakes	Kingston Lake	
	Municipal Reservoir	Lake Bee	
	Negro Fork Reservoir	Lake Busbee	
	Oak Grove Lake	Lake Cherryvale	
	Old City Reservoir	Lake Cynthia	
	Parr Reservoir	Lake Edgar A Brown	
	Parsons Mountain Lake	Lake Edisto	
	Rutledge Lake	Lake George Warren	
	Saluda Lake	Lake James	
	Secession Lake	Lake Katherine	
	Simons Lake	Lake Marion	
	Slade Lake	Lake Merkel	
	Snows Lake	Lake Moultrie	
	Springwood Lake	Lake No 16	
	Stancil Lakes	Lake Timica	
	Stevensons Lake	Lake Trotwood	
	Sunrise Lake	Lake Wallace	
	Swints Lake	Lake Woodlawn	
	Taylor Blalock Lake	Long Lake	
	Teagues Lake	Marsh Lake	
	Wateree Lake	Martins Lake	
	Yonah Lake	Mathis Lake	

TN Lakes

REGION 1	REGION 2	REGION 3
Western	**Central**	**Eastern**
Adams Lake	Acorn Lake	Big Ridge Lake
Bards Lake	Arch Lake	Boone Reservoir
Beech Lake	Bedford Lake	Calderwood Reservoir
Blue Car Lake	Byrd Lake	Campbell Cove Lake
Brown's Creek Lake	Cane Creek Lake	Cherokee Lake
Bullpen Lake	Center Hill Lake	Chilhowee Lake
Carroll Lake	Cheatham Lake	Cove Lake
Chisholm Lake	Chickamauga Lake	Davy Crockett Reservoir (Nolichucky Reservoir)
Cub Lake	Cordell Hull Lake	Douglas Lake
Dogwood Lake	Couchville Lake	Fort Loudon Lake
Edmund Orgill Park Lake	Coy Gaither/Bedford Lake	Fort Patrick Henry Lake
Elk Reservoir	Creech Hollow Lake	Holston Lake
Fort Pillow Lake	Dale Hollow Lake	Indian Boundary Lake
Garrett Lake	Fall Creek Lake	Indian Mountain State Park Lakes
Gibson County Lake	Great Falls Lake	LaFollette City Lake
Glenn Springs Lake	Guntersville Lake	Lake Ocoee
Goldeneye Lake	Huntsville Reservoir	Melton Hill Lake
Goose Lake	J. Percy Priest Lake	Norris Lake
Greenbrier Lake	Jamestown City Lake	South Holston Lake
Hart Lakes	Lake Woodhaven	Steele Creek Lake
Herb Parsons Lake	Laurel Hill Lake	Tellico Lake
Kentucky Lake	Lindsey Lake	Watauga Lake
Lake Barkley	Marrowbone Lake	Wilbur Lake
Lake Graham	Meadow Creek Lake	
Lake Isom	Meadow Park Lake	
Lake Placid	New Lake	
Little Lake	Nickajack Lake	
Maple Creek Lake	Normandy Reservoir	
Mayor Lake	Old City Lake	
McCool Lakes	Old Hickory Lake	
Oneal Lake	Parksville Lake	
Patriot Lake	Percy Priest Reservoir	
Pickwick Lake	Standing Stone Lake	
Piersol Lake	Swan Lake	
Pin Oak Lake	Tims Ford Reservoir	
Pine Lake	VFW Lake	
Poplar Tree Lake	Watts Bar Lake	
Powell Lakes	Williamsport Lakes	
Quail Hollow Lake	Woods Reservoir	
Redbud Lake		
Reelfoot Lake		
Shellcracker Lake		
South Cross Creek Reservoir		
Sunk Lake		
Sycamore Lake		
Tanner Adams Lake		
Travis McNatt Lake		
Whippoorwill Lake		
Whiteville Lake		
Woodie Lake		
Zion Acres Pond		

Virginia Lakes

REGION 1 **Western**	REGION 2 **Central**	REGION 2 **Central**	REGION 3 **Eastern**
Bark Camp Lake	Abbott Lake	Leesville Reservoir	Back Bay
Brakes Interstate Park Laurel Lake	Abel Reservoir	Martinsville Reservoir	Beaverdam Swamp Reservoir
Cave Mountain Lake	Albemarle Lake	Mill Creek Reservoir	Burnt Mills Reservoir
Claytor Lake	Amelia Lake	Motts Run Reservoir	Chandler's Mill Pond
Clifton Forge Reservoir	Bear Creek Lake	Mountain Run	Chickahominy Lake
Douthat Lake	Beaver Creek Lake	Ni Reservoir	Diascund Reservoir
Elkhorn Lake	Beaverdam Creek Reservoir	Northeast Creek Reservoir	Emporia Reservoir
Flannagan Reservoir	Briery Creek Lake	Nottoway Lake	Gardy's Millpond
Gatewood Reservoir	Brunswick Lake	Occoquan Reservoir	Harrison Lake
Hearthstone Lake	Bryan Park	Pelham Reservoir	Harwood's Mill Reservoir
Hidden Valley Lake	Buggs Island Lake	Philpott Reservoir	Lake Airfield
Hungry Mother Lake	Chesdin Reservoir	Powhatan Lakes	Lake Cohoon
Lake Frederick	Chris Greene Reservoir	Quantico MCB Ponds & Lakes	Lake Drummond
Lake Keokee	Crump Park Lake	Ragged Mountain Reservoirs	Lake Kilby
Lake Laura	Cumberland State Forest Lakes	Richmond City Parks Lakes	Lake Maury
Lake Moomaw	Deep Run Park Lakes	Rivanna Reservoir	Lake Meade
Lake Robertson	Dorey Park Lake	Sandy River Reservoir	Lake Prince
Lake Shenandoah	Echo Lake	Slate River Impoundment	Lake Smith
Lake Witten	Fairfax Lake	Smith Mountain Lake	Lake Whitehurst
Laurel Bed Lake	Fairy Stone Lake	Stonehouse Lake	Lee Hall Reservoir
Lovill's Creek Lake	Fluvanna Ruritan	Sugar Hollow	Little Creek Reservoir
North Fork Pound Reservoir	Fort A.P. Hill Ponds and Lakes	Swan Lake	Lone Star Lakes
Rural Retreat Lake	Fort Pickett Lakes	Swift Creek Lake	Northwest River Park Lake
Sherando Lakes	Germantown Lake	Thrasher Lake	Speight's Run
Silver Lake	Great Creek Watershed Lake	Three Lakes Park	Trashmore Lake
Skidmore Reservoir	Henrico County Parks Lakes	Totier Creek Reservoir	Waller Mill Reservoir
Slate Lick Lake	Holliday Lake	Twin Lakes State Park	Western Branch Reservoir
South Holston Reservoir	Horsepen Lake	Walnut Creek Lake	
Staunton Run	Hunting Run Reservoir		
Todd Lake	James River State Park Lakes		
	Kerr Reservoir		
	Lake Anna		
	Lake Brittle		
	Lake Burke		
	Lake Burton		
	Lake Conner		
	Lake Curtis		
	Lake Gaston		
	Lake Gordon		
	Lake Gordonsville (Bowler's Mill Lake)		
	Lake Manassas		
	Lake Nelson		
	Lake Orange		
	Lake Thompson		
	Lakeview Reservoir		

PLEASE WRITE YOUR FIRST NAME HERE:

____

Thank you for participating
in this discussion group.

Please do not open this booklet
until instructed to do so.

There are many different lakes and reservoirs in North Carolina that are within driving distance from your home and that you can easily visit on a day trip.

What are the main things you consider when choosing which of these lakes to visit on a day trip?

I am <u>more</u> likely to visit a lake if it is/has…(LIST 4 THINGS)……….

1. ____
2. ____
3. ____
4. ____

I am <u>less</u> likely to visit a lake if it is/has……(LIST 4 THINGS)……….

1. ____
2. ____
3. ____
4. ____

Please do not turn to the next page until instructed to do so.

Some of the lakes and reservoirs in North Carolina have cleaner water than others in the state.

What words would you use to describe the water in cleaner or dirtier lakes?

The water in <u>cleaner</u> lakes is more likely to be (or to have) ….. (LIST 4 THINGS)……….

1. ____
2. ____
3. ____
4. ____

The water in <u>dirtier</u> lakes is more likely to be (or to have) ….. (LIST 4 THINGS)……….

1. ____
2. ____
3. ____
4. ____

Please do not turn to the next page until instructed to do so.

Which of the following terms do you think best describes the quality of the water in the lake pictured above? (CIRCLE ONE ANSWER)

1. **VERY POOR**
2. **POOR**
3. **FAIR**
4. **GOOD**
5. **VERY GOOD**

How common do you think it is to see water that looks like this in North Carolina lakes? (CIRCLE ONE ANSWER)

1. **VERY UNCOMMON**
2. **SOMEWHAT UNCOMMON**
3. **SOMEWHAT COMMON**
4. **VERY COMMON**

Please do not turn to the next page until instructed to do so.

One way to measure how CLEAR water is, is by measuring how DEEP you can see into the water. For example, how deep would a white plate have to sink before it disappeared from sight?

For lakes in North Carolina, what range of DEPTHS would you associate with the following descriptions (ENTER A RANGE FOR EACH ONE):

POOR WATER CLARITY	**0**	**ft**	**to**	________	**ft**
FAIR WATER CLARITY	________	**ft**	**to**	________	**ft**
GOOD WATER CLARITY	________	**ft**	**or more**		

Which level of water clarity do you think is most common in North Carolina lakes?

1. **POOR**
2. **FAIR**
3. **GOOD**

Please do not turn to the next page until instructed to do so.

Lakes with less than excellent water quality can sometimes (or often) have noticeable ODORS.

How often have you noticed these kinds of odors at lakes you have visited in North Carolina?

1. **NEVER**
2. **RARELY**
3. **SOMETIMES**
4. **OFTEN**
5. **VERY OFTEN**

What words would you use to describe the KINDS of odors you expect to find at lakes in North Carolina with POOR or FAIR water quality?

____

____

____

Please do not turn to the next page until instructed to do so.

Water quality can also affect the number and types of fish found in a lake.

For lakes in North Carolina with the following kinds of water quality, HOW MANY and WHAT TYPES of fish would you expect to find?

	Expect to find….		
Water Quality	**Lots of…**	**Some…**	**No…**
POOR:			
FAIR:			
GOOD:			

Please do not turn to the next page until instructed to do so.

The following picture shows an "ALGAL BLOOM" in a lake.

How common do you think it is to see water that looks like this in North Carolina lakes?

1. **VERY UNCOMMON**
2. **SOMEWHAT UNCOMMON**
3. **SOMEWHAT COMMON**
4. **VERY COMMON**

Please do not turn to the next page until instructed to do so.

The following picture shows an "ALGAL MAT" in a lake.

How common do you think it is to see water that looks like this in North Carolina lakes?

1. **VERY UNCOMMON**
2. **SOMEWHAT UNCOMMON**
3. **SOMEWHAT COMMON**
4. **VERY COMMON**

Please do not turn to the next page until instructed to do so.

	VERY POOR	POOR	FAIR	GOOD	VERY GOOD
COLOR	Green 	Brownish Green 	Bluish Brown 	Brownish Blue 	Blue 
CLARITY	Can see less than 1 foot deep	Can see 1–2 feet deep	Can see 2–5 feet deep	Can see 5–8 feet deep	Can see more than 8 feet deep
ODOR	Strong unpleasant odor, lasting 2–3 weeks, occurs 3–4 times a year	Noticeable unpleasant odor, lasting about 1 week, occurs 3–4 times a year	Noticeable unpleasant odor, lasting less than 1 week, occurs 2 times a year	Faint unpleasant odor, lasting about 1 day, occurs at most 2 times a year	None
FISH	Few or no fish present	A few mostly small and rough fish present	Mostly small and rough fish but a few game fish present such as bass and catfish	Moderately large and diverse population of fish.	Abundant fish with many different types and sizes of game fish
ALGAE	Blooms: large areas, lasting 1–2 months, occur 3–4 times a year. Mats: large clusters present most of the year on large portions of the lake	Blooms: mid-size areas, lasting about 1 month, occur 5 times a year Mats: large clusters are present for almost half the year	Blooms: small areas, lasting less than 1 week, occur 2 times a year Mats: small clusters in parts of the lake occur 5 times a year	Blooms: small area occurs less than 2 times a year Mats: small clusters in a few parts of the lake occur at most 2 times a year	Blooms: None Mats: None

In your opinion, what percentage of lakes in North Carolina fall into each of these 5 categories?

__________ %   __________ %   __________ %   __________ %   __________ %

Please do not turn to the next page
until instructed to do so.

Imagine the following situation…

Sometime next June, the weather forecast for Saturday is perfect so you begin planning a day trip to enjoy your favorite lake recreation activity.

One option is to visit a lake whose water quality is best described as FAIR (using the profiles on the previous pages). It is a 15-minute drive from your home.

A second option is to visit a lake that is almost identical to the first option, <u>except</u> its water quality is best described as VERY GOOD. It is also a longer drive from your home.

If these were your only 2 options, what is the <u>farthest</u> you would be willing to drive to visit the lake with VERY GOOD water quality instead of the lake with FAIR water quality?

What if the second option was a lake with GOOD water quality. What is the <u>farthest</u> you would be willing to drive to visit the lake with GOOD water quality instead of the lake with FAIR water quality?

December 29, 2008

TO: George and Carol

FROM: Dan

SUB: Focus group report

Via this memo I'll try to summarize some of what we learned from the focus group. I'll reference Carol's notes as well, and will include some comments regarding ramifications for our survey design. This document, once you both read and edit as you see fit, can serve as the focus group report. I'll organize my comments by pages in the focus group handout.

<u>Introduction</u>

To start George asked the participants to go around and say their names, and how they've typically used lakes and reservoirs. My sense from this was that:

- The main uses among these people were non-contact, including lots of trail walking and riding, being outside near water.
- There were fewer anglers than I might have expected. Perhaps not the types to respond to focus group recruiting?
- Swimming was mentioned but was not a major activity.

The ramifications of this for our survey is that we will need to make the exercises (and water quality descriptions) salient for both contact and non-contact visitors.

<u>Things you look for</u>

We asked people to list and discuss things they looked for or avoided in a lake recreation site. From my notes here is what was mentioned:

- Walking trails
- Activity support (paddle boat rental, canoe rental, boat facilities)
- Easy access (don't have to drive far)
- Clean and neat: no trash, clean facilities, nice scenery.
- facilities: benches, rest rooms
- quiet, not crowded. Avoid places that are crowded, or have picnic and other facilities near noisy (boat launching) areas.
- Lack of pollution (but was referring to trash and near shore appearance as much as water quality).

I took from this that people look for facilities and amenities, broadly defined to include: things supporting user activities, and an ambience that allows one to feel a 'nature' experience that is not too far from home. In my notes I wrote that few people volunteered water quality as a high priority without prompting. This means our survey will need to direct people to consider how water quality matters in a more general, implicit sense? A holistic sense that merges in with the ambience and nature experience stuff I thought we were hearing?

Perceptions of clean and dirty lakes

We asked people to list things they associate with cleaner and dirtier lakes. Here are some of the things that came up in the *cleaner* discussion:

- more fish and wildlife
- clearer water
- Live trees, more healthy looking vegetation
- Better smells - fresh smelling, feeling
- A fresh feeling

The *dirtier* discussion yielded things that were the mirror of the clear descriptors:

- stagnant
- bad smell
- dead fish
- low water levels

One person noted that low water level makes things seem dirty, since you can see a lot sticking out that you would not when the water is high. In my notes I jotted that all of these reactions are very sensory - see, smell, feel. Perhaps no surprise, but we will need to link our descriptions to perceptible concepts. Carol noted that people seemed to have a hard time coming up with words, and that one person mentioned bacteria. Perceptions related to bacteria might be a can of worms for us - need to make sure our descriptions do not head in that direction.

Rate a picture for quality

We asked people to study a single picture of a lake landscape (there were five varieties) and rate the water quality as very poor,...,very good. We varied the color schemes to check their perceptions. The sheets from the focus group will hold the actual ratings matched to the actual lakes. We also asked people to note how common they thought the lake was in NC. Some notes on what they looked for included:

- looked for a lack of shadows as indicator of a lack of water clarity
- seeing ducks in the picture meant good quality (or not bad) - ducks would not use it if it were bad quality

I had a hard time summarizing what we learned from this, other than that color and visual cues matter. But did we get a systematic sense of how things matter?

From the 'common in NC' part of the exercise I heard the following comments:

- never seen crystal clear lakes in NC

- lakes 'pretty good' in NC
- there is variability across space and time - different seasons, different look and feel. Western part of state - clearer.
- Lakes seemed uncommon due to lack of facilities
- Opinions influenced by recent drought and how bad things looked over the summer.

People seemed to be stressing *variability* here. That is, conditions and the perceptions they provide will be different at different times of year and different parts of the state.

Rating clarity

We asked people to try to rate clarity by deciding how deep one should be able to see a white plate for poor, fair, good clarity. There was some discussion about where one might 'take the reading'. In a boat in the middle? From shore or a pier? Again, space matters and things are not perceived as static. People also found this to be a hard question. Here are some of my notes on the responses:

- people giving *poor* comments said 1-3 feet; one said 5 feet.
- people giving *fair* comments were all over the map - 2-4 feet, 5-8 feet, 3-6 feet, 1-2 feet.
- I did not have note on *good*, though I think I remember someone saying 8 feet.
- Falls lake resident judges by how far one can see boulders down in water
- One participant noted boat oil slicks and speculated such pollution might be bad for fish.

People said this was a hard question and wondered if there was another way to describe clarity. How far one can see a fishing lure? People also had a hard time answering the clarity in NC component. They noted the variability having to do with space and precipitation and said it was hard to generalize. From this exercise I concluded that clarity matters, but that peoples' perceptions of how clarity maps to good vs. bad quality are not very resolute.

Discussing odors

We asked people to think about odors they might have experienced at a lake. First we asked how frequently they've noticed something. People answered with: rarely and sometimes. I sensed that people did not think of noticing smells as super common. We then asked people to list words they associate with bad smells at poor or fair water quality:

- foul, rotten, fishy
- rancid, putrid (noticed when driving by more so than when visiting)
- unpleasant

Some mentioned good smell descriptions:

- fresh, crisp, not overpowered by an odor

People also seemed to suggest bad smells come and go - not always there or always not there. From this I take that smell might be a useful descriptor but that it will only be an occasional thing associated with poor water quality. To link smell to better water quality we might want to use positive words linking to a pleasant ambient nature experience.

Fish in the water

We asked people to associate types and abundance of fish they might find in poor, fair, good waters. Here are some of the comments:

- *poor* water includes carp, catfish, bottom feeders (I would call these rough fish though this word did not come up)
- *fair* water includes catfish, bass, pan fish (bluegills, crappies, etc), perch. There will be some pan fish in fair but more in good water.
- *good* water includes bass and trout.

People found this to be a hard question, but I think there is useful information here in that there is a natural progression of species - arguably from less to more valuable - associated with poor to good water quality. We should fact check some of this with a freshwater fish biologist here on campus.

Algal bloom, algal mat

We asked people to first examine a photo of an algal bloom and comment on its commonness. We then asked people to do the same for an algal mat (a thicker buildup). Most people suggested algal blooms are *somewhat uncommon* in NC lakes. Comments included:

- not often, only locally in lakes (i.e. does not cover entire surface)
- people associate this with smallish ponds
- One person did say somewhat common.
- People noted that is signals something is bad - 'turn and leave'.
- Would not eat fish or swim
- Don't know if it is safe or not for humans but looks gross, kills fish, deplete oxygen
- might smell bad

I took from the bloom comments that people agreed one might see this, but that not many had had actual experiences evaluating something like a bloom. It is a realistic, believable visual cue that something is not quite correct. People seemed to note as well the spatial aspect - no everywhere, perhaps only in shallow areas.

On the mat photo people seemed less familiar with the concept. Most rated it uncommon, and associated mats with stagnant water. Someone noted that it seems like something that might occur further south, in LA. I would speculate from this that using the mat concept to describe NC water quality might be too far outside of people's experience or believability range to be effective.

Bundled descriptions

We asked people to examine five bundled descriptions of lakes, with attributes describing clarity, odor, fish, and algae. We also included a picture with varying colors (brown/green to blue), and they were labeled very poor up to very good. People were to estimate the percentage of lakes in NC that would fall into each category. We noticed that, without prompting, people might have just used the labels rather than carefully read the descriptions. We first asked for reactions to the descriptions:

- each seemed like a place they could experience in the state. But perhaps have not seen a place with no fish, or a lake so blue.
- but could not think of specific places that might fit it.
- Someone thought that color and odor might not be so linearly associated.
- Someone used a scuba diving analogy - where one might go for scuba practice (?).
- Ideas of other drivers - land use, time of year, precipitation - came up.

People were getting tired by the time this question came up. I think the descriptions passed the laugh test but it is hard to conclude more from the comments. Odor might be too much of a distraction to dwell on in the survey (or did we just dwell too much on it). The themes of variability over time and due to changing conditions comes up a lot and will need to be dealt with in our descriptions of attributes.

State behavior question

We asked people to trade off distance for quality hypothetically. In general people were willing to drive further to improve water quality. People volunteered 30-45, 30-35, 45-60, 2 hours to improve from *fair* to *very good* water quality. It seems too that activities matter: would go further for contact activity, less so for non-contact. Would go further for child to swim. Time onsite matters - worth it for a whole day, less so for an 'outing'.

Some of Carol's general observations

- To describe clarity, use pier or on a boat in middle of the lake. Use metaphor of when a lure disappears?
- Big difference between contact users and people who live on lake vs. non-contact users.
- Water quality affects activity people are willing to do in the lake. Maybe we should ask about what activities they are willing to do in different water qualities?
- People would not have read details of the descriptions (attribute levels) if George had not asked them to – how should we use labels like fair, poor, etc. and still get people to pay attention to individual attributes?
- Odor seem to be separable form the other attributes

PLEASE WRITE YOUR FIRST NAME HERE:

____

Thank you for participating in this discussion group.

Please do not open this booklet until instructed to do so.

There are many different lakes and reservoirs in central Virginia (between the Blue Ridge Mountains and the Coast) that are within driving distance from your home and that you can easily visit on a day trip.

What are the main things you consider when choosing which of these lakes to visit on a day trip?

I am <u>more</u> likely to visit a lake if it is/has…(LIST 4 THINGS)……….

1. ____
2. ____
3. ____
4. ____

I am <u>less</u> likely to visit a lake if it is/has……(LIST 4 THINGS)……….

1. ____
2. ____
3. ____
4. ____

Please do not turn to the next page until instructed to do so.

Some of the lakes and reservoirs in central Virginia have cleaner water than others in the state.

What words would you use to describe the water in cleaner or dirtier lakes?

**The water in <u>cleaner</u> lakes is more likely to be (or to have) …..
(LIST 4 THINGS)……….**

1. ____
2. ____
3. ____
4. ____

**The water in <u>dirtier</u> lakes is more likely to be (or to have) …..
(LIST 4 THINGS)……….**

1. ____
2. ____
3. ____
4. ____

Please do not turn to the next page until instructed to do so.

Nitrogen, Phosphorus, and Lake Water Quality

Nitrogen and phosphorus are naturally occurring chemicals in the environment. They are essential for plant and animal growth and for healthy ecosystems. But, when lakes receive too much nitrogen or phosphorus, they can also cause water quality problems.

The oversupply of these chemicals can come from several man-made sources such as fertilizers, water treatment plants, septic tanks, and even air pollution from cars, power plants, and farms.

When a lake receives too much nitrogen or phosphorus, it changes how the water looks and sometimes smells. It makes it harder for many animal and plant species to live and grow. But, only in the worst cases do these conditions sometimes cause health problems for humans.

The next pages describe in more detail how lake waters can be affected by too much nitrogen or phosphorus.

Lake water color

Too much nitrogen or phosphorus entering a lake can cause changes that give it more of a green color than it would otherwise have.

Circle the lake whose color is closest to what you have seen in most lakes in your area?

Please do not turn to the next page until instructed to do so.

Water clarity

Too much nitrogen or phosphorus can cause changes that make lake water less clear. One way to measure clarity is by how deep you can see into the water. For example, if you were fishing from a pier by dropping your line straight down into the water, how deep would your lure go before it disappeared from sight?

Which of the following categories best describes the water clarity you have seen in most lakes in your area?

___ You can see at most 1 foot deep into the water
___ You can see 1 to 2 feet deep into the water
___ You can see 2 to 5 feet deep into the water
___ You can see 5 to 8 feet deep into the water
___ You can see more than 8 feet deep into the water

Please do not turn to the next page until instructed to do so.

Unpleasant Odor

Too much nitrogen or phosphorus can cause changes that sometime give lakes an unpleasant odor, like the smell of decaying leaves or plants.

Which of the following unpleasant odor conditions would you most expect to find in lakes in your area?

__ strong odor, several times a year
__ noticeable odor, several times a year
__ noticeable odor, 2 or 3 times a year
__ faint odor, 1 or 2 times a year
__ none

Please do not turn to the next page until instructed to do so.

Fish Habitat

Too much nitrogen or phosphorus can cause changes in a lake's environment, which make it difficult for some fish to grow, reproduce, or survive. While some "rough fish" like carp and bullhead catfish are more able to tolerate these conditions, most "game fish" like bass, crappie, bluegill and channel catfish are less abundant in lakes with high nitrogen or phosphorus inputs.

Which of the following fish habitat conditions would you most expect to find in lakes in your area?

__ very few fish present
__ a few rough fish but no game fish present
__ many rough fish and a few game fish present
__ many game fish and a few rough fish present
__ abundant game fish and very few rough fish present

Please do not turn to the next page until instructed to do so.

Algae

Too much nitrogen and phosphorus can also cause algae to grow and multiply at a very fast rate, leading to algae “blooms” like the one show in the picture below.

Which of the following algae bloom conditions would you most expect to find in lakes in your area?

__ large areas of algae occur every year and last several weeks
__ small areas of algae occur every year and last several days
__ small areas of algae occur most years and last a few days
__ small areas of algae occur in some years and last a few days
__ algae blooms never occur

Please do not turn to the next page until instructed to do so.

Depending on how much excess nitrogen and phosphorus they receive, lakes in central Virginia generally fall into the 5 following categories:

	A	B	C	D	E
COLOR	Green 	Brownish Green 	Bluish Brown 	Brownish Blue 	Blue 
CLARITY	Can see at most 1 foot deep	Can see 1–2 feet deep	Can see 2–5 feet deep	Can see 5–8 feet deep	Can see more than 8 feet deep
ODOR	Strong unpleasant odor, several times a year	Noticeable unpleasant odor, several times a year	Noticeable unpleasant odor, 2-3 times a year	Faint unpleasant odor, 1-2 times a year	No unpleasant odors
FISH	Very few fish	A few rough fish No game fish	Many rough fish A few game fish	Many game fish A few rough fish	Abundant game fish Very few rough fish
ALGAE BLOOMS	Large areas occur every year, last several weeks	Small areas occur every year, last several days	Small areas occur most years, last a few days	Small areas occur some years, last a few days	Never occur

Based on your own experience, put a "1" under the lake category that you believe is most common in central Virginia. Then put a "2" under the category that is the next most common, and a "3" under the next, etc.

__________ __________ __________ __________ __________

Imagine the following situation…

Sometime next summer, the weather forecast for Saturday is perfect so you begin planning a day trip to enjoy your favorite lake recreation activity. What activity would that most likely be?

____

Imagine that your <u>only</u> two options are to visit Lake 1 or to visit Lake 2.

The <u>only</u> differences between these two lakes are shown in the table below. They are exactly the same in every other respect.

Circle the lake that you would be most likely to visit on this day trip?

		LAKE 1	**LAKE 2**
WATER QUALITY	COLOR	Bluish Brown 	Brownish Blue 
	CLARITY	Can see 2–5 feet deep	Can see 5–8 feet deep
	ODOR	Noticeable unpleasant odor, 2-3 times a year	Faint unpleasant odor, 1-2 times a year
	FISH	Many rough fish A few game fish	Many game fish A few rough fish
	ALGAE	Small areas occur most years, last a few days	Small areas occur some years last a few days
DISTANCE FROM YOUR HOME		30 minute drive	60 minute drive

Please do not turn to the next page until instructed to do so.

Now imagine instead that your __only__ two options are to visit Lake 3 or to visit Lake 4.

The __only__ differences between these two lakes are shown in the table below. They are exactly the same in every other respect.

Circle the lake that you would be most likely to visit on this day trip?

		LAKE 3	**LAKE 4**
WATER QUALITY	COLOR	Bluish Brown 	Blue 
	CLARITY	Can see 2–5 feet deep	Can see more than 8 feet deep
	ODOR	Noticeable unpleasant odor, 2-3 times a year	No unpleasant odors
	FISH	Many rough fish A few game fish	Abundant game fish Very few rough fish
	ALGAE	Small areas occur most years, last a few days	Never occur
DISTANCE FROM YOUR HOME		20 minute drive	120 minute (2 hour) drive

February 26, 2009

TO: George and Carol

FROM: Dan

SUB: Focus group 2 report

With this memo I will summarize what (I think) we learned via focus group 2, held in Richmond on February 24. Recall that our objective was to continue refining our attribute communication strategies, and to begin scoping out how the conjoint questions will look. I've included George's focus group document at the end of this memo. As previously I'll organize my comments by sections of the focus group document and discussion.

Introduction:

The introduction solicited participants' experience with lake recreation. This group was quite different than our first group, in that they had more on-lake/contact experience, with fewer 'walk around the little lake' types. People reported activities that included fishing, boating, water skiing, swimming, using a jet ski, and sailing. Participants took trips with their families, many had kids, and one went for weekends with him motor home. My impression was that the group was quite experience, knowledgeable, and talkative. Many of them had been to multiple lakes in the area, and took multiple trips per season.

More/Less Likely to Visit a Lake If:

Was with the last focus group we began with a discussion on what people look for in a lake to visit. Most of the expected stuff quickly came up:

- Fishing pier
- restrooms, changing areas
- Ramp for boat launching
- Facilities for snacks and supplies, restaurant
- beach
- clean water/ not polluted
- avoid crowds
- avoid place where it is not same to go in the water: debris, evidence of runoff

Pollution themes came up pretty quickly without prompting. I had the impression that 'cleanliness and safeness' were on people's radar screen. Nobody seemed to balk at the idea that this would be among the decision criteria. I concluded from this - as in the first focus group - that cleanliness is among the criteria that people consider, though perhaps not first and perhaps more implicitly than explicitly.

Describing Clean vs. Dirty Lakes:

People listed out criteria they thought were associated with clean vs. dirty. There were not many surprises in that participants again focused on visible and sensory cues. Some examples of things that came up include:

- No visible contributing pipes, sources
- Well placed and sanitary restrooms (?)
- 'healthier' looking plant/animal populations, prettier or more attractive surroundings.
- Less development on and nearby is better
- scum on surface and dead fish floating bad
- color, look, and smell are general cues
- clarity is a good indicator of cleanliness

I took from this discussion that, again, sensory features are how people construct their subjective beliefs on water quality. I found the discussion encouraging in that many of the features we were planning to introduce as quality distinguishers were anticipated (i.e. clarity, water color, surface scum, wildlife populations).

Pollution Description:

We did not spend much time on the pollution description page, and there was little volunteered discussion. While one participant was unaware of testing in general, others seemed to accept as common sense the role of nutrients from common sources as pollutants. The health aspect did not seem to generate controversy or disagreement. I took from the ho-hum response that this is pretty benign - a (hopefully clear) statement of non-controversial fact. I would still like to examine some wording, perhaps shortening where possible.

Color Ranking:

With the color ranking exercise we moved towards evaluating people's response to our communication of quality levels through different attributes. There seemed to be some rejection of our color schemes - particularly as regards the lowest quality, which people thought was non-credibly brown. I sensed there was some acceptance of the others, though perhaps with some skepticism. A few notes and thoughts related to this discussion:

- Many said things like 'I've never seen water that color'. Does this mean they are selecting places that are better, or they don't believe it can exist.
- As I will return to below, we have proceeded assuming we needed to differentiated every attribute across all five quality levels. Perhaps we should soften the extremes by spreading only three attribute levels over the five quality categories - particularly for the ones using pictures, since these seem to distract a bit. More on this later.

Conclusion on the color differentiating pictures? I think the jury is still out on how to best deploy them. I will be interested in how the Melissa-experts respond.

Water Clarity:

The discussion here followed a pattern somewhat similar to the first focus group. People accepted the notion that clarity varies, and that it was better to have clearer water. Most people placed the clarity of the lakes they are familiar with at 2-5 feet, perhaps tending a bit less. Two points from the discussion seem relevant:

- There was discussion of variability - clarity perception varies depending on sun vs. shade, deep vs. shallow, position on the lake, season. This s the temporal and spatial variability aspect that has come up with other attributes as well. I'd like to explicitly consider wording that allows people to feel comfortable with variation while still getting them to think about an average.
- One and perhaps several people rejected the notion of 8 feet of clarity at the top quality level. This is another spot where we might consider softening the extremes.
- People commented on geographical variability - i.e. clearer in the west, less so in the piedmont. This suggests people do accept the notion that this attribute can and does vary.

Odor

I found the discussion on this attribute a little disjointed. I'll list a few things from my notes, and will then to try summarize an impression:

- There was less willingness in this focus group to say they had noticed unpleasant odors.
- There was agreement on 'normal crick smells', but less readiness to say this was pollution-related.
- People did agree that drought conditions can lead to unpleasant smells - i.e. the dried up areas, exposed and rotting vegetation can cause smells. Pollution related?
- Most agreed that an unpleasant odor would signal lower water quality - but they said it was not a big deal at places they go.

I think there is some selection going on here, in that people are not going to (and hence do not experience) lakes with this problem. The task for us is to figure out if the idea of an unpleasant odor as a quality reflection is credible. There did seem to be some scenario rejection on some of the wording used to describe odor - i.e. strong, noticeable. We'll need to soften some of our wording (perhaps) to reflect the less emphasis people place on this.

Fish Habitat:

Several people in the group had fishing experience, and I think some of them interpreted this discussion as one of fish catch rate as opposed to population existence and size (one mentioned things depending on skill level). A few relevant points:

- Most seemed to say the lakes they were familiar with held many game fish and some rough fish.
- The fishermen are going to the lakes to catch fish - so there is a selection affect in their answers.
- Some noted that good fishing need not like up perfectly with good water quality. There was a

comment from someone that they would fish some places they would never swim. This, in some ways, might suggest a violation of our monotinicity assumption regarding the lineup of levels across attributes.

I felt like this discussion did not have much clarity or resolution. Was there scenario rejection regarding potential correlation between fish populations and pollution? A murkiness on game vs. rough fish? Too much fishing talk and not enough wildlife health talk?

<u>Algae:</u>

This too was something of a muddled discussion. People had a hard time saying 'my lake is like this' - i.e. they did not know how often it might bloom, though most had not experienced it at their lake. People did seem comfortable with the idea that it does happen. A few, perhaps expected, comments came up:

- size matters - probably see this more in smaller lakes
- the variability issue - might happen sometimes but don't see it, might happen some places on lake but not all over.
- Was there some rejection of this scenario too?
- There was the 'gambler' discussion. It was noted that, if it is only 3 days a year, perhaps one would hope not to bump into those three days?

NOTE: our discussion seemed to center a lot on the lakes they go to, which is perhaps a sensible difference from the first focus group, for which the participants were less experienced. When we saw mild scenario rejection was it due to them not having experience with conditions at *their* lakes (selection) or was it based on it being non-credible (a bigger problem)?

<u>Health and Nutrients:</u>

There was a brief discussion on peoples' perceptions of health effects and nutrient pollution. People basically used visual cues - if it was 'nasty' they assumed it was unsafe. I sensed a lot of common sense response on this. My impression was that it was consistent with the idea that vanilla-variety nutrient pollution was not a health threat, but when things got really bad you would not want contact.

<u>Impressions Upon Viewing Five Levels and Attributes:</u>

People seemed to accept the idea of ranking the lakes according to the five categories, after having been taken through the attributes one by one. One person noted that 'it was not hard to rank the lakes after having considered the attributes one by one' - or something to that effect. Most people chose lakes C and D as descriptive of lakes in the area. People seemed to think E was good, and that A was to bad - but here my notes are a bit incomplete. A few other points:

- People found the pictures more of a distraction than they were worth. They also thought the picture wording was a bit unclear and/or awkward.

- As noted, they seemed to agree we did 'teach' them about the attributes earlier, and that helped with this exercise.
- It was during this exercise that it occurred to me that all lake categories do not need to have separate levels for all the attributes - this can help address the implausibility of the extremes, and the fact that these categories are really more of continuum.

Tradeoff Questions:

Our goal here was to learn the extent to which distance/quality tradeoffs are realistic, how people react to the lake characterization, and what the role of activity on choices would be. We also wanted to scope a bit on the degree to which we need to identify other attributes - or do we just ask them to imagine them otherwise the same. Some points from my notes:

- People had an easy time saying what their activity would be - just based on experience
- People readily accepted distance/quality tradeoffs, but did not like the 2 hour choice - said it was not something they would consider.
- I sensed that people were OK imagining the lakes being 'otherwise similar'. This suggests we don't need a lot of attribute fill in? I don't have many notes on this discussion. Do you guys have any recollection?
- It seemed fishermen wanted to go where there was more fish, above other things. One woman noted that how far she would drive depended on whether her kids were with. Others noted that quality for swimming would matter differently than for other activities.
- There was some opt-out like discussion. Some people said that they might change the activity they would do, rather than drive further, given the water quality options. Based on this we (as a research team) discussed the degree to which we need to present activity-specific choices, rather than letting them strictly name the activity. I have a note too on threshold effects (this phrase was not used) - perhaps people will need a certain level of quality to consider doing an activity?

PLEASE WRITE YOUR FIRST NAME HERE:

____

Thank you for participating in this discussion group.

Please do not open this booklet until instructed to do so.

Nitrogen, Phosphorus, and Lake Water Quality

Nitrogen and phosphorus are naturally occurring substances. They are essential nutrients for plant and animal growth, and for a healthy environment. But, when lakes receive too much nitrogen or phosphorus, they can also cause water quality problems.

The oversupply of nitrogen and phosphorus can come from several man-made sources, such as too much fertilizer applied to farmland or lawns, outflows from water treatment plants, leaking septic tanks, and even air pollution from cars, power plants, and farms.

When a lake receives too much nitrogen or phosphorus, changes can occur. These changes can make the water look (and sometimes smell) different. The changes can also make it harder for some animals and plants to live and grow. But, only in the worst cases can these conditions sometimes cause health problems for humans.

The next pages describe in more detail how lake waters can be affected by too much nitrogen or phosphorus.

Please do not turn to the next page until instructed to do so.

Lake water color

Too much nitrogen or phosphorus entering a lake can cause changes that give it more of a green color than it would otherwise have.

Green

Brown/Green

Blue/Brown

Blue

Circle the lake whose color is closest to what you have seen in most lakes in your area.

Please do not turn to the next page until instructed to do so.

Water clarity

Too much nitrogen or phosphorus can cause changes that make lake water less clear. One way to measure water clarity is by how deep you can see into the water. For example, if you were fishing from a pier and dropped your line straight down into the water, how deep would your bait go before it disappeared from sight?

Which of the following categories best describes the water clarity you have seen in most lakes in your area?

___ You can see at most 1 foot deep into the water
___ You can see 1 to 2 feet deep into the water
___ You can see 2 to 5 feet deep into the water
___ You can see 5 feet or more deep into the water

Please do not turn to the next page until instructed to do so.

Fish Habitat

Too much nitrogen or phosphorus can cause changes in a lake's environment, which make it difficult for some fish to grow, reproduce, or survive. While some "rough fish" like carp and bullhead catfish are more able to tolerate these conditions, most "game fish" like bass, crappie, bluegill and channel catfish are less abundant in lakes with high nitrogen or phosphorus levels.

Which of the following fish types would you most expect to find in lakes in your area?

__ a few rough fish but no game fish
__ many rough fish and a few game fish
__ many game fish and a few rough fish
__ abundant game fish and a few rough fish

Please do not turn to the next page until instructed to do so.

<u>Algae</u>

Too much nitrogen and phosphorus can also cause algae to grow and multiply at a very fast rate, leading to algae "blooms" like the one shown in the picture below. These blooms mainly occur during the summer, when lake water is warmer, and especially in drier years. They are also more likely to occur in shallow water and in areas closer to where creeks or streams enter the lake.

Which of the following algae bloom conditions would you most expect to find in lakes in your area?

__ large amounts of thick algae appear near shore every year and last for most of the summer
__ large amounts of algae (see picture above) appear near shore about once a year and last for 2 to 3 weeks.
__ small amounts of algae appear near shore most years, and last for about 1 week
__ small amounts of algae appear near shore in some years, and last 1 to 2 days
__ algae blooms never occur

Please do not turn to the next page until instructed to do so.

Unpleasant Odor

Too much nitrogen or phosphorus can also cause changes the give lake water an unpleasant odor, like the smell of decaying leaves or plants. These odors often occur after algae blooms, as the algae die off.

Which of the following unpleasant odor conditions would you most expect to find in lakes in your area?

__ noticeable odor, several days a year
__ noticeable odor, 3 to 4 days a year
__ faint odor, 1 to 2 days a year
__ no unpleasant odor

Please do not turn to the next page until instructed to do so.

Depending on how much excess nitrogen and phosphorus they receive, lakes in North Carolina and South Carolina generally fall into the 5 following categories:

CATEGORY	A	B	C	D	E
COLOR	Green 	Brown/Green 	Brown/Green 	Blue/Brown 	Blue 
CLARITY	Can see at most 1 foot deep	Can see at most 1 foot deep	Can see 1-2 feet deep	Can see 2-5 feet deep	Can see 5 feet deep or more
FISH	A few rough fish but no game fish	A few rough fish but no game fish	Many rough fish and a few game fish	Many game fish and a few rough fish	Abundant game fish and a few rough fish
ALGAE BLOOMS	Large, thick areas near shore; every year, most of summer	Large areas near shore; once a year, 2-3 weeks	Small areas near shore; most years, 1 week	Small areas near shore; some years, 1-2 days	Never occur
ODOR	Noticeable odor, several.days a year	Noticeable odor, 3-4 days a year	Faint odor, 1-2 days a year	Faint odor, 1-2 days a year	No unpleasant odor

Based on your own experience, put a "1" under the lake category that you believe is most common in the Carolinas. Then put a "2" under the category that is the next most common, and a "3" under the next, etc.

__________ __________ __________ __________ __________

Please do not turn to the next page until instructed to do so.

Imagine the following situation…

Sometime next summer, the weather forecast for Saturday looks good so you begin planning a day trip to enjoy your favorite lake recreation activity. What activity would that most likely be?

____

Imagine that your <u>only</u> two options are to visit Lake 1 or to visit Lake 2.

The <u>only</u> differences between these two lakes are shown in the table below. Otherwise, they are exactly the same in every other way.

Circle the lake that you would be most likely to visit on this day trip?

		LAKE 1	**LAKE 2**
WATER QUALITY	CATEGORY	**C**	**D**
	COLOR	Brown/Green 	Blue/Brown 
	CLARITY	Can see 1-2 feet deep	Can see 2-5 feet deep
	FISH	Many rough fish and a few game fish	Many game fish and a few rough fish
	ALGAE	Small areas near shore; most years, 1 week	Small areas near shore; some years, 1-2 days
	ODOR	Faint odor, 1-2 days a year	Faint odor, 1-2 days a year
DISTANCE FROM YOUR HOME		30 minute drive	60 minute drive

Please do not turn to the next page until instructed to do so.

Now imagine instead that your only two options are to visit Lake 3 or to visit Lake 4.

The only differences between these two lakes are shown in the table below. Otherwise, they are exactly the same in every other way.

Circle the lake that you would be most likely to visit on this day trip?

		LAKE 3	**LAKE 4**
WATER QUALITY	CATEGORY	**C**	**B**
	COLOR	Brown/Green 	Brown/Green 
	CLARITY	Can see 1-2 feet deep	Can see at most 1 foot deep
	FISH	Many rough fish and a few game fish	A few rough fish but no game fish
	ALGAE	Small areas near shore; most years, 1 week	Large areas near shore; once a year, 2-3 weeks
	ODOR	Faint odor, 1-2 days a year	Noticeable odor, 3-4 days a year
DISTANCE FROM YOUR HOME		60 minute drive	15 minute drive

To: Dan, George and Roger
From: Carol
Date: 4/27/09
Re: Focus group #3 in Charlotte

This memo summarizes my notes from the third focus group held in Charlotte, NC, on April 21, 2009. It does not include a tabulation of the responses from the written exercises.

Introduction

The group consisted of 9 participants: 5 women and 4 men. Unlike previous focus groups, there were no avid fishermen in the group. One woman said she fished in NC lakes, but was not a serious angler. Most of the individuals mentioned some kind of contact recreation in lakes including boating, canoeing, water skiing, along with noncontact recreation such as picnicking, camping, and walking. One participant lived near a lake.

Pollution Description

- As a whole, the group did not seem too familiar with nitrogen and phosphorous, except the woman who used to work at a water quality testing lab. Some said they had heard of the pollutants or nutrient pollutants before.
- They thought that the nutrients would cause health problems (before reading our description)

Lake Color

- Blue or blue/brown most common
- "lakes around here seem pretty clean"
- "lakes look nice, it is the rivers that are all brown"

Water Clarity

- Asked about size of lakes, noted that larger lakes are cleaner and smaller lakes are yucky
- Many participants joked about a lake in Freedom Park that must be really gross

Carol: I wondered if there is some anchoring bias – few (or no) people put 5', but they did put 2-5'. They may just not pick the highest category – people do have trouble judging distance.

Fish Habitat

- The only angler selected the second highest level. She thought the word "abundant" in the highest level sounded like too many fish
- The angler had never heard of the terms game and rough fish, she had never caught any "bad" fish (rough)
- Several pointed out that they have bass fishing tournaments, so the lakes must support bass

Carol: It seemed to me that people looked confused about the relationship between water quality and the number of fish

<u>Algae</u>

- One person had seen algae on the right side of Lake Norman where the water stands
- Some had not heard of the term “algae bloom”
- Most didn’t seem to know that N and P caused algae to grow
- About half said they had seen something that looked like the picture
- Some said they would boat in the water in the picture if they didn’t have to touch the water
- Algae was “nasty, but not unhealthy”
- During drought, one person had been to Lake Lure and said the water level was way down but didn’t remember any algae

<u>Odor</u>

- Thought that odds you would go to the lake on the 1-2 days when smelled bad were very low
- No one had noticed odor at a lake
- They thought the descriptions sounded believable (Freedom Park lake smelled, but it was more of a pond)

Carol: I wonder if we should just get rid of odor? People in the focus groups don’t seem to notice it at lakes they go to, but it is a big negative when they answer the trade-off question

<u>All 5 categories</u>

- Most people thought that lakes were mostly B’s or A’s
- Almost people said B,A,C,D,E
- One respondent put A last – had never seen a blue lake
- Reasons B most common – based on Lake Wylie, B sounded good except didn’t know about fish
- Lake Phelps an A – sandy bottom, grassy, very clear
- Lakes at the coast might be C or D, murky and disgusting

Carol: In D vs. E – how does “several” differ from “3 ro4”?

<u>First Trade-off Question: B/60 min. drive vs. C/30 minute drive</u>

- Most chose B/60 min. drive over C/30 minute drive
- 30 minutes not so long
- If just in the middle of the lake and didn’t have to touch the bottom (assumed C had yucky bottom), then might choose C, but what about children who play in shallow area?
- 30 minutes made choice hard, but if you only did it once and awhile it would be worth the extra drive

- One person pointed out that they don't have the information we gave them, so she would probably go to the closer lake
- B sounds a lot cleaner
- If just an occasional trip and spend the whole day, then 60 minute drive okay
- Drive longer if going to the mountains for the weekend
- Limit: 60 or 90 minutes the limit
- How decide where to go?
    - One man just drives where his wife tells him
    - With kids and dog, no nasty water
    - For one person his decision wouldn't change if alone vs. with a group
    - One person said her husband would want to stay home instead of drive 1 hour with 4 kids in car
    - Want beauty, good water clarity – much more relaxing

Carol: I think people were viewing the longer drive as an infrequent trip, not where they would go most of the time. If usually went to the mountains for the weekend, hard to think about a day trip

<u>Second Trade-off: C/60 min. drive vs. D/15 min. drive</u>

- "Do we have to go?"
- One person chose D and 15 min. – if the lake was bad, he could just drive home, not that far
- 3 people said they would not go to either place

<u>CV on cleaning up lakes in the area baseline (p. 12)</u>

- Pie chart for baseline: Color differentiation between C,D,E not good, some wanted best counterclockwise to worst, others wanted the opposite
- Don't need arrows under pie chars
- Bar chart: most people liked the bar chart better for baseline

<u>Program Description (p. 13)</u>

- Cars, road run-off not on list
- Some thought might not be fair?
- Most had not heard of these types of programs for cleaning up water
- One person said they didn't want to take money from schools to clean water
- All thought that water treatment plants should already be doing everything they could to clean water – NOTE: we think they were confused between drinking water treatment and wastewater treatment plants

<u>Benefit with pie chart (p. 14)</u>

- What "program"?
- We should just do this?
- Wouldn't conditions get worse without the plan?
- Building around lakes will lower water quality
- Should include trend from past to now – forecast getting worse

Benefit with bar chart (p. 15)

- Like pie chart better for showing change
- Pie chart should include a key describing A to E, people might just think about color and forget other attributes

Cost and CV question (p. 16)

- Only 1 person voted "no"
- Not very much money
- Like that costs spread evenly
- Would costs change? What is timeframe for costs (how many years last)?
- Flat rate per household not fair – should be based on size of household
- Some people were thinking about drinking water (at least they said they were when prompted by George) – more expensive to treat drinking water if more nutrients
- Some felt that people who don't go to lakes won't care about water quality unless it affects their drinking water

Carol:

- *I think people just thought $90 not too much money and that there would be some benefit, I don't think they knew exactly how much benefit they were paying for (or cared)*
- *Description of benefits needs to be more specific*
- *Lots of discussion about costs for businesses vs. people – maybe more explicit text that the cost of things they buy will go up if businesses have to comply with rules?*
- *What about offering a behavioral alternative along with money – like not using fertilizer on your lawn?*
-

Appendix D: Peer Review Reports

Comments on Nutrient Reductions survey: Dr. Kevin Boyle

Overall

- Survey looks quite good, but still appears a little rough with some details not addressed.

Introductory

- Why are the demographic questions first?

- Why are there two forms of the education response categories?

- I'm assuming for the categorical demographic questions when it says to type in a number there is a panel of response categories that respondents will see. Why not just put in the categorical response categories?

- Why the fine breakdowns of household ages and why do the categories jump around and not go sequentially?

I focused on WQ5

- If I answer that I have not visited in the last 12 months and are unlikely to visit in the next year the survey stills asks me to categorize lakes without a don't know option. These respondents may really not know. Even though people can just click to respond, there may be some frustration if they cannot tell you that they don't know, and you will not be able to differentiate between people who don't know and just skip through this question.

- I have found that people do not always know what reservoirs are. Ponds are sometimes bigger than lakes. Why exclude ponds? Is it just small private impoundments that you want to exclude? If yes, why not just say this?

- "Either" in the last sentence of the second paragraph on the introductory page reads awkwardly and is not grammatically correct.

- I have found that people do not accept human activities that contribute nitrogen and phosphorus as naturally occurring. I think it would be good to say that there are naturally occurring p and n, <u>and</u> additional amounts come from human activities such as …

- People in Virginia are well aware, I think, of the contributions from animal agriculture. While farmers may consider this is a fertilizer I do not think the public does.

- Do the example species cover all of the major species people in the study states are likely to encounter? Are these example lists customized to the states? I think you might want to tell people what game and rough fish are beyond just examples. Most will probably know/understand game, but rough is not a common term in every day language. What if people know about one type of fish (e.g. game) but not the other (rough)? There is information to be learned, but you have forced them into the don't know category.

- The algae bloom question is also double barreled and forces me into the don't' know category. I know what the blooms look like, but do not know how long they occur.

- Odor also has this double-barreled response, odor and time.

- The five category question is difficult to pick one category if you have already indicated don't know on previous questions and respondents are now forced to provide a response when they may really not know.

- I was able to skip answering all of the individual quality questions until I get to the 5-catergory question. Since there are don't know options for each of the individual quality questions, I certainly would work on people to respond. I am not going to check this throughout the survey, but I see that this should be carefully checked for all questions.

- I also note that on questions that you ask people to answer if they click without responding, that it is possible to click a second time and move on without answering. Is this intended? E.g., on the 5 category you will not be able to differentiate between the don't knows, people who keep clicking to move on, and people who double click and skip by mistake.

- My experience is that color and clarity are not linked as you describe in the five category question. I have seen green lakes with varying clarity and the same for brown and blue lakes. So this classification seems a little odd – do you need to categorize by color?

- I am concerned that once people make a choice in the five categories you keep pushing them further – they may know first, but not second or first and second, but not third – this is a further problem of not giving a don't know option with this question.

- Having people select their favored activity may influence value estimates: 1) through favored activity and 2) perhaps missing an activity that a respondent participates in that is most affected by compromised water quality.

- How do you aggregate values that you estimate for a trip that is not representative and may be associated with the most frequent trips?

- I could also move forward without answering these questions on activity and participants. I could also enter a category of use that I never cited earlier in the survey on what I do on lakes.

- I have a problem with the choice question and the times of the unpleasant circumstances. For someone who is knowledgeable about the lake they visit, they will know when these bad days occur and you are left wondering if this nice day is supposed to be a bad day or a good day for water quality – the choice info is generic for a typical (?) year.

- Note, then survey allows me to proceed without answering the first choice question. If you want a forced choice here, this is a problem.

- In choice questions, some odor categories are missing a capital letter on the first word and have stray commas at the end.

- I think you should emphasize the A, B, C, D and E labels when you present the five categories. They are there but you do not mention them explicitly and they are subtly carried forward until they become explicit with the percentages.

- I would make the axis on the bar graph go to 100%.

- There is more than one state agency in Virginia involved in water quality – I would make it plural, agencies. Federal programs with the Chesapeake Bay are well known and have indirect benefits for lakes in the watershed.

- As I noted before, manure application has been a big issue in the news in Virginia and I do not think people will think this fits your category examples to reduce nitrogen and phosphorous run off.

- There are no grey bar graphs on my screen for the change – they show up as white and blue.

- I'm wondering if some respondents will have difficulty when you combine categories in your discussion, but put them in separately in the graphs. I think the text should follow the graph and not combine categories, X% in A and y% in B, the two best categories.

- The payment vehicle is for households, but the valuation question is individual, which do you want? Right now I think you will get a mix of assumptions in responses to the valuation question.

- I am also concerned that the payment vehicle seems a little mixed, e.g., renters who pay water bills would pay more for bills and rent. I think these needs to be cleaned up a bit.

- I think people should see the graph of change when answering the valuation question. They have had one slide between the graph and the valuation question, and I think it should be repeated here.

- I am not a fan of multiple bounded questions because of anchoring and the concerns psychologists have with how this affects respondent's attitudes toward the questions.

- I am always concerned with follow-up questions after CV questions because people have multiple reasons for answering, some of which appear valid and some of which do not. I prefer circle all that apply or rank them.

- I think that the contingent behavior questions will influence the responses to the CV question, particularly for heavy users. Why not randomize the order in the survey.

- Is it necessary that the screen for testing only shows to respondents or will this disappear in the final version?

Review of Phaneuf et al.'s "Water Recreation Survey"
John Whitehead, March 5, 2010

The survey is in excellent shape. I've made several comments on the survey itself (see PDF) but I avoided nitpicky comments about particular wording that are likely a function of researcher taste. My comments are focused on the contingent valuation scenario as the revealed preference and stated preference recreation questions seem fine as is.

1. Hypothetical Bias: the "cheap talk" text seems fine but I think it would also be useful to add a certainty-rating question as a follow-up to the "for" referendum votes. Hypothetical bias is a perplexing problem and most economists will want to see some recognition of it so I support the use of the cheap talk script (it can't hurt, can it?). However, my preference is to use certainty rating questions (e.g., "how certain are you about your positive answer to the CVM question?"). Responses are either quantitative (10 = very certain, …, 1 = not certain at all) or qualitative (very certain, somewhat certain, not certain at all). Blumenschein et al. (*Econ. J.*, 2008) find that certainty questions mitigate hypothetical bias while cheap talk does not. The complaint about certainty follow-up questions is that the adjustment process is ad-hoc, especially with quantitative response categories and no real willingness-to-pay value to compare. However, since certainty ratings are follow-up questions they can be ignored or used in sensitivity analysis (i.e., model 1 is the raw CVM responses, model 2 are only the very certain responses, etc). It can't hurt to add this question, can it?

2. Debriefing Questions: In terms of Dan's concern about the payment vehicle ("some prefer a very specific payment vehicle, while others are OK with the 'cost of living increase' that we've used") I say you can't win. Whatever you choose there will be a criticism. Therefore, your choice should be guided by what is most realistic and my feeling is that the cost of living increase is most realistic since there are a number of factors that would go into the cost increase (and you have described these well). I do have a suggestion that might help: include a payment vehicle-bid debriefing question: "How likely do you think it is that <u>your</u> cost of living will rise by $V? Do you think it is very likely, somewhat likely or not likely at all?" The responses to this question are very useful when understanding CVM responses (e.g., try splitting the sample based on likelihood of payment and you'll likely find a steeper bid function for those who think they would actually pay). Plus, when reviewers complain about the payment vehicle you can produce some evidence that respondents took it seriously (or not, and that is useful too).

   Also, it is a good idea to add a debriefing question to determine if respondents think that the quality improvement can be achieved: "How likely do you think it is that lakes in [home state] will improve to this level at the end of 10 years? Do you think that it is …?" Responses to this question help convince readers/reviewers that respondents found the scenario credible and help understand oddities such as lack of sensitivity to scope. Plus, this question makes respondents think a bit more about the magnitude of the quality change.

April 2012

User Manual for the
Water Quality Benefits Spreadsheet

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CONTENTS

SECTION 1
INTRODUCTION

The Water Quality Benefits Spreadsheet is the result of a project, funded by a grant from the U.S. Environmental Protection Agency Office of Water (Grant #X7-83381001-0), whose objective was to provide an integrated protocol for state water quality managers to use in setting numeric ambient nutrient pollution standards for surface water. The tool links measured nutrient pollution (e.g., ambient nitrogen, phosphorous) to a qualitative ranking of water quality and produces dollar-denominated benefits of nutrient reductions as they pertain to recreation services. Section 8 provides references for the two primary reports from the project that present details on the approach, the data, the analysis and the results. The Water Quality Benefits Spreadsheet uses the results from the project to create a tool that can be used to estimate the benefits of reducing nutrient pollution.

The study was conducted using water quality data from freshwater lakes in North Carolina and a survey of adults in Alabama, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia. Extrapolating the results from the Water Quality Benefits Spreadsheet beyond recreational use of freshwater lakes in the southeast is not recommended.

This document provides background information and instructions for using the Water Quality Benefits Spreadsheet to estimate the benefits of meeting a set of nutrient targets at a single lake undergoing policy analysis. Figure 1 outlines the general structure of the model. The user enters baseline water quality measures that are specific to the policy lake and sets the target or nutrient criteria, and the spreadsheet calculates the monetary values for the recreation benefits associated with the change from baseline water quality to the target water quality. The models underlying the spreadsheet calculations are described in the technical documents associated with the project (references are listed in Section 8). In this manual, Section 2 provides a description of the spreadsheet structure, Section 3 describes each of the necessary inputs, Section 4 explains how to run each model, and Section 5 explains the model outputs. In Sections 6 and 7, we provide more technical information on the computations that occur within the spreadsheet as well as example calculations.[1] Section 8 contains references for the project reports that provide the technical details underlying the Water Quality Benefits Spreadsheet.

[1] The workbook structure and underlying code are protected by a password. Users who wish access to the code should use the password “wq”.

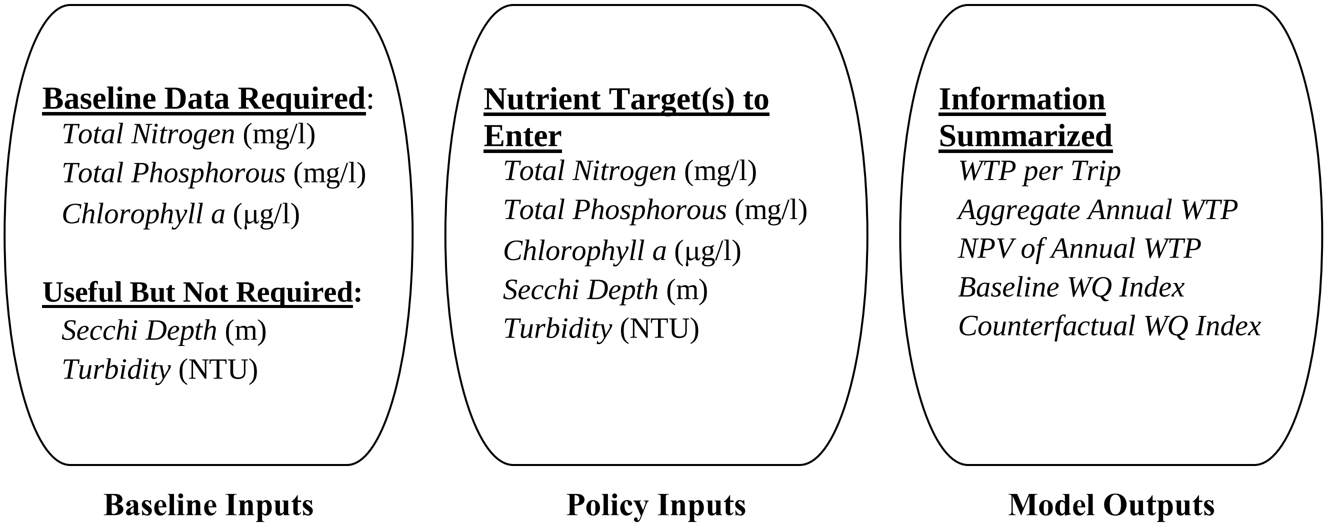

Figure 1. Water Quality Benefits Spreadsheet Overview

SECTION 2
WATER QUALITY BENEFITS SPREADSHEET STRUCTURE

The spreadsheet consists of six individual worksheets that together provide two ways of interacting with the model. The first three worksheets, labeled **Input Data**, **Output Table**, and **Chart,** comprise the *single input* version of the model. The single input version of the model uses mean values for the baseline water quality inputs to calculate the benefits of reaching the target over a designated length of time. The major assumptions used in the single input version of the model include the following:

- Baseline water quality is constant over the time period being evaluated.
- Trips to the lake are constant over the time period.
- Water quality improves to the target level immediately and stays at the target level for the entire time period.

The next three worksheets, labeled **Annual Input**, **Annual Output,** and **Annual Value Chart**, comprise the *multiple input* version of the model. The multiple input version of the model allows for more realism in how policies are defined. The user may vary the water quality baseline, targets, and other inputs annually over a designated number of years. With the multiple input version of the model, the user can

- enter new values for baseline water quality for each year (e.g., allowing baseline water quality to deteriorate over time),
- increase the number of trips to the lake over time as water quality improves, and
- enter intermediate targets for each year to account for interim benefits as water quality improves before reaching the final target.

SECTION 3
INPUTS

Both the single and multiple input versions of the model require similar inputs. In general, these inputs include

- water quality values that establish the baseline conditions at the lake;
- water quality values that establish the policy target—or counterfactual—conditions at the lake;
- an estimate of the annual number of recreation visits to the lake;
- the number of years over which the policy is to be evaluated; and
- a discount rate.

We describe each of these inputs in turn. Section 4 describes how to enter the inputs and run the model.

Baseline Water Quality

Our protocol defines baseline water quality using the ambient concentrations of five nutrient parameters: total nitrogen (TN, mg/l), total phosphorous (TP, mg/l), chlorophyll a (CLA, μg/l), Secchi depth (S, m), and turbidity (T, NTU). The user must have an estimate of baseline values for TN, TP, and CLA, measured in the units shown above. The model will impute values for S and T if needed, however measured values provided by the user will probably be more reliable.

The *single input* version of the model starts with the **Input Data** worksheet, where the user enters a single row of nutrient values according to the column headings. The single row might be based on the mean or median of several monitoring station readings or the output from a simulation model. The user must enter data for TN, TP, and CLA; entering data for S and T is optional but recommended. If data for S and/or T are not available, values will be imputed from the other parameters (see Section 6 of this manual for details on the imputation). After the model is executed, if there are imputed values for S and/or T, they are shown in red.

The *multiple input* version of the model allows the user to enter baseline data for multiple years, allowing the baseline to change (e.g., deteriorate or improve) in future years. Using the **Annual Input Data** worksheet, the user can enter different baseline values for TN, TP, and CLA (and S and T) for each year of the analysis. The row of values for each year is entered according to the year index in the time column. For example, if the user wants to analyze the benefits of a policy over the next 10 years, s/he can enter different values for TN, TP, and CLA (and S and T) as they are expected to evolve without a policy intervention. As in the single input case, the data are entered according to the column headings, and values for S and T are imputed if not provided.

Target (Counterfactual) Water Quality

The model estimates the benefits of achieving a particular set of nutrient criteria targets, which we refer to as the counterfactual nutrient values, relative to baseline levels. For the counterfactual nutrient values, the user must enter criteria s/he wants to evaluate. For both the single and multiple input versions, criteria can be entered in one of two ways:

- Evaluating criteria based on a target for a single parameter (e.g., a target value for CLA): Any one of the five water quality measures can be selected.
- Evaluating criteria based on a combination of multiple parameters (e.g., targets for both TN and TP concentrations): Any combination of two or more of the water quality measures can be selected.

Section 4 provides details on how the counterfactual values are entered.

Recreation Trips

The model estimates the benefits accruing to recreational users of the lake. The benefits to recreational users can come from the enhanced value of existing trips or from new trips that occur due to the improvement. The user needs to enter an estimate of the total annual visits to the lake that will occur once the target quality level is in place. If the user is uncertain about future visitation under improved water quality conditions, current visitation provides a conservative approximation of future visitation in these circumstances.

Timeframe and Discount Rate

Many policies have costs and benefits that unfold over multiple years. Typically, policy analysis evaluates the benefits and costs of a water quality target over a set number of years. The model allows a user to enter the number of years over which the benefits are to be evaluated. To calculate the net present value (NPV) of the benefits over time, a discount rate must be specified. The discount rate deflates the value of future dollars to make them comparable to current dollars. If the user wants to calculate the undiscounted value of benefits, the discount rate can be set to 0%.

SECTION 4
RUNNING THE WATER QUALITY BENEFITS SPREADSHEET

The single and multiple input versions of the model run in slightly different ways. We describe each model below.

Single Input Model

1. Enter a single row of baseline data for TN, TP, and CLA (and if possible S and T) into the **Input Data** worksheet following the column headings.

2. Click on the button "Launch Model" on the right-hand side of the worksheet. A box called **"Model Options"** will appear.

3. In the first column, the user enters the expected number of recreational trips per year to the lake under the improved (or counterfactual) water quality conditions. The user enters a single number is provided, which is assumed to hold for the entire time frame of the analysis. Next the user enters the number of years over which benefits are to be computed (and discounted), and finally, the user enters a discount rate (e.g., 3%). It is possible to enter zero for the discount rate.

4. In the second column, the user enters the target (or counterfactual) nutrient value(s). The form prompts the user for information on nutrient targets to be evaluated. The user indicates via a checked box the parameter(s) for which explicit numeric criteria will be entered and then enters the target value(s), measured in the units defined above. Parameters that do not have an explicit target value are then imputed from those that do. The imputation strategy is described in Section 6 of this manual. Once the model is executed, any imputed target values are shown in light grey on the form and red on the input worksheet. To erase the nutrient values and enter new values, click on "Reset Defaults" (found at the bottom of the Model Options box). After all inputs have been provided, the user clicks "Run" (found at the bottom of the Model Options box). The model will run and the worksheet labeled **Output Table** will open.

Multiple Input Model

1. All the input data for the multiple input model are entered in the **Annual Input Data** worksheet. The user can type the values for each column directly into the worksheet or copy data from another spreadsheet organized according to the headings in the first row. Column A lists the years over which the analysis takes place. The values for columns B through L can vary by year. Column B contains the number of recreational trips expected in each year. Columns C to G contain the baseline water quality measures for TP, TN, CHA, S, and T. As described above, values for TP, TN, and CHA must be entered, but S and T are optional. Once the model is executed, the imputed values for S and/or T are shown in the worksheet if not specified in the data. Columns H to L contain the target (counterfactual) values for at least one of the five water quality measures or some combination of two or more of the measures. Again the imputed values will be shown in the worksheet when the model is executed. Note

that the user does not provide a discount rate. The NPVs of the benefits at four discount rates (0%, 3%, 5%, and 7%) are provided as part of the output.

2. After all inputs have been provided, the user clicks “Launch Annual Model” (found on the right side of the worksheet). The model will run and the worksheet labeled “Annual Output” will open.

SECTION 5
OUTPUTS

The spreadsheet model provides four pieces of output information:

- a prediction for the baseline water quality index;
- a prediction for the improvement in the water quality index arising if the target (counterfactual) is met;
- point estimates for the recreation-based benefits of improving water quality from baseline to the target (counterfactual) level (per-trip, aggregate annual, and NPV for the annual and aggregate); and
- summaries of uncertainty associated with the benefit estimates.

The *single input* version of the model provides details for all of these, while the *multiple input* version focuses only on the annual and total benefits. We describe each of the outputs in turn.

Baseline and Counterfactual Water Quality Index

The modeling framework takes readings of TN, TP, CLA, S, and T and converts them to a single dimension ordinal index of eutrophication (described in detail in the project documents listed in Section 8). We defined five categories of lake water quality based on their nutrient status: A, B, C, D, and E, where A is the best quality and E is the worst quality. These are assigned the numbers A = 1, B = 2, ... , E = 5. Because the actual level of eutrophication for a particular lake will depend on other factors in addition to the five nutrients, an underlying statistical model predicts the probability that a lake with a specific set of nutrient values might fall into each of the five eutrophication categories. The statistical model estimates a continuous number contained in the (1,5) interval that provides an index of the baseline level of eutrophication for the lake. Likewise, the model uses the nutrient concentration targets provided by the user to compute the same index of the potential improvement in the water quality of the lake.

For the *single input* version of the model, the **Output Table** worksheet contains a summary of the results along with measures to characterize the uncertainty in the results. For each output, the rows provide the mean estimate, the standard deviation, the minimum, the 1st quartile (the 25th percentile), the median (the 50th percentile), the 3rd quartile (the 75th percentile), and the maximum (labels appear in column A). Columns B to K [labeled prob(1), ... ,prob(5)] report the estimated probability that a lake with the baseline nutrient levels entered by the user would fall into each of the five eutrophication categories. Column L contains the computed index of water quality for baseline conditions and, in column M, the index for the new, improved level arising from the nutrient criteria targets. Detailed summaries of the probabilities and indices are not provided in the output for the *multiple input* version of the model.

Estimates for Annual and Total Benefits

The Water Quality Benefits Spreadsheet uses an underlying economic model that computes the per-trip value of moving from the baseline to a proposed criteria-based value for the water quality index. The change in the water quality index, along with the numbers for the total annual trips feed into another statistical model that computes the annual aggregate benefits from the criteria under evaluation. The total benefits are computed for the user-defined benefits time frame and discount rate.

For the *single input* model, the **Output Table** worksheet contains a summary of the distributions for the per-trip value of the improvement (column N), as well as summaries for the annual aggregate benefits (column O) and total NPV of benefits (column P). The total NPV distribution is also shown graphically in the plot contained in the **Chart** worksheet.

For the *multiple input* model version, the worksheet **Annual Output** contains the benefit estimates. The distribution of the annual aggregate value of the benefits for each of the policy years is shown in columns B through H. Columns K to O show the distribution for the NPV using four different candidate discount rates.

Uncertainty Assessment

Estimates of water quality changes and economic benefits are subject to uncertainty from a number of sources including the baseline data, the functional form of the model, and the parameters. Some sources of uncertainty can be quantified, while others cannot. The uncertainty surrounding the underlying statistical and economic models that produce the water quality indices and per-trip values can be quantified to some degree. For the baseline probabilities, baseline and counterfactual water quality index, per trip value, annual value, and NPV, the standard deviations and order statistics (e.g., median, percentiles) shown in the **Output Table** and **Annual Output** worksheets reflect the uncertainty in the underlying statistical and economic models.

SECTION 6
TECHNICAL DETAILS

The spreadsheet has been programmed to implement a simple version of the Water Quality Benefits model in a way that does not require the user to engage with the technical details underlying the calculations. A full technical description of the protocol and its development can be found in the documents associated with the research project listed in Section 8. Here we provide a brief overview of the technical features of the spreadsheet.

Imputation

Computation of the baseline and target water quality indexes requires readings for TN, TP, CLA, S, and T. The baseline index computation uses the water quality data entered by the user. Because only TN, TP, and CLA are required, the program needs to be able to impute S and/or T when they are not provided. For this imputation, we use results from a collection of linear regressions. For S, the regressions are

$$\ln S = \beta_0 + \beta_1 \ln TN + \beta_2 \ln TP + \beta_3 \ln CLA + \varepsilon$$
$$\ln S = \beta_0 + \beta_1 \ln TN + \beta_2 \ln TP + \beta_3 \ln CLA + \beta_4 \ln T + \varepsilon$$

For T, the regressions are

$$\ln T = \delta_0 + \delta_1 \ln TN + \delta_2 \ln TP + \delta_3 \ln CLA + \varepsilon$$
$$\ln T = \delta_0 + \delta_1 \ln TN + \delta_2 \ln TP + \delta_3 \ln CLA + \delta_4 \ln S + \varepsilon$$

where β and δ are the estimated coefficients from the regressions and ε is the error term. We have estimated the β's and δ's in these four equations using a data set of water quality readings taken in reservoirs throughout the state of North Carolina. The equations are used to impute values for S and/or T using the values for the other water quality measures, with the particular equation(s) selected based on the configuration of data the user has provided. For example, if the user has provided measures for *TN*, *TP*, and *CLA*, imputations for *S* and *T* are computed as

$$\hat{S} = \exp\left(\hat{\beta}_0 + \hat{\beta}_1 \ln TN_u + \hat{\beta}_2 \ln TP_u + \hat{\beta}_3 \ln CLA_u + \sigma^2 / 2\right)$$

and

$$\hat{T} = \exp\left(\hat{\delta}_0 + \hat{\delta}_1 \ln TN_u + \hat{\delta}_2 \ln TP_u + \hat{\delta}_3 \ln CLA_u + \sigma^2 / 2\right)$$

respectively, where TN_u, TP_u, and CLA_u are the parameter values entered by the user, and σ is an estimate for the standard deviation of ε. Although this imputation capability is provided, we believe it will usually be best to use actual monitoring station readings (or a more lake-specific imputation approach) for specifying the baseline levels of turbidity and Secchi depth.

Similarly, target (or counterfactual) water quality criteria are imputed using the targets the user has entered. For this imputation, a large collection of regressions was estimated, which included all possible combinations of the water quality variables on the left- and right-hand sides:

$$
\begin{aligned}
\ln TN &= \gamma_0 + \gamma_1 \ln CLA + \varepsilon \\
\ln TP &= \gamma_0 + \gamma_1 \ln CLA + \varepsilon \\
\ln S &= \gamma_0 + \gamma_1 \ln CLA + \varepsilon \\
\ln T &= \gamma_0 + \gamma_1 \ln CLA + \varepsilon \\
\ln TP &= \gamma_0 + \gamma_1 \ln CLA + \gamma_2 TN + \varepsilon \\
\ln S &= \gamma_0 + \gamma_1 \ln CLA + \gamma_2 TN + \varepsilon \\
\ln T &= \gamma_0 + \gamma_1 \ln CLA + \gamma_2 TN + \varepsilon \\
\ln S &= \gamma_0 + \gamma_1 \ln CLA + \gamma_2 TN + \gamma_3 TP + \varepsilon \\
\ln T &= \gamma_0 + \gamma_1 \ln CLA + \gamma_2 TN + \gamma_3 TP + \varepsilon \\
&\vdots
\end{aligned}
$$

The many γs in these equations were estimated using the North Carolina water quality readings, and the results are coded into the model. Given the parameter(s) provided to define the counterfactual criteria and the baseline values, the program selects the appropriate equations and estimates, and uses them to impute the other counterfactual parameter values. For example, if the user provided values CLA_{cf} and TN_{cf} as the policy counterfactual, the remaining counterfactual pollution levels are computed as follows:

$$
\begin{aligned}
\hat{TP}_{cf} &= TP_b \times (CLA_{cf} / CLA_b)^{\gamma_1} \times (TN_{cf} / TN_b)^{\gamma_2} \\
\hat{S}_{cf} &= S_b \times (CLA_{cf} / CLA_b)^{\gamma_1} \times (TN_{cf} / TN_b)^{\gamma_2} \\
\hat{T}_{cf} &= T_b \times (CLA_{cf} / CLA_b)^{\gamma_1} \times (TN_{cf} / TN_b)^{\gamma_2},
\end{aligned}
$$

where the subscript *b*s are the baseline values for the pollutants. With these two steps all the water quality parameter values are available for use in the subsequent computations. Once again, it is preferable to use imputations for the missing criteria that are specific to the policy lake, if possible.

Predicting Index Values

The water quality index component of the spreadsheet uses the results of an expert elicitation framework to map values for TN, TP, CLA, S, and T into predictions for the water quality index.[1] In particular, as part of a larger project a sample of water quality experts reviewed different sets of readings for the five quality parameters and made a judgment on where a typical

[1] The expert elicitation method is summarized in the project documents.

lake producing these readings would fit in the qualitative A, ... ,E eutrophication scale. The resulting data were used to parameterize functions of the form $p_j = f(\text{TN},\text{TP},\text{CLA},\text{S},\text{T})$, where p_j is the probability that a lake with the given readings is of quality type j, for j = A, ... ,E. These functions are coded into the Water Quality Benefits Spreadsheet so that we can predict $p_A,...,p_E$ for any row of water quality parameter readings. With these, the index value is simply

$$I(TN,TP,CLA,S,T) = (1\times p_A) + (2\times p_B) + (3\times p_C) + (4\times p_D) + (5\times p_E).$$

Predicting Economic Values

The Water Quality Benefits Spreadsheet uses the results from an economic choice experiment survey to map values for I^0 and I^1—the predicted index values at baseline and counterfactual water quality levels—to an estimate of the dollar-valued benefits a recreation visitor to the lake would receive from the improvement. This takes the form of a function $g(I^0,I^1)$, which is coded into the spreadsheet. Thus, we can predict the per-trip value of any improvement from the baseline to the user-provided counterfactual.

Define the per-trip value by PTV. The annual value (AV) is simply PTV × T, where T is the number of trips to the lake expected per year. The total NPV of benefits for the counterfactual target is

$$TV = \sum_{t=1}^{years} \frac{AV}{(1+r)^t},$$

where r is a discount rate. Note that for $r > 0$ the contribution of AV to TV is smaller as we move further out in time. When $r = 0$ (i.e., we do not discount future benefits) the expression simplifies to TV = AV × years.

Quantifying Uncertainty

The functions $f(\cdot)$ and $g(\cdot)$ referred to above were estimated using a sample of lakes and the sample of survey respondents rather than entire populations. Thus, in standard statistical parlance, our estimates contain sampling error. We account for this by examining distributions for our estimates using bootstrapping, which provides distributions for the functions $f(\cdot)$ and $g(\cdot)$. We quantify the sampling error uncertainty in our estimates by computing predictions using a range of estimates for $f(\cdot)$ and $g(\cdot)$, all drawn from their underlying distribution.

SECTION 7
EXAMPLES

We present examples using both the single input and multiple input versions of the model.

Example 1: Single Input Version

Suppose baseline nutrient levels in a policy lake are summarized as follows:

TN	TP	CLA	S	T
1.052	0.109	44.813	0.708	13.870

Suppose as well that there are 900,000 recreation trips each year at this lake and that we want to evaluate a CLA standard of 40 µg/l over a 10-year time horizon using a 5% discount rate. The **Input Data** worksheet would appear as follows:

Lake Name	Total Nitrogen (mg/l)	Total Phosphorous (mg/l)	Chlorophyll a (ug/l)	Secchi Depth (m)	Turbidity (NTU)
Example Lake	1.051648026	0.108963455	44.81270492	0.71	13.87

Launch Model

To continue, the user clicks on the **Launch Model** button, which produces an editable form. The user enters the number of trips, discount rate, and the value of policy parameter(s) defining the standard and clicks on **run**. The worksheet **Output Table** will appear behind the form (which can be canceled away). An excerpt from the output showing the main policy information is provided here:

	Water Quality Index		WTP per Trip	Annual Aggregate WTP	Net Present Value (NPV)
	Baseline	Counterfactual			
Mean (Xbar)	4.03	3.89	$5.24	$4,714,761	**$36,406,135**
St. Dev (s)	0.04	0.04	$0.41	$369,148	**$2,850,463**
Min	3.90	3.78	$4.48	$4,033,291	**$31,144,003**
1st Quartile	4.00	3.87	$4.91	$4,419,731	**$34,127,990**
Median	4.03	3.89	$5.19	$4,673,987	**$36,091,291**
3rd Quartile	4.06	3.91	$5.54	$4,984,312	**$38,487,538**
Max	4.11	3.97	$6.47	$5,822,892	**$44,962,826**

Note that the baseline mean water quality index estimate is 4.03 and that it improves to 3.89 under the policy. This generates $5.24 in benefits per trip; the 10-year time frame and 5% discount rate lead to aggregate benefits of approximately $36.4 million.

If information on S and T were not available at the baseline, the **Input Data** worksheet would appear as shown here:

Lake Name	Total Nitrogen (mg/l)	Total Phosphorous (mg/l)	Chlorophyll a (ug/l)	Secchi Depth (m)	Turbidity (NTU)
Example Lake	1.051648026	0.108963455	44.81270492		

Launch Model

After launching the model, the user will see the imputed values for S and T appear in red upon returning to the input information:

Lake Name	Total Nitrogen (mg/l)	Total Phosphorous (mg/l)	Chlorophyll a (ug/l)	Secchi Depth (m)	Turbidity (NTU)
Example Lake	1.051648026	0.108963455	44.81270492	0.60	16.92

Launch Model

An excerpt from the **Output Table** given this change is:

	Water Quality Index		WTP per Trip	Annual Aggregate WTP	Net Present Value (NPV)
	Baseline	Counterfactual			
Mean (Xbar)	4.07	3.93	$4.97	$4,470,310	**$34,518,548**
St. Dev (s)	0.04	0.04	$0.40	$363,201	**$2,804,543**
Min	3.95	3.82	$4.11	$3,700,101	**$28,571,201**
1st Quartile	4.05	3.91	$4.70	$4,228,544	**$32,651,698**
Median	4.07	3.93	$4.94	$4,446,375	**$34,333,732**
3rd Quartile	4.10	3.96	$5.22	$4,701,586	**$36,304,397**
Max	4.16	4.02	$6.20	$5,583,131	**$43,111,461**

The differences in model outputs arise from the differences between the observed and imputed baseline water quality values.

Example 2: Multiple Input Version

Suppose current nutrient levels in a lake are measured as follows:

TN	**TP**	**CLA**	**S**	**T**
0.76	0.05	32.00	0.70	9.65

where these numbers are the medians of the quality reading distributions. For CLA the 75th percentile is 40 μg/l and the 90th percentile is 62 μg/l. Suppose as well that there are currently 500,000 recreation trips per year at this lake. Absent intervention, we expect median quality conditions will deteriorate 1% per year. We want to evaluate a CLA standard in which no more than 10% of readings are more than 40 μg/l; that is, we want to shift the distribution so that the 90th percentile is 40 μg/l. We estimate that the median of this shifted (counterfactual) distribution is 24 μg/l. We are interested in evaluating a 10-year program. For the first 5 years, we expect the median CLA will be 30 μg/l and that it will reach its policy goal of 24 μg/l in Year 6.

To evaluate this scenario, we set the *baseline* columns of the **Annual Input Data** worksheet as shown here:

Year	Trips	Baseline				
		Total Nitrogen (mg/l)	Total Phosphorus (mg/l)	Chlorophyll a (ug/l)	Secchi Depth (m)	Turbidity (NTU)
1	500000	0.76	0.05	32.00	0.70	9.65
2	500000	0.77	0.05	32.32	0.69	9.75
3	500000	0.78	0.05	32.64	0.69	9.84
4	500000	0.78	0.05	32.97	0.68	9.94
5	500000	0.79	0.05	33.30	0.67	10.04
6	500000	0.80	0.05	33.63	0.67	10.14
7	500000	0.81	0.05	33.97	0.66	10.24
8	500000	0.81	0.05	34.31	0.65	10.35
9	500000	0.82	0.05	34.65	0.65	10.45
10	500000	0.83	0.05	35.00	0.64	10.55

We set the counterfactual columns as indicated below:

Counterfactual				
Total Nitrogen (mg/l)	Total Phosphorus (mg/l)	Chlorophyll a (ug/l)	Secchi Depth (m)	Turbidity (NTU)
		30		
		30		
		30		
		30		
		30		
		24		
		24		
		24		
		24		
		24		

To run the model, we click on the **Launch Annual Model** button. The **Annual Output** worksheet will appear. An excerpt from this page is shown here:

	NPV					
Discount Rate	Mean (Xbar)	Min	1st Quartile	Median	3rd Quartile	Max
0%	$59,860,806	$4,041,694	$51,782,220	$56,995,950	$59,937,098	$63,306,303
3%	$48,648,881	$3,286,466	$42,082,567	$46,317,401	$48,711,483	$51,450,398
5%	$42,627,188	$2,880,769	$36,873,124	$40,582,311	$42,682,331	$45,082,896
7%	$37,527,646	$2,537,141	$32,461,474	$35,725,584	$37,576,408	$39,690,531

The distribution of the total NPV is shown in the table, broken out by commonly used discount rates. For a 5% discount rate, the median estimate is approximately $40.6 million. By returning to the **Annual Input Data** page, the user can view the imputed counterfactual values in red:

Counterfactual				
Total Nitrogen (mg/l)	Total Phosphorus (mg/l)	Chlorophyll a (ug/l)	Secchi Depth (m)	Turbidity (NTU)
0.75	0.05	30	0.72	9.4
0.75	0.05	30	0.71	9.45
0.76	0.05	30	0.71	9.51
0.76	0.05	30	0.7	9.57
0.77	0.05	30	0.7	9.62
0.72	0.05	24	0.75	8.84
0.73	0.05	24	0.74	8.89
0.73	0.05	24	0.74	8.94
0.74	0.05	24	0.73	9
0.74	0.05	24	0.73	9.05

SECTION 8
PROJECT DOCUMENTS

This project was funded by a grant from the U.S. Environmental Protection Agency Office of Water (Grant #X7-83381001-0). We produced two reports to document the research project and the results. The first report describes the water quality data, the expert elicitation process and the models used link the water quality readings to the qualitative eutrophication index. The second report describes the survey used to value changes in the water quality and the analysis of the survey data. The data and results contained in these two reports are the basis for the Water Quality Benefits Spreadsheet. The documents can be found on the EPA website or they are available from the lead author, Dr. Phaneuf.

Phaneuf, D. J., M. Kenney, and K. Reckhow. *Measuring Nutrient Reduction Benefits for Policy Analysis Using Linked Non-Market Valuation and Environmental Assessment Models—An Interim Report on Water Quality Modeling*, EPA Project Report, 2010.

Phaneuf, D. J., C. Mansfield, G. Van Houtven, and R. von Haefen. *Measuring Nutrient Reduction Benefits for Policy Analysis Using Linked Non-market Valuation and Environmental Assessment Models: Final Report on Stated Preference Surveys*, EPA Project Report, 2013.

U.S. Environmental Protection Agency (EPA), Office of Water. 2007. "FY2007 Nutrient Benefits Valuation" Request for proposals.

Appendix F: State do file

```
clear
set memory 500m
capture log close

********************************************
* Do file to accompany survey report
* Prepared by Dan Phaneuf
* Updated 15 August 2011
********************************************

log using survey_report.out, text replace

* load in raw data
use final_survey

*************************************
* some survey version summaries and
* housekeeping
*************************************
gen wq3     = 0
replace wq3 = 1 if wqversion == 1

rename ppstaten homestate
gen str2 hstate = "NC" if homestate == 56
replace hstate = "VA" if homestate == 54
replace hstate = "SC" if homestate == 57
replace hstate = "GA" if homestate == 58
replace hstate = "KY" if homestate == 61
replace hstate = "TN" if homestate == 62
replace hstate = "AL" if homestate == 63
replace hstate = "MS" if homestate == 64

* Produce summary for Table 5
tab hstate
tab wqversion
tab conjversion
tab abversion

*************************************
* some basic socio-economic summaries
*************************************
rename ppage    age
rename ppincimp inc
rename ppeduc   education
rename ppethm   race
rename pphhsize hhsize
rename ppgender gender

gen male = 0
replace male = 1 if gender == 1

gen income = 0
replace income = 5 if inc == 1
replace income = 5 if inc == 2
replace income = 7.5 if inc == 3
replace income = 10 if inc == 4
replace income = 12.5 if inc == 5
replace income = 15 if inc == 6
replace income = 20 if inc == 7
replace income = 25 if inc == 8
replace income = 30 if inc == 9
replace income = 35 if inc == 10
replace income = 40 if inc == 11
replace income = 50 if inc == 12
replace income = 60 if inc == 13
```

```
replace income = 75 if inc == 14
replace income = 85 if inc == 15
replace income = 100 if inc == 16
replace income = 125 if inc == 17
replace income = 150 if inc == 18
replace income = 175 if inc == 19

gen nonwhite = 0
replace nonwhite = 1 if race >= 2

gen highschool = 0
gen college    = 0
replace highschool = 1 if education == 9
replace college    = 1 if education >= 12

gen owner = 0
replace owner = 1 if pphouse == 1 & pprent == 1

gen working = 0
gen retired = 0
replace working = 1 if ppwork == 1 | ppwork == 2
replace retired = 1 if ppwork == 5

* Summary for Table 6
sum income age highschool college nonwhite hhsize working retired gender owner

rename q9_num lake_drive
sum lake_drive
sum lake_drive if lake_drive < 241

*************************************
* Some behavior summaries
* Produced for Section 4.2 in report
*************************************
gen recreator = 0
replace recreator = 1 if q1 == 1
sort hstate
by hstate: sum recreator

gen potential_recreator = 0
replace potential_recreator = 1 if (q1b == 1 | q1b == 2) & q1 ~= 1

gen cesample = 0
replace cesample = 1 if recreator == 1 | potential_recreator == 1

tab recreator
tab potential_recreator
tab cesample

* main activity dummies
gen main_swim     = 0 if q2 ~= .
replace main_swim = 1 if q2 == 1
gen main_fish     = 0 if q2 ~= .
replace main_fish = 1 if q2 == 2
gen main_boat     = 0 if q2 ~= .
replace main_boat = 1 if q2 == 3
gen main_sail     = 0 if q2 ~= .
replace main_sail = 1 if q2 == 4
gen main_view     = 0 if q2 ~= .
replace main_view = 1 if q2 == 5
gen main_game     = 0 if q2 ~= .
replace main_game = 1 if q2 == 6
gen main_walk     = 0 if q2 ~= .
replace main_walk = 1 if q2 == 7
gen main_othr     = 0 if q2 ~= .
replace main_othr = 1 if q2 == 8
```

```
* additional activity dummies
rename q301 addi_swim
rename q302 addi_fish
rename q303 addi_boat
rename q304 addi_sail
rename q305 addi_view
rename q306 addi_game
rename q307 addi_walk
rename q308 addi_othr

* did activity dummies
gen did_swim     = 0 if q2 ~= .
replace did_swim = 1 if main_swim == 1 | addi_swim == 1
gen did_fish     = 0 if q2 ~= .
replace did_fish = 1 if main_fish == 1 | addi_fish == 1
gen did_boat    = 0 if q2 ~= .
replace did_boat = 1 if main_boat == 1 | addi_boat == 1
gen did_sail     = 0 if q2 ~= .
replace did_sail = 1 if main_sail == 1 | addi_sail == 1
gen did_view     = 0 if q2 ~= .
replace did_view = 1 if main_view == 1 | addi_view == 1
gen did_walk     = 0 if q2 ~= .
replace did_walk = 1 if main_walk == 1 | addi_walk == 1
gen did_game     = 0 if q2 ~= .
replace did_game = 1 if main_game == 1 | addi_game == 1
gen did_othr     = 0 if q2 ~= .
replace did_othr = 1 if main_othr == 1 | addi_othr == 1

* group composition
gen group_alone     = 0 if q2 ~= .
replace group_alone = 1 if q4 == 1
gen group_adult     = 0 if q2 ~= .
replace group_adult = 1 if q4 == 2
gen group_kids      = 0 if q2 ~= .
replace group_kids  = 1 if q4 == 3

* Summary for Table 7
sum did*
sum main*
sum group*

* trip count summaries
gen total_sites = 0
gen total_trips = 0

foreach var of varlist q7_* {
      quietly replace `var' = 0 if `var' == .
      quietly replace total_sites = total_sites + 1 if `var' > 0
      }

foreach var of varlist q8_* {
      quietly replace `var' = 0 if `var' == .
      quietly replace total_trips = total_trips + `var' if `var' > 0
      }

sum total_sites total_trips if recreator == 1, detail

* overnight stay summary
gen overnight     = 0
replace overnight = 1 if q9a ~= 0
sum overnight
sum q9a if overnight == 1, detail

*************************************
* Some water quality belief summaries
* Used for Section 4.3
*************************************
```

```
* category in your state
gen think_wqA     = 0
replace think_wqA = 1 if q11 == 1
gen think_wqB     = 0
replace think_wqB = 1 if q11 == 2
gen think_wqC     = 0
replace think_wqC = 1 if q11 == 3
gen think_wqD     = 0
replace think_wqD = 1 if q11 == 4
gen think_wqE     = 0
replace think_wqE = 1 if q11 == 5
gen think_dnk     = 0
replace think_dnk = 1 if q11 == -1

* Summary for Table 8
sum think*
sort hstate
by hstate: sum think*

save data_cleaned, replace

******************************************
* Set up data for the CE analysis
* including opp cost of time assumptions
******************************************
use data_cleaned, replace
drop if cesample == 0

* main activity answers - self reported
gen sp_swim  = 0
replace sp_swim = 1 if q14 == 1
gen sp_fish  = 0
replace sp_fish = 1 if q14 == 2
gen sp_boat  = 0
replace sp_boat = 1 if q14 == 3
gen sp_sail  = 0
replace sp_sail = 1 if q14 == 4
gen sp_view  = 0
replace sp_view = 1 if q14 == 5
gen sp_game  = 0
replace sp_game = 1 if q14 == 6
gen sp_walk  = 0
replace sp_walk = 1 if q14 == 7
gen sp_othr  = 0
replace sp_othr = 1 if q14 == 8

* group composition answers - self reported
gen sp_alone     = 0
replace sp_alone = 1 if q15 == 1
gen sp_adult     = 0
replace sp_adult = 1 if q15 == 2
gen sp_kids      = 0
replace sp_kids  = 1 if q15 == 3

* Summary for Table 7
sum sp_*

* importance of attributes summary
* not included in survey report
rename q22_1 imp_color
rename q22_2 imp_clarity
rename q22_3 imp_fish
rename q22_4 imp_algae
rename q22_5 imp_odor
rename q22_6 imp_distance
```

```
sum imp_color if imp_color ~= -1
sum imp_clarity if imp_clarity ~= -1
sum imp_fish if imp_fish ~= -1
sum imp_algae if imp_algae ~= -1
sum imp_odor if imp_odor ~= -1
sum imp_distance if imp_distance ~= -1

* Second activity answers - some assigned
gen sp1_swim  = 0
replace sp1_swim = 1 if activity == 1 | (activity == 8 & sp_swim == 1)
gen sp1_fish  = 0
replace sp1_fish = 1 if activity == 2 | (activity == 8 & sp_fish == 1)
gen sp1_boat  = 0
replace sp1_boat = 1 if activity == 3 | (activity == 8 & sp_boat == 1)
gen sp1_sail  = 0
replace sp1_sail = 1 if activity == 4 | (activity == 8 & sp_sail == 1)
gen sp1_view  = 0
replace sp1_view = 1 if activity == 5 | (activity == 8 & sp_view == 1)
gen sp1_game  = 0
replace sp1_game = 1 if activity == 6 | (activity == 8 & sp_game == 1)
gen sp1_walk  = 0
replace sp1_walk = 1 if activity == 7 | (activity == 8 & sp_walk == 1)
gen sp1_othr  = 0
replace sp1_othr = 1 if activity == 8 | (activity == 8 & sp_othr == 1)

sum sp1*

keep caseid hstate wqversion conjversion q15 q16 q17 q18 q19 q20* q21* q23* q24* income
sp*

* question 1 outcome
gen c11a = 0
gen c11b = 0
gen c11c = 0
replace c11a = 1 if q16 == 1 & q17 == 1
replace c11b = 1 if q16 == 2 & q17 == 1
replace c11c = 1 if q17 == 2

gen c12a = 0
gen c12b = 0
gen c12c = 0
replace c12a = 1 if q16 == 1 & q17 == 2
replace c12b = 1 if q16 == 2 & q17 == 2

* question 2 outcome
gen c21a = 0
gen c21b = 0
gen c21c = 0
replace c21a = 1 if q18 == 1 & q19 == 1
replace c21b = 1 if q18 == 2 & q19 == 1
replace c21c = 1 if q19 == 2

gen c22a = 0
gen c22b = 0
gen c22c = 0
replace c22a = 1 if q18 == 1 & q19 == 2
replace c22b = 1 if q18 == 2 & q19 == 2

* question 3 outcome
gen c31a = 0
gen c31b = 0
gen c31c = 0
replace c31a = 1 if q20 == 1 & q21 == 1
replace c31b = 1 if q20 == 2 & q21 == 1
replace c31c = 1 if q21 == 2

gen c32a = 0
```

```
gen c32b = 0
gen c32c = 0
replace c32a = 1 if q20 == 1 & q21 == 2
replace c32b = 1 if q20 == 2 & q21 == 2

* question 4 outcome
gen c41a = 0
gen c41b = 0
gen c41c = 0
replace c41a = 1 if q21a == 1 & q21b == 1
replace c41b = 1 if q21a == 2 & q21b == 1
replace c41c = 1 if q21b == 2

gen c42a = 0
gen c42b = 0
gen c42c = 0
replace c42a = 1 if q21a == 1 & q21b == 2
replace c42b = 1 if q21a == 2 & q21b == 2

* question 5 outcome
gen c51a = 0
gen c51b = 0
gen c51c = 0
replace c51a = 1 if q23 == 1 & q24 == 1
replace c51b = 1 if q23 == 2 & q24 == 1
replace c51c = 1 if q24 == 2

gen c52a = 0
gen c52b = 0
gen c52c = 0
replace c52a = 1 if q23 == 1 & q24 == 2
replace c52b = 1 if q23 == 2 & q24 == 2

* question 6 outcome
gen c61a = 0
gen c61b = 0
gen c61c = 0
replace c61a = 1 if q24a == 1 & q24b == 1
replace c61b = 1 if q24a == 2 & q24b == 1
replace c61c = 1 if q24b == 2

gen c62a = 0
gen c62b = 0
gen c62c = 0
replace c62a = 1 if q24a == 1 & q24b == 2
replace c62b = 1 if q24a == 2 & q24b == 2

* check for non-answers
* note if people did not answer a
* question, they have 0 for all choices
gen c11 = c11a + c11b + c11c
gen c21 = c21a + c21b + c21c
gen c31 = c31a + c31b + c31c
gen c41 = c41a + c41b + c41c
gen c51 = c51a + c51b + c51c
gen c61 = c61a + c61b + c61c

gen c12 = c12a + c12b
gen c22 = c22a + c22b
gen c32 = c32a + c32b
gen c42 = c42a + c42b
gen c52 = c52a + c52b
gen c62 = c62a + c62b

sum c11 c21 c31 c41 c51 c61
sum c12 c22 c32 c42 c52 c62
```

```
drop c11 c21 c31 c41 c51 c61
drop c12 c22 c32 c42 c52 c62

* coding the explanatory variables for choice C11,...,C61
gen c11time1 = 0
gen c21time1 = 0
gen c31time1 = 0
gen c41time1 = 0
gen c51time1 = 0
gen c61time1 = 0

gen c11time2 = 0
gen c21time2 = 0
gen c31time2 = 0
gen c41time2 = 0
gen c51time2 = 0
gen c61time2 = 0

gen c11water1 = 0
gen c21water1 = 0
gen c31water1 = 0
gen c41water1 = 0
gen c51water1 = 0
gen c61water1 = 0

gen c11water2 = 0
gen c21water2 = 0
gen c31water2 = 0
gen c41water2 = 0
gen c51water2 = 0
gen c61water2 = 0

replace c11water1 = 1 if conjversion == 1
replace c11water2 = 3 if conjversion == 1
replace c21water1 = 5 if conjversion == 1
replace c21water2 = 3 if conjversion == 1
replace c31water1 = 1 if conjversion == 1
replace c31water2 = 4 if conjversion == 1
replace c41water1 = 3 if conjversion == 1
replace c41water2 = 4 if conjversion == 1
replace c51water1 = 2 if conjversion == 1
replace c51water2 = 3 if conjversion == 1
replace c61water1 = 5 if conjversion == 1
replace c61water2 = 4 if conjversion == 1

replace c11water1 = 5 if conjversion == 2
replace c11water2 = 4 if conjversion == 2
replace c21water1 = 1 if conjversion == 2
replace c21water2 = 5 if conjversion == 2
replace c31water1 = 2 if conjversion == 2
replace c31water2 = 3 if conjversion == 2
replace c41water1 = 2 if conjversion == 2
replace c41water2 = 1 if conjversion == 2
replace c51water1 = 5 if conjversion == 2
replace c51water2 = 4 if conjversion == 2
replace c61water1 = 1 if conjversion == 2
replace c61water2 = 5 if conjversion == 2

replace c11water1 = 5 if conjversion == 3
replace c11water2 = 2 if conjversion == 3
replace c21water1 = 1 if conjversion == 3
replace c21water2 = 3 if conjversion == 3
replace c31water1 = 3 if conjversion == 3
replace c31water2 = 5 if conjversion == 3
replace c41water1 = 2 if conjversion == 3
replace c41water2 = 5 if conjversion == 3
replace c51water1 = 1 if conjversion == 3
```

```
replace c51water2 = 2 if conjversion == 3
replace c61water1 = 4 if conjversion == 3
replace c61water2 = 3 if conjversion == 3

replace c11water1 = 4 if conjversion == 4
replace c11water2 = 3 if conjversion == 4
replace c21water1 = 1 if conjversion == 4
replace c21water2 = 2 if conjversion == 4
replace c31water1 = 5 if conjversion == 4
replace c31water2 = 3 if conjversion == 4
replace c41water1 = 2 if conjversion == 4
replace c41water2 = 5 if conjversion == 4
replace c51water1 = 4 if conjversion == 4
replace c51water2 = 3 if conjversion == 4
replace c61water1 = 1 if conjversion == 4
replace c61water2 = 2 if conjversion == 4

replace c11water1 = 1 if conjversion == 5
replace c11water2 = 3 if conjversion == 5
replace c21water1 = 1 if conjversion == 5
replace c21water2 = 4 if conjversion == 5
replace c31water1 = 4 if conjversion == 5
replace c31water2 = 2 if conjversion == 5
replace c41water1 = 1 if conjversion == 5
replace c41water2 = 4 if conjversion == 5
replace c51water1 = 2 if conjversion == 5
replace c51water2 = 3 if conjversion == 5
replace c61water1 = 5 if conjversion == 5
replace c61water2 = 4 if conjversion == 5

replace c11water1 = 1 if conjversion == 6
replace c11water2 = 4 if conjversion == 6
replace c21water1 = 5 if conjversion == 6
replace c21water2 = 2 if conjversion == 6
replace c31water1 = 4 if conjversion == 6
replace c31water2 = 2 if conjversion == 6
replace c41water1 = 2 if conjversion == 6
replace c41water2 = 5 if conjversion == 6
replace c51water1 = 4 if conjversion == 6
replace c51water2 = 1 if conjversion == 6
replace c61water1 = 2 if conjversion == 6
replace c61water2 = 3 if conjversion == 6

replace c11time1 = 3 if conjversion == 1
replace c11time2 = 2 if conjversion == 1
replace c21time1 = 3 if conjversion == 1
replace c21time2 = 4 if conjversion == 1
replace c31time1 = 4 if conjversion == 1
replace c31time2 = 1 if conjversion == 1
replace c41time1 = 3 if conjversion == 1
replace c41time2 = 2 if conjversion == 1
replace c51time1 = 2 if conjversion == 1
replace c51time2 = 1 if conjversion == 1
replace c61time1 = 1 if conjversion == 1
replace c61time2 = 4 if conjversion == 1

replace c11time1 = 2 if conjversion == 2
replace c11time2 = 4 if conjversion == 2
replace c21time1 = 3 if conjversion == 2
replace c21time2 = 1 if conjversion == 2
replace c31time1 = 4 if conjversion == 2
replace c31time2 = 1 if conjversion == 2
replace c41time1 = 2 if conjversion == 2
replace c41time2 = 4 if conjversion == 2
replace c51time1 = 3 if conjversion == 2
replace c51time2 = 4 if conjversion == 2
replace c61time1 = 3 if conjversion == 2
```

```
replace c61time2 = 2 if conjversion == 2

replace c11time1 = 1 if conjversion == 3
replace c11time2 = 2 if conjversion == 3
replace c21time1 = 4 if conjversion == 3
replace c21time2 = 3 if conjversion == 3
replace c31time1 = 4 if conjversion == 3
replace c31time2 = 2 if conjversion == 3
replace c41time1 = 4 if conjversion == 3
replace c41time2 = 3 if conjversion == 3
replace c51time1 = 3 if conjversion == 3
replace c51time2 = 1 if conjversion == 3
replace c61time1 = 1 if conjversion == 3
replace c61time2 = 3 if conjversion == 3

replace c11time1 = 1 if conjversion == 4
replace c11time2 = 4 if conjversion == 4
replace c21time1 = 4 if conjversion == 4
replace c21time2 = 3 if conjversion == 4
replace c31time1 = 1 if conjversion == 4
replace c31time2 = 2 if conjversion == 4
replace c41time1 = 4 if conjversion == 4
replace c41time2 = 1 if conjversion == 4
replace c51time1 = 1 if conjversion == 4
replace c51time2 = 2 if conjversion == 4
replace c61time1 = 3 if conjversion == 4
replace c61time2 = 2 if conjversion == 4

replace c11time1 = 3 if conjversion == 5
replace c11time2 = 1 if conjversion == 5
replace c21time1 = 4 if conjversion == 5
replace c21time2 = 3 if conjversion == 5
replace c31time1 = 1 if conjversion == 5
replace c31time2 = 4 if conjversion == 5
replace c41time1 = 3 if conjversion == 5
replace c41time2 = 2 if conjversion == 5
replace c51time1 = 4 if conjversion == 5
replace c51time2 = 2 if conjversion == 5
replace c61time1 = 1 if conjversion == 5
replace c61time2 = 2 if conjversion == 5

replace c11time1 = 3 if conjversion == 6
replace c11time2 = 1 if conjversion == 6
replace c21time1 = 1 if conjversion == 6
replace c21time2 = 3 if conjversion == 6
replace c31time1 = 1 if conjversion == 6
replace c31time2 = 2 if conjversion == 6
replace c41time1 = 4 if conjversion == 6
replace c41time2 = 2 if conjversion == 6
replace c51time1 = 2 if conjversion == 6
replace c51time2 = 4 if conjversion == 6
replace c61time1 = 4 if conjversion == 6
replace c61time2 = 3 if conjversion == 6

gen c12time1 = c11time1
gen c22time1 = c21time1
gen c32time1 = c31time1
gen c42time1 = c41time1
gen c52time1 = c51time1
gen c62time1 = c61time1

gen c12time2 = c11time2
gen c22time2 = c21time2
gen c32time2 = c31time2
gen c42time2 = c41time2
gen c52time2 = c51time2
gen c62time2 = c61time2
```

```
gen c12water1 = c11water1
gen c22water1 = c21water1
gen c32water1 = c31water1
gen c42water1 = c41water1
gen c52water1 = c51water1
gen c62water1 = c61water1

gen c12water2 = c11water2
gen c22water2 = c21water2
gen c32water2 = c31water2
gen c42water2 = c41water2
gen c52water2 = c51water2
gen c62water2 = c61water2

save hold_conjoint, replace

* double checked the coding above 24 Sept 10 - DP
* Added some new notation to allow 2 choice outcomes per
* choice. 10 May 11 - DP

* stack up individual questions into long form

* quesion 1
use hold_conjoint, replace
keep caseid hstate wqversion income c11* sp*
rename c11a c11
rename c11b c12
rename c11c c13
gen bad = c11 + c12 + c13
drop if bad == 0
drop bad

reshape long c1 c11water c11time, i(caseid wqversion income) j(alt)
rename c1 choice
rename c11water water
rename c11time time
gen str question = "1"
save conjoint_long, replace

use hold_conjoint, replace
keep caseid hstate wqversion income c12* sp*
rename c12a c11
rename c12b c12
rename c12c c13
gen bad = c11 + c12
drop if bad == 0
drop bad

reshape long c1 c12water c12time, i(caseid wqversion income) j(alt)
rename c1 choice
rename c12water water
rename c12time time
gen str question = "1a"
append using conjoint_long
sort caseid question alt
save conjoint_long, replace

* question 2
use hold_conjoint, replace
keep caseid hstate wqversion income c21* sp*
rename c21a c21
rename c21b c22
rename c21c c23
gen bad = c21 + c22 + c23
drop if bad == 0
drop bad
```

```
reshape long c2 c21water c21time, i(caseid wqversion income) j(alt)
rename c2 choice
rename c21water water
rename c21time time
gen str question = "2"
append using conjoint_long
sort caseid question alt
save conjoint_long, replace

use hold_conjoint, replace
keep caseid hstate wqversion income c22* sp*
rename c22a c21
rename c22b c22
rename c22c c23
gen bad = c21 + c22
drop if bad == 0
drop bad

reshape long c2 c22water c22time, i(caseid wqversion income) j(alt)
rename c2 choice
rename c22water water
rename c22time time
gen str question = "2a"
append using conjoint_long
sort caseid question alt
save conjoint_long, replace

* question 3
use hold_conjoint, replace
keep caseid hstate wqversion income c31* sp*
rename c31a c31
rename c31b c32
rename c31c c33
gen bad = c31 + c32 + c33
drop if bad == 0
drop bad

reshape long c3 c31water c31time, i(caseid wqversion income) j(alt)
rename c3 choice
rename c31water water
rename c31time time
gen str question = "3"
append using conjoint_long
sort caseid question alt
save conjoint_long, replace

use hold_conjoint, replace
keep caseid hstate wqversion income c32* sp*
rename c32a c31
rename c32b c32
rename c32c c33
gen bad = c31 + c32
drop if bad == 0
drop bad

reshape long c3 c32water c32time, i(caseid wqversion income) j(alt)
rename c3 choice
rename c32water water
rename c32time time
gen str question = "3a"
append using conjoint_long
sort caseid question alt
save conjoint_long, replace

* question 4
use hold_conjoint, replace
```

```
keep caseid hstate wqversion income c41* sp*
rename c41a c41
rename c41b c42
rename c41c c43
gen bad = c41 + c42 + c43
drop if bad == 0
drop bad

reshape long c4 c41water c41time, i(caseid wqversion income) j(alt)
rename c4 choice
rename c41water water
rename c41time time
gen str question = "4"
append using conjoint_long
sort caseid question alt
save conjoint_long, replace

use hold_conjoint, replace
keep caseid hstate wqversion income c42* sp*
rename c42a c41
rename c42b c42
rename c42c c43
gen bad = c41 + c42
drop if bad == 0
drop bad

reshape long c4 c42water c42time, i(caseid wqversion income) j(alt)
rename c4 choice
rename c42water water
rename c42time time
gen str question = "4a"
append using conjoint_long
sort caseid question alt
save conjoint_long, replace

* question 5
use hold_conjoint, replace
keep caseid hstate wqversion income c51* sp*
rename c51a c51
rename c51b c52
rename c51c c53
gen bad = c51 + c52 + c53
drop if bad == 0
drop bad

reshape long c5 c51water c51time, i(caseid wqversion income) j(alt)
rename c5 choice
rename c51water water
rename c51time time
gen str question = "5"
append using conjoint_long
sort caseid question alt
save conjoint_long, replace

use hold_conjoint, replace
keep caseid hstate wqversion income c52* sp*
rename c52a c51
rename c52b c52
rename c52c c53
gen bad = c51 + c52
drop if bad == 0
drop bad

reshape long c5 c52water c52time, i(caseid wqversion income) j(alt)
rename c5 choice
rename c52water water
rename c52time time
```

```
gen str question = "5a"
append using conjoint_long
sort caseid question alt
save conjoint_long, replace

* question 6
use hold_conjoint, replace
keep caseid hstate wqversion income c61* sp*
rename c61a c61
rename c61b c62
rename c61c c63
gen bad = c61 + c62 + c63
drop if bad == 0
drop bad

reshape long c6 c61water c61time, i(caseid wqversion income) j(alt)
rename c6 choice
rename c61water water
rename c61time time
gen str question = "6"
append using conjoint_long
sort caseid question alt
save conjoint_long, replace

use hold_conjoint, replace
keep caseid hstate wqversion income c62* sp*
rename c62a c61
rename c62b c62
rename c62c c63
gen bad = c61 + c62
drop if bad == 0
drop bad

reshape long c6 c62water c62time, i(caseid wqversion income) j(alt)
rename c6 choice
rename c62water water
rename c62time time
gen str question = "6a"
append using conjoint_long
sort caseid question alt
save conjoint_long, replace

qui by caseid question : gen cset = 1 if _n == 1
replace cset = sum(cset)
order wqversion caseid cset question alt choice water time income hstate sp*

drop if question == "1a" & alt == 3
drop if question == "2a" & alt == 3
drop if question == "3a" & alt == 3
drop if question == "4a" & alt == 3
drop if question == "5a" & alt == 3
drop if question == "6a" & alt == 3

gen roger = 0
replace roger = 1 if question == "1a"
replace roger = 1 if question == "2a"
replace roger = 1 if question == "3a"
replace roger = 1 if question == "4a"
replace roger = 1 if question == "5a"
replace roger = 1 if question == "6a"

replace question = "1" if question == "1a"
replace question = "2" if question == "2a"
replace question = "3" if question == "3a"
replace question = "4" if question == "4a"
replace question = "5" if question == "5a"
replace question = "6" if question == "6a"
```

```
destring question, replace

save conjoint_long, replace

******************************************
* Some conjoint modeling
* Analayis for Section 5.1
******************************************
use conjoint_long, replace

replace water  = 0 if water == .
replace time   = 0 if time  == .
gen optout     = 0
replace optout = 1 if alt == 3

replace time = 40 if time == 1
replace time = 80 if time == 2
replace time = 120 if time == 3
replace time = 240 if time == 4

gen swim     = 0
replace swim = 1 if sp_swim  == 1 & question < 5
replace swim = 1 if sp1_swim == 1 & question >= 5

gen fish     = 0
replace fish = 1 if sp_fish  == 1 & question < 5
replace fish = 1 if sp1_fish == 1 & question >= 5

gen view     = 0
replace view = 1 if sp_view  == 1 & question < 5
replace view = 1 if sp1_view == 1 & question >= 5

gen boat     = 0
replace boat = 1 if (sp_boat  == 1 | sp_sail == 1)  & question < 5
replace boat = 1 if (sp1_boat == 1 | sp1_sail == 1) & question >= 5

gen walk     = 0
replace walk = 1 if sp_walk  == 1 & question < 5
replace walk = 1 if sp1_walk == 1 & question >= 5

gen kids     = 0
replace kids = 1 if sp_kids == 1

* just with attributes - no adjusting for op cost of time
* note: don't use rull ranking information at this time,
*       which means include only rows with roger == 0
* look at full sample then various sub-sample regressions

* summaries for CE data
sum choice if alt == 3

* Regressions for Table 9
clogit choice optout time water if roger == 0, group(cset) vce(cluster caseid)
nlcom _b[water]/(_b[time]*60)

clogit choice optout time water if roger == 0 & hstate == "AL", group(cset) vce(cluster
caseid)
nlcom _b[water]/(_b[time]*60)

clogit choice optout time water if roger == 0 & hstate == "GA", group(cset) vce(cluster
caseid)
nlcom _b[water]/(_b[time]*60)

clogit choice optout time water if roger == 0 & hstate == "KY", group(cset) vce(cluster
caseid)
nlcom _b[water]/(_b[time]*60)
```

```
clogit choice optout time water if roger == 0 & hstate == "MS", group(cset) vce(cluster
caseid)
nlcom _b[water]/(_b[time]*60)

clogit choice optout time water if roger == 0 & hstate == "NC", group(cset) vce(cluster
caseid)
nlcom _b[water]/(_b[time]*60)

clogit choice optout time water if roger == 0 & hstate == "SC", group(cset) vce(cluster
caseid)
nlcom _b[water]/(_b[time]*60)

clogit choice optout time water if roger == 0 & hstate == "TN", group(cset) vce(cluster
caseid)
nlcom _b[water]/(_b[time]*60)

clogit choice optout time water if roger == 0 & hstate == "VA", group(cset) vce(cluster
caseid)
nlcom _b[water]/(_b[time]*60)


* Regressions for Table 10
clogit choice optout time water if roger == 0 & swim == 1, group(cset) vce(cluster caseid)
nlcom _b[water]/(_b[time]*60)

clogit choice optout time water if roger == 0 & fish == 1, group(cset) vce(cluster caseid)
nlcom _b[water]/(_b[time]*60)

clogit choice optout time water if roger == 0 & boat == 1, group(cset) vce(cluster caseid)
nlcom _b[water]/(_b[time]*60)

clogit choice optout time water if roger == 0 & walk == 1, group(cset) vce(cluster caseid)
nlcom _b[water]/(_b[time]*60)

clogit choice optout time water if roger == 0 & view == 1, group(cset) vce(cluster caseid)
nlcom _b[water]/(_b[time]*60)

clogit choice optout time water if roger == 0 & kids == 1, group(cset) vce(cluster caseid)
nlcom _b[water]/(_b[time]*60)

sort wqversion
by wqversion: clogit choice optout time water if roger == 0, group(cset) vce(cluster
caseid)

* Some models with same marg util income, but with
* water quality interacted.
* Note: these are not reported in the survey report document

gen water_fish = fish*water
gen water_swim = swim*water
gen water_kids = kids*water
gen water_walk = walk*water
gen water_boat = boat*water

clogit choice optout time water water_fish water_swim if roger == 0, group(cset) vce
(cluster caseid)
clogit choice optout time water water_kids if roger == 0, group(cset) vce(cluster caseid)

* Some models with opportuntiy cost of time
* Note that standard assumptions are used. We use one-third the wage rate for the
opportunity cost
* of time, gas price of $2.75 per gallon, an average of 20 miles per gallon, and $0.20 per
mile
* vehicle depreciation.

replace time = time/60
gen wage     = (income*1000)/2000
```

```
gen oct      = 0.33
gen gas      = 2.75
gen mpg      = 20
gen speed    = 45
gen dep      = 0.20

gen cost     = oct*wage*time
gen costalt  = cost + (gas/mpg + dep)*time*speed
drop cost
rename costalt cost

gen wq3         = 0
replace wq3     = 1 if wqversion == 1
gen wq3_water   = wq3*water
gen water2      = water^2

* Regressions for Table 11
clogit choice optout water cost if roger == 0, group(cset) vce(cluster caseid)
nlcom _b[water]/_b[cost]

clogit choice optout water wq3_water cost if roger == 0, group(cset) vce(cluster caseid)
nlcom _b[water]/_b[cost]
nlcom (_b[water] + _b[wq3_water])/_b[cost]

clogit choice optout water water2 cost if roger == 0, group(cset) vce(cluster caseid)
nlcom (_b[water] + _b[water2]*4)/_b[cost]
nlcom (_b[water] + _b[water2]*9)/_b[cost]

gen D1 = 0
replace D1 = 1 if water == 1
gen D2 = 0
replace D2 = 1 if water == 2
gen D3 = 0
replace D3 = 1 if water == 3
gen D4 = 0
replace D4 = 1 if water == 4
gen D5 = 0
replace D5 = 1 if water == 5

clogit choice D1 D2 D3 D4 D5 cost if roger == 0, group(cset) vce(cluster caseid)
nlcom -(_b[D4] - _b[D5])/_b[cost]
nlcom -(_b[D3] - _b[D4])/_b[cost]
nlcom -(_b[D2] - _b[D3])/_b[cost]
nlcom -(_b[D1] - _b[D2])/_b[cost]


* Marginal WTP estimates from model V in Table 11
disp -(_b[D4] - _b[D5])/_b[cost]
disp -(_b[D3] - _b[D4])/_b[cost]
disp -(_b[D2] - _b[D3])/_b[cost]
disp -(_b[D1] - _b[D2])/_b[cost]


* Regressions interacting with activity - not in report
clogit choice optout water water_swim cost if roger == 0, group(cset) vce(cluster caseid)
clogit choice optout water water_fish cost if roger == 0, group(cset) vce(cluster caseid)
clogit choice optout water water_walk cost if roger == 0, group(cset) vce(cluster caseid)
clogit choice optout water water_boat cost if roger == 0, group(cset) vce(cluster caseid)
clogit choice optout water water_swim water_fish water_boat cost if roger == 0, group
(cset) vce(cluster caseid)


* Note this will be the model used for the spreadsheet
* No constraints and full travel cost
* Sent the boostrap output to Ross for the spreadsheet on 11 May 2011
```

```
clogit choice D1 D2 D3 D4 D5 cost, group(cset) vce(cluster caseid)

* clogit choice D1 D2 D3 D4 D5 cost, group(cset) vce(bootstrap, rep(100) saving(bsout))
disp -(_b[D4] - _b[D5])/_b[cost]
disp -(_b[D3] - _b[D4])/_b[cost]
disp -(_b[D2] - _b[D3])/_b[cost]
disp -(_b[D1] - _b[D2])/_b[cost]

save conjoint_long, replace

* Generate results for conjoint policy model
* shown in table 12

use conjoint_long, replace
clogit choice D1 D2 D3 D4 D5 cost, group(cset) vce(cluster caseid)
nlcom -(_b[D4] - _b[D5])/_b[cost]
nlcom -(_b[D3] - _b[D4])/_b[cost]
nlcom -(_b[D2] - _b[D3])/_b[cost]
nlcom -(_b[D1] - _b[D2])/_b[cost]


sort hstate
by hstate: clogit choice D1 D2 D3 D4 D5 cost, group(cset) vce(cluster caseid)

****************************************************
* Start pulling togeher the data for the CV analysis
****************************************************
use data_cleaned, replace

gen progA     = 0
replace progA = 1 if abversion == 1
gen progB     = 0
replace progB = 1 if abversion == 2
gen progC     = 0
replace progC = 1 if abversion == 3
gen progD     = 0
replace progD = 1 if abversion == 4

gen cost     = 0
replace cost = 24  if v_starting == 1
replace cost = 120 if v_starting == 2
replace cost = 216 if v_starting == 3
replace cost = 360 if v_starting == 4

gen costf     = 0
replace costf = 120 if q26 == 1 & v_starting == 1
replace costf =  12 if q26 == 2 & v_starting == 1
replace costf = 216 if q26 == 1 & v_starting == 2
replace costf =  24 if q26 == 2 & v_starting == 2
replace costf = 360 if q26 == 1 & v_starting == 3
replace costf = 120 if q26 == 2 & v_starting == 3
replace costf = 480 if q26 == 1 & v_starting == 4
replace costf = 216 if q26 == 2 & v_starting == 4

gen choice1      = 0
replace choice1  = 1 if q26 == 1
gen choice2      = 0
replace choice2  = 1 if q26 == 2

gen choicef1     = 0
replace choicef1 = 1 if q29 == 1 | q30 == 1
gen choicef2     = 0
replace choicef2 = 1 if q29 == 2 | q30 == 2


* Summary for Table 13
sum choice1
```

```
sort cost
by cost: sum choice1
sort costf
by costf: sum choicef1

sort abversion
by abversion: sum choice1

gen very_certain     = 0
replace very_certain = 1 if q26a == 1
gen certain          = 0
replace certain      = 1 if q26a == 2
gen uncertain        = 0
replace uncertain    = 1 if q26a == 3

sum very_certain certain uncertain

sort uncertain
by uncertain: sum choice1

sort very_certain
by very_certain: sum choice1

* make a continuous variable out of the program dummies
* consider just first moment
gen qbase  =  1*0.05 + 2*0.15 + 3*0.55 + 4*0.20 + 5*0.05
gen qA     =  1*0.10 + 2*0.25 + 3*0.50 + 4*0.15 + 5*0
gen qB     =  1*0.15 + 2*0.35 + 3*0.40 + 4*0.10 + 5*0
gen qC     =  1*0.20 + 2*0.45 + 3*0.30 + 4*0.05 + 5*0
gen qD     =  1*0.10 + 2*0.55 + 3*0.30 + 4*0.05 + 5*0

drop q501-q510
drop states*
drop q7*
drop q8*
save cv_hold, replace

****************************************************
* Simple CV analysis
* Analysis for Section 5.2
****************************************************

use cv_hold, replace
drop choicef1 choicef2 costf

reshape long choice, i(caseid) j(alt)
replace cost  = 0 if alt == 2
replace progA = 0 if alt == 2
replace progB = 0 if alt == 2
replace progC = 0 if alt == 2
replace progD = 0 if alt == 2

gen quality     = 0
replace quality = qbase if alt == 2
replace quality = qA if alt ~= 2 & progA == 1
replace quality = qB if alt ~= 2 & progB == 1
replace quality = qC if alt ~= 2 & progC == 1
replace quality = qD if alt ~= 2 & progD == 1

gen inc_qual     = income*quality
gen college_qual = college*quality
gen rec_qual     = recreator*quality

gen     statquo = 0
replace statquo = 1 if alt == 2

replace income    = 0 if alt == 2
```

```
replace college   = 0 if alt == 2
replace recreator = 0 if alt == 2
gen quest = 1
save cv_q1, replace

use cv_hold, replace
drop choice1 choice2 cost
rename choicef1 choice1
rename choicef2 choice2
rename costf cost

reshape long choice, i(caseid) j(alt)
replace cost  = 0 if alt == 2
replace progA = 0 if alt == 2
replace progB = 0 if alt == 2
replace progC = 0 if alt == 2
replace progD = 0 if alt == 2

gen quality     = 0
replace quality = qbase if alt == 2
replace quality = qA if alt ~= 2 & progA == 1
replace quality = qB if alt ~= 2 & progB == 1
replace quality = qC if alt ~= 2 & progC == 1
replace quality = qD if alt ~= 2 & progD == 1

gen inc_qual     = income*quality
gen college_qual = college*quality
gen rec_qual     = recreator*quality

gen     statquo = 0
replace statquo = 1 if alt == 2

replace income    = 0 if alt == 2
replace college   = 0 if alt == 2
replace recreator = 0 if alt == 2
gen quest = 2
save cv_q2, replace
append using cv_q1
sort caseid quest alt

keep caseid alt quest statquo choice quality cost choice prog* inc* coll* rec* abversion
hstate
save cv_long, replace

qui by caseid quest : gen cset = 1 if _n == 1
replace cset = sum(cset)
order caseid abversion cset quest alt choice cost quality prog* statquo inc* coll* rec*
hstate
save cv_long, replace

* Regressions for Table 14
clogit choice cost progA progB progC progD if quest == 2, group(caseid)
test progA = progB
test progA = progC
test progB = progC

clogit choice cost progA progB progC progD income if quest == 1, group(caseid)
clogit choice cost progA progB progC progD income college recreator if quest == 1, group
(caseid)
test progA = progB
test progA = progC
test progB = progC

* Regressions for Table 15
clogit choice cost quality statquo if quest == 1, group(caseid)
clogit choice cost quality rec_qual statquo if quest == 1, group(caseid)
```

```
clogit choice cost quality college_qual rec_qual statquo if quest == 1, group(caseid)
clogit choice cost quality inc_qual rec_qual statquo if quest == 1, group(caseid)

save cv_long, replace


log off
```