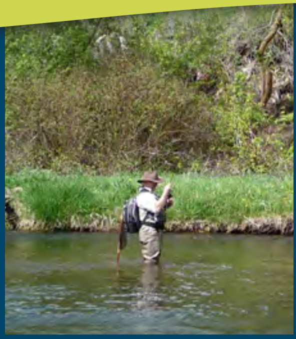
Economic Benefits of Nutrient Reductions in Utah's Waters



State of Utah

Prepared by
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FINAL REPORT

Economic Benefits of Nutrient Reductions in Utah's Waters

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State of Utah

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Executive Summary

(Under Separate Cover)

Contents

Appendices

Tables **Page**

Figures **Page**

Abbreviations and Acronyms

AAPOR	American Association for Public Opinion Research
CVM	contingent valuation method
CWA	Clean Water Act
DQO	data quality objective
DWQ	Utah Division of Water Quality
EPA	U.S. Environmental Protection Act
ERU	equivalent residential unit
POTW	publicly owned treatment works
PV	present value
QAPP	Quality Assurance Project Plan
TEV	total economic value
TMDL	total maximum daily load
U.S.	United States
WTP	willingness to pay
WYSAC	Wyoming Survey and Analysis Center

1.0 Introduction

1.1 The Contribution of Water—Based Recreation to the Utah Economy

Tourism is often thought of simply in terms of attracting people outside of the area to destinations within the state. The local counterpoint to tourism is livability, including how local residents use and enjoy their surroundings and take pride in their state's sense of place, attractiveness, and uniqueness. Areas that are vibrant and foster a sense of personal and social well-being attract more visitors, more investors, and those that want to not only recreate but also live in the area.

Along these lines, the analysis of water-based tourism addresses how clean water leads to a more vibrant local economy. One concrete measure is the amount of money that people expend to recreate on or near Utah's waters. The approach to estimating this contribution to Utah's economy is to collect survey data on water-based recreation activities and expenditures and aggregate these data based on the share of the population that engages in these activities. This will be important information for Utah's businesses and residents who rely on such spending for their livelihood. The resultant expenditures and associated economic impacts will provide a conservative lower bound estimate of the importance of Utah's surface waters to the state's economy as it will not include the sizeable expenditures by visitors from other parts of the U.S. and abroad. As reported in the Salt Lake Tribune (November 29, 2011), tourism and recreation is big business in Utah, generating over $6 billion and accounting for more than 122,000 jobs in 2010. Expenditures on waterfowl hunting on the Great Salt Lake were estimated at approximately $62 million annually in a separate study (Duffield et al., 2011). This same study attributed more than 1,600 jobs to support waterfowl hunting on the Great Salt Lake. Chapter 9 shows that Utah households took an estimated 7.7 to 13.5 million trips to lakes and rivers in 2011. On these trips, they spent about $1.4 to $2.4 billion on gasoline, restaurants, grocery stores, outfitters, overnight accommodations, and other retail stores to enjoy their recreation experiences. These expenditures support 30,000 to 50,000 jobs in the state and provide a measure of the importance of the state's waters to the Utah economy while the number of recreation trips is an indicator of their importance to quality of life in Utah.

1.2 The Environmental Problem—Excess Nutrients in Surface Waters

For more than a decade nutrients have consistently ranked as one of the top five causes of beneficial use impairment in United States (U.S.) waters (U.S. Environmental Protection Agency [EPA], 2008a). Excess concentrations of nitrogen and phosphorus cause eutrophication, which impairs water quality by causing many deleterious effects, including: harmful algal blooms, hypoxia (low oxygen), and reduced wildlife and habitat. Under the Clean Water Act, water bodies are protected to serve a designated beneficial use or uses. Designated beneficial uses describe the essential services that are provided by a particular water body—such as aquatic life support, recreational use (for example, swimming, fishing, and boating), and drinking water supply. A variety of uses are impacted by excessive nutrients, but the principal uses are aquatic life, recreation, and drinking water.

With a few exceptions (for example, ammonia toxicity), nutrients do not directly impact uses. Unlike many toxins, which directly threaten human health or aquatic life, nutrients act through a series of causal pathways resulting in diminished water quality and impacting designated uses (EPA, 2010). Nutrients can also alter the physical habitat. Excess plant and algal growth change the physical flow environment and, therefore, available habitat for movement, growth, and reproduction of a variety of invertebrate and vertebrate taxa (Allan, 1995). In addition, excess plant growth affects recreation, making swimming and/or boating impossible, or at least undesirable (Horner et al., 1983; Welch et al., 1988). Excess plant growth can also affect drinking water treatment by increasing treatment costs associated with filtration (Knappe et al., 2004). Lastly, nutrients affect the abundance of different plant and algal taxa (Allan, 1995; Wetzel, 2001; Dodds, 2006). Several eutrophic taxa—cyanobacteria— are also known to produce neurotoxins that are a threat to livestock and to human health

(Carmichael, 2001; Crane et al., 1980; Knappe et al., 2004). Other taxa produce chemicals that are known to cause taste and odor problems in drinking water (Izaguirre et al., 1982; Knappe et al., 2004).

While nutrient over-enrichment can be a problem, it can be difficult to establish a causal relationship between pollutant loads and excess nutrients. Nonetheless, because of the broad geographic scope associated with nutrient problems, EPA is under pressure from a conglomerate of environmental groups calling for regulations that require additional reduction of nitrogen and phosphorus from lakes, streams, and estuaries. The understandable response from the regulated community has been to focus on the costs of compliance and the difficulties with ensuring that reducing nutrient loads will have the desired effect of improving water quality. However, there is also an unknown cost of failing to take additional action to manage nutrients. This study contributes to filling that gap by improving understanding about the benefits of achieving water quality improvements from the reductions.

One of the primary objectives of this benefits analysis was to provide "information on the value of clean water to the citizens of Utah and the contribution of water-based recreation spending to the Utah economy." As such, it is a companion document to analyses of the costs of various measures to manage point sources and nonpoint sources of nutrients. In addition, this report describes the contribution of water-based recreation to the Utah economy.

1.3 Costs of Nutrient Criteria Implementation

The cost of additional wastewater treatment is likely the most significant economic impact that would result from any additional nitrogen and phosphorus reduction regulations. In 2010, the Utah Division of Water Quality (DWQ) released a report that shows the costs associated with treating wastewater to meet several hypothetical nutrient discharge standards (CH2M HILL, 2010). The total net present value cost to the utilities included the initial capital improvements and incremental O&M expenditures over a 20-year period. All costs were reported in 2009 dollars, and future costs were discounted at the real interest rate of 2.7 percent. Depending on the level of treatment, the net present value of the capital and incremental operation and maintenance costs over a 20-year period fell between $114 million and more than $1.35 billion.

The estimated monthly bill increase associated with implementing nutrient controls was also estimated for the typical residential customer of each utility provider. The impact on sewer use rates varied based on the level of nutrient control, but the state-wide average ranged from $1.19 to $15.30 per month for every equivalent residential unit (ERU).

The cost of reducing nitrogen and phosphorus from publicly owned treatment works (POTW) wastewater varies across the POTWs and depends on the capacity of the facility and the existing treatment processes. The cost study provides important information to assist DWQ with prioritizing future nutrient reductions from these facilities and for comparing the costs of reducing loads from other sources.

The State of Utah is continuing to study the environmental improvements that would result from setting lower discharge limits for nitrogen and phosphorus. Eventually, limits may lead to costs that are within or outside the range studied previously. The State is also investigating the cost and effectiveness of stormwater and agricultural best management practices as well as the costs of administering total maximum daily loads (TMDLs) to better understand the full costs of any nitrogen and phosphorus regulations.

Thus far, the focus of the State's efforts had been on the costs of nutrient criteria implementation. No information was forthcoming on the benefits of reducing nutrient loads to Utah's receiving waters. This important gap in knowledge is addressed in this report.

1.4 The Benefit Study

The economic benefits of removing nutrient-related impairments and restoring and maintaining healthy waters include the following:

- The value that the public derives from recreational and aesthetic use and enjoyment on and near clean lakes, rivers, and streams (Chapter 6).

- The value that the public places on maintaining a healthy aquatic ecosystem for fish and habitat for wildlife for current and future generations (Chapter 5).
- The aesthetic value of lakefront properties (Chapter 8).
- Cost savings in treating drinking water (Not included).

It is sound economics to compare the costs of reducing nutrient loads to receiving waters with the economic benefits that result from reducing nutrient concentrations. The comparison will inform regulatory decisions related to nutrient criteria development and help set priorities for addressing nutrient over-enrichment.

In addition to the economic efficiency aspects driving this investigation of the economic benefits of nutrient criteria implementation, a second factor is the contribution of water-based recreation spending to Utah's economy. This study quantifies the contribution to Utah's economy from the expenditures by visitors who use and enjoy Utah's lakes, rivers, and streams. As such, it provides another measure of how improving and maintaining Utah's waters contributes to the quality of life of its citizens.

An analysis of the benefits anticipated from nutrient criteria implementation will provide the following:

- Pertinent information for DWQ to use in communicating the net costs of criteria implementation during the rulemaking process.
- Useful information to support DWQ in meeting the requirements of Utah's antidegradation rules related to the development of objective rules for evaluating the least degrading "feasible" treatment alternatives.
- Assistance in prioritizing watershed restoration efforts on the basis of the anticipated recreational benefit of improving water quality.
- Information to be used by DWQ for the prioritization and evaluation of future nutrient reduction projects from wide-ranging sources (recognizing that POTWs are not the only nutrient sources).
- Information on the value of clean water to the citizens of Utah and the contribution of water-based recreation spending to the Utah economy. It is important to convey this information to politicians and other lawmakers with decision making authority.

Fundamental to the evaluation of costs and benefits of nutrient criteria implementation is defining a clear pathway from future nutrient reduction to improvements in the condition of aquatic life and quantity and quality of recreation uses of Utah's water bodies. The primary economic benefits of these changes can vary somewhat across the state depending on how each water body is used by households, business, and industry, as well as how much importance the public places on protecting and improving Utah's waters to preserve quality of life for future generations of Utahns.

The benefits of reducing nutrients were estimated in multiple, interrelated ways in order to attempt to capture a comprehensive assessment. One component of this study was designed to capture the total economic value (TEV) that Utah households place on reducing nutrient over-enrichment. This total value includes the households' direct use of the state's waters for recreation as well as the value that households place on protecting the state's waters for future generations—also called "nonuse value" or "passive use value." The TEV study relies upon survey data and people's statements about what they would pay to maintain and improve surface water quality. To cross validate these results, a separate analysis of recreation benefits derived from higher water quality was also conducted. This second analysis relies upon direct observation of the recreation choices made by Utah households to ascertain the extra value derived from the lakes, rivers, and streams with improved water quality. Thus, the analysis of recreation benefits serves to increase the robustness of the study results—although the recreation benefits are just a subset of the TEV of improved water quality. Finally, the impacts to lakefront property values from changes in lake water quality are separately assessed as it was not cost-effective to capture such values in the TEV study. As such, these property value results represent a net addition to TEV. Some of the benefits of water quality improvements are omitted from the study. Specifically, cost savings for water treatment purveyors and for industrial water users are not included; however, the State of Utah is investigating the potential for treatment costs savings, which will be reported separately.

An important feature of the economic benefit analyses is the reliance on water quality parameters provided by DWQ that depict current conditions as well as project future conditions—with and without the additional nutrient reductions. This means that the study design takes advantage of the best available science to value policy relevant changes in water quality. Nonetheless, it is understood that people do not respond to degraded water quality per se, but rather to the deleterious effects of nitrogen and phosphorus pollution. Hence, the challenge of designing the study is in identifying the water quality parameters that matter to the public and that are responsive to changes in nutrient loads. This challenge is not unique to Utah. Across the nation, regulators are wrestling with defining nutrient criteria that reflect both changes in nutrient loadings and the systems' responses (for example, excessive algal blooms, decreases in fish populations, and/or reductions in the diversity of aquatic life). These water quality responses must also be linked back to changes in nutrient loads and the cost to implement these controls so informed decisions can be made about the cost and benefits of nutrient removal. This study achieved considerable success in meeting these challenges. These issues are discussed in more detail in the following sections that describe the survey designs, the model specifications, and the results of the analyses.

2.0 Types of Benefits Arising from Improved Water Quality

In this section the terms and methods used by economists to estimate the benefits arising from improved water quality from nutrient reductions are presented, followed by a review of similar studies found in the literature.

2.1 Use Values

There are many uses of water in Utah, and several are affected in one way or another by the quality of that water. Use of Utah's water resources can either be consumptive or non-consumptive, depending on their effect on the resource. Consumptive use includes water for household use, commercial food processing, manufacturing, cooling water for power plants, treating and conveying human waste, and of course the largest water use in Utah—irrigated agriculture. Hunting and fishing are also considered consumptive use. Each of these consumptive uses changes the aquatic ecosystem to satisfy human needs. Non-consumptive use, on the other hand, leaves the aquatic ecosystem relatively intact and unchanged. Examples of non-consumptive use include bird watching, photography, hiking, and canoeing, as well as the enjoyment that property owners receive from living close to lakes, rivers and streams.

Different characteristics of water quality matter differently to different users. Salinity of the water often matters more to agriculture, while the amount of nutrients and sediment (turbidity) matters to water treatment plants. However, in all cases, improved water quality provides direct benefits to the various users of Utah water. Some of these benefits of improved water quality are cost savings to commercial and municipal water users and may be observed in reduced monetary costs. Improved water quality clearly has benefits to households that receive their drinking water from a municipal source through improvements in water clarity, taste, and odor. In addition, high-quality water may require less treatment and hence fewer chemical additives that are regulated by EPA because of their potential health risks (EPA, 2006).

The economic values of other beneficiaries of water quality are not easily observable in markets and hence do not have market prices. These nonmarket benefits of water quality include people engaged in water-based recreation. This includes water contact (for example, swimming, water skiing), fishing (especially if the fish are to be eaten), waterfowl hunting, and boating. Oftentimes near-shore recreationists also receive enjoyment from picnicking, hiking, jogging, and walking next to streams and rivers with high-quality water (clear, no offensive smells).

2.2 Passive Use Values

In addition to receiving such use values from surface waters, benefits may also be received by some people from simply knowing that water quality is improved and maintained at rivers and lakes. These benefits are called passive use values or non-use values because they are not directly derived from one's use of the water resources, but rather because of stewardship motivations (Freeman, 1993). Within passive use values there are two main reasons people may receive benefits from protecting water quality at rivers and lakes they may never visit: (1) existence values received by the person from knowing that water quality is sufficient to sustain aquatic species, birds, etc.; and (2) bequest values obtained today from knowing that protecting water quality in the present will help ensure a high quality of life for future generations (their own children or grandchildren, or future generations in general). These passive use values are what economists call a pure public good, as once a lake is cleaned up, all can enjoy the knowledge of this clean lake. Thus passive use values accrue to the public at large, not just visitors. Passive use values can be substantial and are included in benefit cost analysis for all major government initiatives (Office of Management and Budget, 2003: 5519).

2.3 Total Economic Value

Total economic value (TEV) is the sum of use values and passive use values. Thus, from an anthropocentric or human centered value system, use and passive use values capture the total benefits to society arising from improving and protecting water quality. Recreation use values are a subset of use values. In addition, recreation values are only received by water-based or near-water recreationists. As such, not everyone in the population receives recreation use values. Passive use values, while they may be smaller per person than visitors' use value, are public goods and hence received by everyone in the population. Thus, for these two reasons, estimates of recreation use values should be lower than TEV. In some cases, the passive use value component can be the majority of TEV for restoring water resources in general (Loomis, 2006) as well as rivers and their associated riparian areas (Wilson and Carpenter, 1999; Loomis, et al., 2000).

2.4 Definition of Economic Value

The term "value" has many possible meanings depending on the context; however, economic value is defined by what a person would pay to obtain a benefit. This value concept is called "willingness to pay," which is shorthand for willingness and ability to pay. For market goods, the willingness to pay (WTP) is reflected in the market price for a unit of the market good. However, the absence of a market does not mean absence of WTP. Visitors to recreation sites do not generally reveal their WTP when they visit a river because many rivers have no or minimal entrance fees. However, if recreationists could be excluded because of private ownership (for example, in Texas or Europe), then certain visitors would pay to use the recreation resource rather than forgo the recreation opportunity. Similarly, as the cost of travel increases (for example, $4 per gallon of gasoline), many visitors would pay this higher amount to enjoy the recreation site. Such out of pocket expenditures that visitors may be required to pay may be less than their maximum WTP before they would stay home. This additional amount they would pay beyond their travel costs and any entrance fees reflects their net WTP, or what economists call "consumer surplus." In summary, consumer surplus is a net gain in economic value, and it is measured by taking the difference between what the consumer has to pay for a good or service and the maximum amount he or she would be willing to pay before forgoing that good or service.

Economists apply the same WTP standard to estimating the value households have for use and passive use values. One of the advantages of a WTP standard of value is that the WTP dollars can be compared with the costs of maintaining clean water. Thus, for the purposes of asking how clean a particular river or lake should be from an economic perspective, it is important to make sure the costs and benefits are measured in a commensurate fashion.

2.5 Techniques to Estimate WTP for Water Quality

To estimate the recreation benefits of improved water quality, economists often record (1) which water bodies a person visits, (2) the amount a visitor pays to travel to a particular water body, and (3) how many trips visitors make to these water bodies. From these data, an economist can infer how much more people will pay to go to water bodies with higher water quality. This "travel cost method" has been approved for use by federal water resource agencies since 1979 (U.S. Water Resources Council, 1979). Several hundred applications of the travel cost method exist, with many of these applied to estimate the benefits of water quality improvements—especially those related to improved fishing. These estimates will be summarized in the recreation section of this report (Section 6).

2.5.1 Stated Preference Methods Including Contingent Valuation Method

Passive use values are more difficult to quantify because these values cannot be inferred from observed behavior like traveling further to cleaner rivers or paying more for a home by a lake with better water quality. Nonetheless, economists have developed valuation techniques for estimating WTP for nonmarket goods, including improved water quality. One particularly effective technique is the use of simulated referenda, in which households are asked whether they would vote to increase their taxes or water bills by a given amount in exchange for a specific improvement in water quality. This is one example of a class of methods called "stated preference methods." Such methods rely on surveys to elicit respondents' statements about their behavior (for example, how they would vote in a referendum or how much they would pay in an entrance fee). The resultant estimates of economic value are thus contingent on the survey context and the accuracy and validity of people's responses. Hence, this approach is often referred to as the contingent valuation method (CVM), or the contingent behavior method. Stated preference methods have been used extensively by economists to value not only water quality but also endangered species, air quality, improved health, etc. The method has been used for decades to quantify not only passive use values but use values as well. As of 2011, more than 7,500 CVM studies have been completed in over 130 countries (Carson, 2011).

2.5.2 Hypothetical Bias in CVM

Substantial literature exists on the strengths and weaknesses of CVM (see Alberini and Kahn [2006] for a series of CVM papers discussing these issues). Of course one of the biggest concerns is that the number of people stating that they would pay in a survey is different from the number who would actually pay in a real-choice situation. This is known as hypothetical bias. Tests of hypothetical biases show a tendency toward overstatement of WTP (for example, Cummings and Taylor [1999]; Champ, et al. [1997]; Champ et al. [2009]); although, exceptions exist (for example, Brookshire et al., 1982; Vossler and Kerkvliet, 2003). However, on balance, most CVM studies (even those conducted in the laboratory with real money) show hypothetical bias. The studies where little or no hypothetical bias exists often involve salient, familiar, and well-defined public goods (air quality to residents of Los Angeles in the Brookshire et al. [1982] study; open space in Corvallis, Oregon, in the Vossler and Kerkvliet [2003] study of Corvallis residents). This suggests that familiarity with the good in question may reduce hypothetical bias because respondents are more certain about their preferences toward these goods as compared with less direct and familiar benefits such as saving rain forests or aiding whooping crane populations. Most people directly understand the importance of water quality because it is an essential life service. Thus, the valuation of water quality by Utah households should have lower hypothetical bias than the bias that is sometimes found for unfamiliar goods (for example, Champ et al., 1997]). Utah residents are aware of water quality in the state, especially because approximately two-thirds of the survey sample in this study are users.

Nonetheless, this study takes steps to reduce hypothetical bias in the WTP estimates regarding the DWQ-proposed Nutrient Reduction Program to maintain and improve water quality in Utah. As described later in this report, extensive focus groups and pretesting was undertaken to ensure that respondents understood the consequences of excessive nutrients in water bodies and that they understood the proposed Nutrient Reduction Program—including how it would be paid for. Hypothetical bias of responses to the dollar amount households are asked to pay can be easily assessed. If the percentage or probability that households will pay goes down as the dollar amount they are asked to pay goes up, the CVM responses have internal validity. Some residual hypothetical bias may remain, but these can be corrected or accounted for when presenting WTP results.

There are several competing and plausible hypotheses about how a person may respond when asked how much they would, hypothetically, be willing to pay for a particular public good (Loomis, 2011). Each suggests an alternative approach for correcting hypothetical bias. A proven and popular method—and the one used in this study—is *ex post* recoding, or calibration of WTP responses to correct or reduce the stated WTP based upon hypothetical bias. The recoding method works by recoding some "yes, would pay" responses to "no, would not pay" responses for people who state they are uncertain about whether they would actually pay the amount they agreed to in the referendum WTP question. Pioneered by Champ et al. (1997), the *ex post* method can, after the fact, produce estimates of CVM WTP that match actual cash donations (Either et al., 2000; Champ and Bishop, 2001; Blumenshein et al., 1998).

There are two ways that respondent uncertainty have been elicited in past surveys: (1) a 10-point scale, where 10 is very certain and 1 is very uncertain (Champ et al., 1997; Either et al., 2000; Champ and Bishop, 2001); and (2) qualitative categories such as "definitely sure" and "probably sure" (Blumenshein et al., 2008) or "absolutely sure" and "probably sure" (Johanneson et al., 1999).

The criterion validity field experiments generally show that counting "Yes, would pay" responses as "Yes" responses with a certainty level of 7 or higher generally produce "hypothetical payment responses to correspond to actual payment decisions" (Champ et al., 2009: 169). Those "Yes, would pay" responses with less certainty (6 or less) are recoded as "No" responses. All initial "No" responses are also retained as "No." Likewise, the criterion validity field experiments for the qualitative approaches keeping only "Yes" responses of definitely sure and recoding probably sure responses to "No" yielded CVM WTP responses similar to actual payment (Blumenshein et al., 1998). However, in another experiment such methods proved overly conservative because retaining only the "Yes" responses with "absolutely sure" certainty level and recoding "fairly sure" as a "No" produced an underestimate of actual payments (Johanneson et al., 1999).

In the survey developed for this study, respondents were asked "How sure are you of this answer?" Their answers were coded using a 9-point scale with 9 being labeled "certain," 5 being labeled "somewhat," and 1 labeled "not sure at all." Hypothetical bias was quantified by recoding values less than 7 as "No," which is a conservative but reasonable threshold. This threshold is somewhat more conservative than is suggested by Champ et al. (1997), which recommends a 7 on a 10-point scale as opposed to the 9-point scale used in this study. However, level 6—a comparable level to the Champ et al. recommendations—is just one away from the midpoint, which was defined as only "somewhat" sure. Thus the team felt that using 7 would provide a conservative or lower bound estimate of WTP valuations.

The next section discusses how CVM has been applied by others in the past to value protecting or improving water quality.

2.6 Review of the Economic Benefits of Water Quality Literature

The purpose of this section is to (1) establish that the methods and approach the research team undertook have been previously applied to estimate TEV of water quality in freshwater systems and (2) to summarize their empirical results so they can be compared with the results of this study. Studies that focus primarily on relationships between water quality and recreation, either for general onsite recreation or for improving fishing quality, are discussed in the Recreation section (Section 6) of this report.

The use and passive use values of water quality have been estimated using CVM for more than three decades. In this section, a review is provided of those studies most relevant to this investigation. This is done to provide context by comparing the WTP estimates obtained from this investigation with previously reported WTP estimates. The literature review is organized based on the spatial scale of inference, going from site-specific studies, to statewide studies, and finally to nationwide studies. Within those categories, the studies are presented chronologically to illustrate how one study builds on the other. A summary table of all the studies evaluated is provided at the end of this section.

2.6.1 Local WTP for Improving Water Quality of Specific Water Resources

The first similar water quality valuation studies date back to the Greenley et al. (1982) study of improving water quality in the South Platte River in Colorado. The WTP question was asked in an older "iterative bidding" format. In this format, the in-person interviewer asked if the respondent will pay a particular amount, and if they agree the amount is raised and the question repeated until they reach their highest WTP. Likewise with an initial "no" response to the first bid, the bids are lowered. This study found the recreation use value of improving water quality elicited via WTP a higher water bill was $1.86 per month or $22.30 per year in 1981 dollars ($55 in 2011 dollars). The passive use value (what the authors called preservation value) was about $4 per month or nearly $48 per year in 1981 dollars ($120 in 2011 dollars).

A significant study in the early 1980s was the Desvousges et al. (1983) study of improving water quality in the Monongahela River that flows from West Virginia into western Pennsylvania. The use and option value for future use among users and nonusers was estimated for improving water quality such as managing for a "swimmable" beneficial use rather than only a "boating" beneficial use. Recreation user benefits were about $53 per year, while nonuser was $20 per year (both in 1983 dollars, or $120 and $50, respectively, in 2011 dollars).

Stumborg et al. (2001) performed a CVM survey for nonpoint source pollution control at Lake Mendota in Wisconsin. The state capital and several suburbs surround this lake, for a total population near the lake of approximately 400,000 people. The lake is affected by nutrient pollution resulting in algae blooms that emit a foul odor, which reduces enjoyment of water-based recreation and shore recreation. In addition, the low dissolved oxygen levels have changed the fish populations and resulted in fish kills. A mail contingent valuation WTP survey of county residents was conducted. The water quality improvement question was to reduce phosphorus coming into the lake by 50 percent to improve water quality. The payment mechanism was a combination of increased state income taxes and property taxes. The survey obtained a 44 percent response rate. Respondents were asked to pay this annually, but the time horizon was varied to one subsample at 3 years and the other to annual for

10 years. The authors then calculated a present value of $353 per household over the two time horizons using a 4 percent interest rate. The authors then generalized their sample to the entire county. The lower bound of their countywide WTP exceeded the cost to the Wisconsin Department of Natural Resources to clean up the lake by a factor of two.

Azevedo et al. (2001) valued two plans for maintaining and then improving water quality at Clear Lake in Iowa. Water quality was described in ways similar in many respects to this study. In particular, water clarity, algae blooms, water color, water odor, bacteria, and type of fish present. Water clarity and color was illustrated using color photographs. Local residents living in two towns near the lake and visitors were surveyed using mailed questionnaires. Questionnaires mailed to visitors received a 66 percent response, and those mailed to households received a 58 percent response rate. Similar to this study, deterioration of water quality was the future scenario unless action was taken to improve conditions. The payment vehicle was described as higher state or local taxes. Respondents were presented the amount of additional taxes and then asked whether they would accept or reject the program at the additional price (a voter referendum WTP question). The highest water quality improvement program would show results in the next 10 to 20 years. Annual WTP is $21 ($28 in 2011 dollars) for visitors to avoid deterioration in water quality in Clear Lake and $85 ($112 in 2011 dollars) per year for a substantial improvement. Households who lived in the same geographic area of the lake would pay about $110 per year ($144 in 2011 dollars) to prevent deterioration of lake water quality (for example, to maintain current conditions).

2.6.2 Statewide WTP for Improving Water Quality of Specific Water Resources

Several valuation studies have been conducted at a statewide scale, but each was limited to a single major water resource. The first study was by Sutherland and Walsh (1985) and was a valuation of recreation use and passive use (what they called preservation values) for water quality at Flathead Lake in Montana. Using a mail survey, they obtained a response rate of 61 percent. An open-ended WTP question was used. The payment mechanism was payment into a special fund to be only used to protect water quality. Mean annual recreation use value for a single lake was $18 per household in 1981 dollars, and passive use was $46 per households in 1981 dollars ($45 and $140, respectively, in 2011 dollars). The authors expanded their household WTP to all households in t Montana. Given the state population at the time of the study, this translated to $32.82 million in 2011 dollars. Updating the sample expansion using the 2000 Census estimate of the number of households in Montana (358,667), the estimate would be $57.184 million in 2011 dollars.

The second study involved residents in Ohio and the value they placed on managing water quality in one large river basin, the Maumee River Basin in Ohio that drains into Lake Erie (de Zoya, 1995). Similar to the current study related to valuing implementation of nutrient criteria for managing Utah's surface waters, this study valued the reduction in sediments and chemical nutrients that result in algae blooms. The study emphasized avoiding adverse effects on aquatic life and in particular the loss of clear-water fish, which would be replaced by fish species more tolerant of low oxygen and greater turbidity. The program was targeted at reducing nonpoint source pollution, particularly from farm fields. A 15 percent reduction in sediment coming into the river and Lake Erie was proposed. Recreation in the river and improved quality of water supplied to two towns would be improved. A one-time tax was the payment vehicle, so the WTP is not annual. In this study, a mail survey of Ohio residents was used and obtained a 51 percent response rate after five follow-up mailings of either post cards or surveys. A dichotomous choice WTP question was used. Several econometric models were estimated. In the study's summary table of household benefits that were being generalized to the entire state of Ohio for improving, surface water was a minimum of $50 per household in 1994 dollars ($76 in 2011 dollars), two estimates of slightly more than $100 per household in 1994 (which translates into $157 in 2011 dollars). The author expands this to the entire state of Ohio which had 4.27 million households at the time of the study (1994). This yielded total state of Ohio benefits for protecting the Maumee River Basin of $673 million in 2011 dollars.

The third study (Herriges et al., 2010) is similar to the prior Iowa Clear Lake study by Azevedo et al. (2001) in that the same survey design is used (improving water clarity, reducing odor, algae blooms, etc.). Similar to the Azevedo et al. study, respondents were asked to value improving water quality at one lake. However, the sample in the Herriges et al. study is statewide residents rather than local residents living near the lake being valued, as was the Azevedo et al. study. Thus, the lake the respondents were asked to value is farther away than Clear Lake was from local respondents in the Azevedo et al. study. A voter referendum format to ask WTP was used. The Herriges et al. study had five different survey versions, one of which was purposefully vague about how the study results would affect Iowa Department of Natural Resources decisions about lake cleanup compared with the other four versions. Herriges et al. put more faith in the WTP results from the four versions of what the authors called "consequential" survey versions (better linkage of survey to policy). An average of the WTP from these four versions was used to calculate average WTP of state residents for improving water quality at one lake in Iowa. The resulting average of the reported median WTP is $55 annually in 2004 dollars ($65 annually in 2011 dollars). This $65 compares to the more than $100 annual WTP of local residents living near Clear Lake's WTP to achieve the same level of cleanup of their nearby lake. The reader can see the WTP values, using the same survey design, vary in a logical fashion—people are willing to pay more to clean up a lake closer to where they live. The Iowa team also valued a good that is quite similar to Utah. Specifically, Egan, et al. (2004) conducted a statewide survey of Iowa households to collect data for valuing improvements in water quality to move 65 impaired lakes to non-impaired status. Iowa household annual WTP was $12.24 in 2004 ($14.56 in 2011 dollars). The authors generalized this value to all Iowa households at $16.776 million in 2011 dollars.

2.6.3 Statewide WTP for Improving Water Quality of State Water Resources

Perhaps the study most similar in scope to this study is Larson et al. (2001). Their study conducted a CVM mail survey of California households regarding their WTP for a program that would improve water quality in all lakes, rivers, streams, coastal waters, wetlands, and estuaries in California. This scope of this program is broader than the program in Utah because it includes coastal waters and estuaries. The increase in water quality was framed as raising water quality to levels that would be in compliance with state and federal clean water laws such that it would protect beneficial uses of that water type. A referendum CVM WTP question was used with an increase in water bills as the payment vehicle. The mail survey had a 60 percent response rate. The monthly WTP in 2000 dollars ranged from $15.46 ($20 in 2011 dollars) and $20.81 per month ($27 in 2011 dollars). Converting the average of these two numbers into annual WTP by multiplying by 12 months yields $285.56 in 2011 dollars. They then generalized their sample WTP to all 10 million households in California, which in 2011 dollars would over $2 billion per year.

2.6.4 Nationwide WTP to Avoid a Regional Reduction in Water Quality

The most recent national stated preferences study of water quality is by Viscusi et al. (2008). During 2004, a nationally representative web panel sample of slightly more than 4,000 respondents was obtained and a response rate of 75 percent obtained from this panel sample. The study valued having water quality of lakes and rivers in "good" condition, where good is defined as water safe to swim; fish are safe to eat; and the water supports a large number of plants, fish, and other aquatic wildlife. Drinking water was explicitly excluded from the valuation task. Respondents were told that 65 percent of the nation's water resources are in good condition (meeting this definition). The payment vehicle was increased cost of living. Individuals were asked to value changes (increases or decreases) in water quality at water resources in a region that was within 100 miles of their home. This radius was chosen since this is the distance that about 80 percent of water based visitors travel. The respondent was asked a dichotomous choice or "paired comparison" trading off cost of living in each region and percent of water resources in good condition. Within the same internet survey, individuals were asked a conjoint task as well. The annual average household WTP per percent change in water quality is $31.70 in 2004 dollars, or $37.72 in 2011 dollars. Median household WTP per person is considerably lower at $13.23 in 2004 dollars ($15.74 in 2011 dollars) per percent change. The benefits for a 6 percentage point change in the number of lakes and rivers in the good condition is calculated by the authors to be $196.54 per household in 2004 dollars ($234 in 2011 dollars). This value is generalized to just the population living in the region the respondent valued and then added up across all regions of the U.S. to arrive at a total WTP of $21.8 billion in 2004 dollars ($26 billion in 2011 dollars) to avoid a reduction in water quality.

2.6.5 Nationwide WTP for Nationwide Improvement in Water Quality

The Mitchell and Carson (1984) study was the first national CVM WTP study of improving water quality. This study emphasized the use benefits of improving water quality to water-based recreationists and nonvisitors in the form of asking a nationally stratified sample their WTP to improve all U.S. water bodies to a water quality to a fishable level. A payment card was used to elicit WTP. Higher taxes and product prices was the payment mechanism. Water-based recreationists reported a total WTP of $258 in 1981 dollars (Fisher and Raucher, 1984), or $643 in 2011 dollars. Households that were not visitors to water-based recreation would pay $121 in 1981 dollars ($301 in 2011 dollars). The WTP of these nonvisiting households reflect what is termed passive use values but were sometimes referred to as intrinsic values (Fisher and Raucher, 1984). Table 2-1 provides a summary of this literature.

TABLE 2-1
Total Economic Value of Water Quality Improvement Study Summary

State	Good Being Valued	Payment Mechanism	WTP Question Format	Survey	Annual WTP per Household in $2011	Generalized to Population Surveyed?
Colorado-South Platte River in urban Denver Front Range	WTP to bring water from polluted (green) to clear	Water bill	Iterative bidding	Interviews	$120	Yes
Lake Mendota (urban lake in Wisconsin)	Reduce algae related nutrients by 50 percent	Combined income and property taxes	Multiple bounded dichotomous choice	Mail	$463 (present value)	Yes
Clear Lake, Iowa	Maintain water quality	Local and state taxes	Referendum dichotomous choice	Mail	$144	Not evident
Montana in Flathead (state largest lake in rural area)	Protect water quality in Flathead Lake	Payment into a fund	Open-ended WTP	Mail	$168	Yes
Monogahela River Basin (WV, PA)	Boatable to fishable	Higher taxes and product prices	Open-ended WTP	Interviews	$165	Not evident
Major river basin in Ohio that drains into Lake Erie	Reduce algae and turbidity and increase sport fish	Tax	Dichotomous choice	Mail	$157	Yes
One lake in Iowa	Maintain water quality	Local and state taxes	Referendum dichotomous choice	Mail	$65	Not evident
Sub-state regional water quality	Maintain good water quality	Cost of living	Dichotomous choice	Internet	$234 for a 6 percent change or $38 for each 1 percent	Yes
California	Improve water quality statewide to support all beneficial uses	Water bill	Dichotomous choice	Mail	$285	Yes
U.S. TEV water based users	Improve water quality from boatable to fishable levels	Higher taxes and product prices	Payment card	Interviews	$643	Yes
U.S. Passive Use Value of Nonusers	Improve water quality from boatable to fishable levels	Higher taxes and product prices	Payment card	Interviews	$301	Yes

3.0 Designing the Questionnaires

As discussed in the previous section, protecting water quality in Utah's lakes and rivers results in a number of benefits that may have economic value. These benefits arise from the services provided by surface water resources, such as opportunities for healthy and enjoyable water-based recreation and maintaining healthy aquatic ecosystems for future generations. Utahns may derive direct use benefits arising from improvements in the water quality of Utah's lakes, rivers, and streams to the extent that cleaner water enhances the recreation experience. They may also place a positive economic value on improving and maintaining the state's waters for the quality of life of future generations. Further, water quality improvements that enhance biodiversity may, at first, only benefit humans indirectly, yet ultimately these enhancements will likely provide direct benefits through improved fishing opportunities and/or passive use values associated with maintaining healthy and diverse fish communities. Thus, it is important to communicate the ways in which the levels of nutrients in surface waters can affect people so that they, in turn, can express their informed preferences and values for maintaining and improving water quality in Utah water bodies. This section describes the two questionnaires that were designed for this study, which together provided the data to estimate the value Utahns hold for improved water quality expected as a result of implementing numeric nutrient criteria.

3.1 The Total Economic Value Questionnaire

The TEV of adopting numeric nutrient criteria is the sum of the direct use and passive use values. Neither of these values – direct use and passive use – is observed in the market. As covered in the previous section, economists have developed several approaches for measuring the nonmarket economic benefit associated with a change in the provision of a nonmarket resource such as water quality. The method used in this study was CVM. CVM relies on a survey instrument to elicit respondents' statements about their WTP for a change in water quality.

The resulting design of the TEV questionnaire, discussed below, was informed by work previously conducted by others including the Iowa State Lakes and Rivers Survey (see http://www.card.iastate.edu/environment/nonmarket_valuation/iowa_lakes/) and research on the economic valuation of benefits from reducing nutrient levels completed by researchers at North Carolina State University (Roger H. von Haefen, North Carolina State University, personal communication).

3.1.1 Structure of the TEV Questionnaire

The TEV questionnaire is presented in Appendix A and consisted of six sections. The first two sections served to establish the context for the WTP scenario and provided respondents with sufficient information for deciding whether or not they preferred to pay for an enhanced nutrient reduction program. Specifically, the survey began with information about nutrients, their sources, and the changes in water quality that result from excess nutrients. After reading this material, respondents were asked to reveal the level of importance they personally placed on preventing a number of changes to aquatic ecosystems that are caused by excess nutrients.

The second section described current and future water quality conditions of lakes and rivers combined as a function of nutrient concentrations. Respondents were informed that although DWQ already limits the amount of nutrients that can enter surface water, nutrient concentrations will increase and the quality of Utah's lakes and rivers will degrade over time with population growth. The follow-up question in this section was structured to gauge the respondent's passive use value for water quality, as well as the importance of cost (how much and to whom) Utahns are willing to pay to manage excess nutrients.

The third section introduced DWQ's proposed Nutrient Reduction Program that would further limit the amount of nutrients that reach Utah's lakes and rivers. It included a brief description of the various mechanisms that will be used in the proposed program to meet the new standards. Respondents were informed that the new program would be financed through an increase in monthly water and sewer bills (what is called the bid or payment vehicle) and that the cost of the program would be shared by households, businesses, and industry in proportion to their share of total nutrient discharge. The monthly water and sewer bill was chosen as the bid vehicle because it was the most relevant means of assessing costs for the program and, as such, would be deemed by respondents as being the most plausible approach to collect the necessary funds.

The change in water quality to be valued was presented as two future states of overall water quality: one with the current regulation to limit nutrients and the other with the Nutrient Reduction Program in place. Then the valuation question asked respondents to choose either the current regulation to limit nutrients at no additional cost to their household or the Nutrient Reduction Program at a specified additional cost to their household. This bid price was varied across respondents to analyze the likelihood of voting for the enhanced reduction of nutrients as a function of the cost to the household. This dichotomous-choice format (also known as referendum or "take it or leave it") is cognitively less challenging than asking respondents an open-ended question about how much they would be willing to pay for such a program. Furthermore, the voting approach mimics a real-life referendum, which is familiar to households and resembles the market decision making process whereby a good is offered at a certain price and the consumer decides whether to buy it at that price (Cameron and James, 1987). These features have been shown to increase the reliability and validity of the results. It is worth noting that in some circumstances it is possible to improve upon this approach by first offering one bid price and then following-up with a higher or lower bid price if the respondent accepted/rejected the initial offer (Hanemann et al., 1991). Although statistically more powerful, this approach does not work in a mail survey, where respondents can see that the next question is contingent upon their answer to the first question. Also, the National Oceanic and Atmospheric Administration Blue Ribbon Panel on contingent valuation surveys recommends the single offer price for its compatibility with a voter referendum (Carson and Groves, 2007).

Next, the survey included three debriefing questions that enabled respondents to explain their votes. The first question asked the respondent how certain they were of their answer to the valuation question. This information was used to estimate a lower bound on household WTP (discussed in more detail in Section 5.2). The remaining two questions were structured so as to separate out economically valid reasons for not being willing to pay the bid amount (for example, they do not value the good or cannot afford to pay) from those responses that may not actually reflect a respondent's benefits arising from the Nutrient Reduction Program. People who voted no for the Nutrient Reduction Program because they reject one or more aspects of the CVM scenario are often referred to as protest bidders. Their protest responses may include that the program is unrealistic or it is unfair to expect them to pay (for example, others such as the government or industry should pay the entire cost). These protest responses are usually dropped from the analysis as their responses do not provide accurate indications of the benefits they may receive from the program specified in the survey. In this study, protest bids were not dropped from the analysis, which is one of many decisions that were made to make the valuations as conservative as possible.

As previously mentioned, economic benefits arising from water quality improvements may be quantified as direct use values and/or as passive use values. Therefore, the fourth section of the survey included questions on the household's use of rivers and lakes in Utah over the last 12 months and also gathered information on the main activity the household engaged in during their visits.

Unique to this CVM survey was the inclusion of a series of photos (in section five) depicting rivers with varying levels of nutrient loading as measured by benthic chlorophyll-a concentrations. Respondents were asked to review the photographs and, for each one, indicate whether the level of algae would be desirable or undesirable for their most common uses of a river, if any. These data will be used by DWQ to compare Utahns' perspective of desirable river water quality conditions to a similar study conducted in Montana (Suplee et al., 2009). Ultimately, these responses provide a direct tie from one deleterious effect of nutrients—excessive algae growth—to recreation beneficial uses. Several states have used such ties to establish recreation numeric criteria and DWQ is considering similar action.

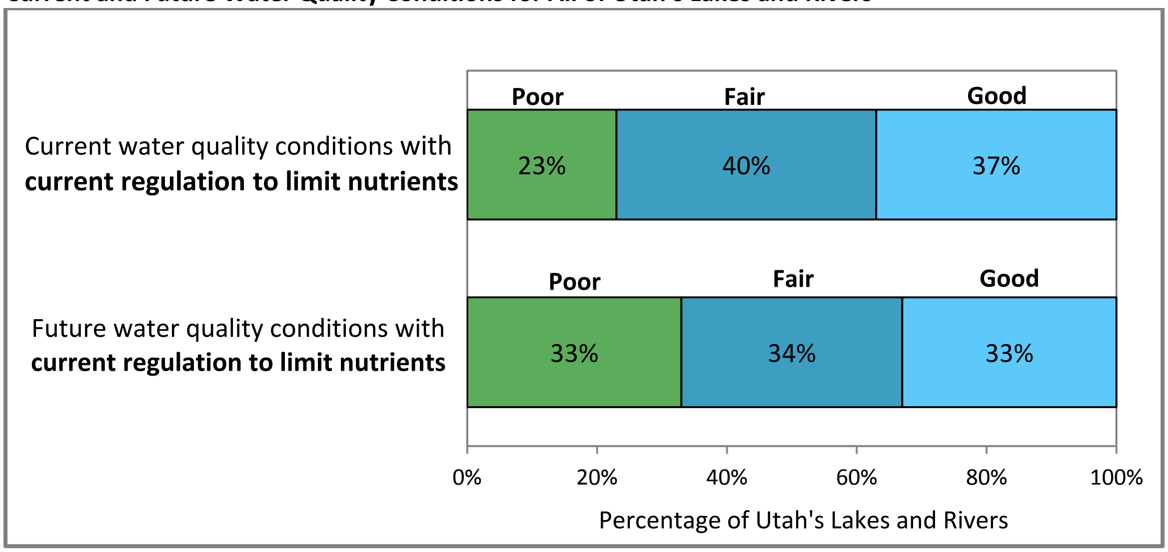
The sixth section of the TEV questionnaire consisted of demographic questions to measure factors that may affect an individual's WTP. Demographic data are also used to evaluate the representativeness of the sample to the target population so that adjustments can be made if the demographic make-up of the returned questionnaires is not representative of Utah's households (for example, more male, more wealthy, more educated).

3.1.2 The Science Used to Develop the Valuation Scenario

In order for respondents to make informed judgments of their WTP, they should be given adequate, unbiased information on the good and its hypothetical market. The good in this case is the change in water quality resulting from the implementation of nutrient criteria. The survey design challenge is to characterize the expected changes in surface water quality in a meaningful way to respondents, while retaining scientific accuracy so that they can make informed decisions.

The valuation scenario in this study was based on DWQ's assessment of current and future states of water quality for all of the state's lakes and rivers combined. Water quality condition was described as being Good, Fair, or Poor. Water bodies classified as having Good water quality were described as having the "right amount" of nutrients to support aquatic life, supply drinking water free of odor and taste issues, and provide high-quality recreation such as trout fishing. Poor water quality was described as having excess nutrients that caused frequent algae blooms, changes in composition of fish species such as trout, reduced biodiversity, degraded aesthetics, resulted in lower-quality recreation, and degraded drinking water aesthetics. The Fair category was described as having water quality characteristics in between Good and Poor. Figure 3-1 shows the current and future water quality conditions for all of Utah's lakes and rivers according to DWQ's assessment.

FIGURE 3-1
Current and Future Water Quality Conditions for All of Utah's Lakes and Rivers



A report detailing the methodology and results for evaluating the nutrient conditions in Utah's water bodies is provided in Appendix B. For the assessment of current conditions, DWQ used data and methods from EPA's National Lakes Assessment (EPA, 2009) and Environmental Monitoring and Assessment Program (EPA, 2008b). The EPA approach selected water bodies considered to be in reference condition to determine good, fair, and poor thresholds for lakes (based on chlorophyll a) and streams (based on total phosphorus and total nitrogen) by ecoregion. Based on the thresholds for Western Mountains and Xeric West ecoregions, DWQ classified randomly selected monitoring sites in Utah as good, fair, or poor. The percentages in each class were extrapolated statewide based on surface area for lakes and length for streams.

Based on the existing science and their best professional judgment, DWQ provided two potential scenarios on the future state of water quality: an ultra-conservative (or worst-case) estimate and a conservative best-case estimate. These two scenarios resulted in two versions of the survey.

In one version of the survey, implementation of the Nutrient Reduction Program would, over the next 20 years, maintain current water quality conditions (this version of the survey will hereafter be referred to as "Maintain"). Under the Maintain scenario, it was estimated that the Nutrient Reduction Program would just offset the increased loading of nutrients resulting from population growth.

In the second version of the survey, implementation of the Nutrient Reduction Program would, over the next 20 years, improve water quality conditions as compared to current conditions (this version of the survey will hereafter be referred to as “Improve”). Under the Improve scenario, it was estimated that the Nutrient Reduction Program would result in reclassifying approximately 78 percent of the Poor water bodies to Fair, and 20 percent of the Fair water bodies to Good.

In both versions of the survey, the future state of water quality resulting from adopting numeric nutrient criteria was compared with the future state of water quality with only the current regulation to limit nutrients. Because of population growth, DWQ expects nutrient concentrations to increase and the quality of Utah’s lakes and rivers to decrease over time in the absence of additional nutrient reduction programs. Based on nutrient trend analyses conducted by the U.S. Geological Survey (Sprague et al., 2009), it was estimated that 25 percent of Fair water bodies would be reclassified as Poor and 11 percent of Good water bodies would be reclassified as Fair. Figures 3-2 and 3-3 depict the valuation scenarios as presented in the Maintain and Improve versions of the survey, respectively.

FIGURE 3-2
Future Water Quality Scenario—Maintain Version

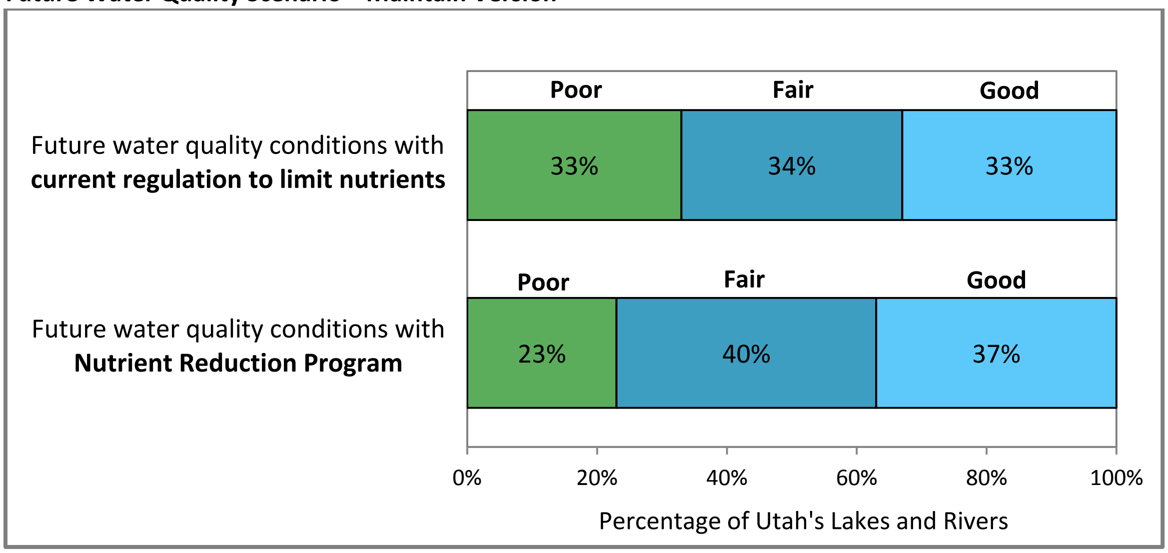
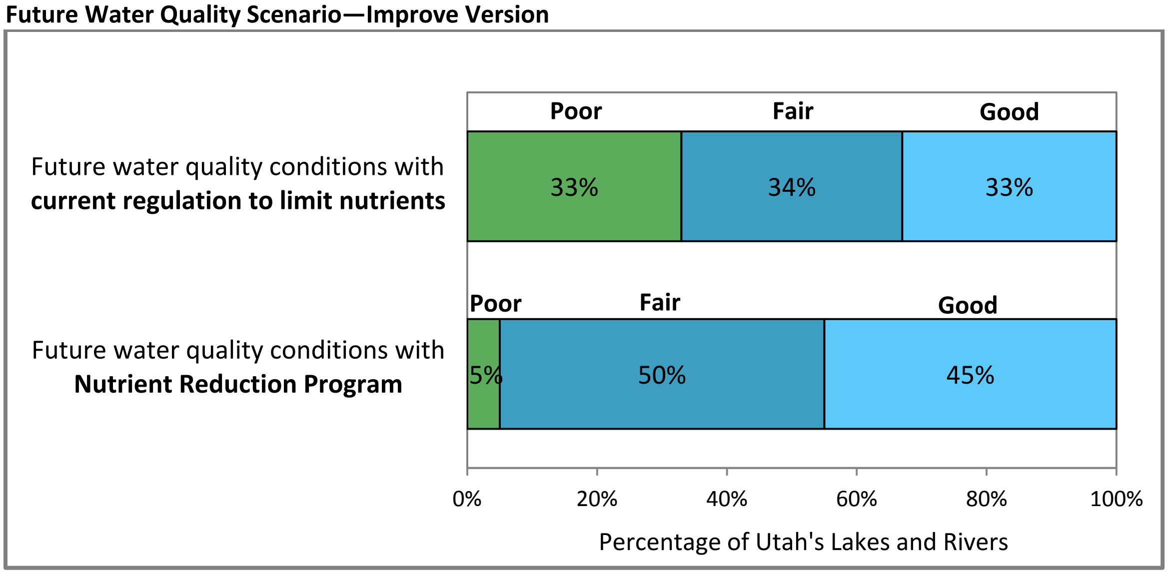


FIGURE 3-3
Future Water Quality Scenario—Improve Version



3.1.3 Specifying How the Respondent Will Pay and the Willingness to Pay Question

While Figures 3-2 and 3-3 describe the good to be valued, to elicit an economic value of these two water quality scenarios it is necessary to specify a realistic means for how they would pay for them. As described in Section 3.1.4, it was determined that a water bill would be used as the means of payment or payment vehicle.

Thus, respondents were told, "If a majority of people favor the new program, it will be paid for by increasing the amount each household and business will pay for their monthly water and sewer bill. If you do not currently receive a water and sewer bill (for example, you rent your home or your house is on a septic system), you will receive a separate monthly bill for this program. The funds collected will be used to implement and enforce the Nutrient Reduction Program."

Respondents were then told that to maintain (or improve) water quality, that the "Nutrient Reduction Program will require:

- Upgrades in wastewater treatment plants for treating sewage from your home, your neighbors' homes, and businesses
- Programs to encourage proper application of lawn fertilizers and maintenance of septic systems
- Structures to control storm water runoff from streets, parking lots, and roof-tops
- Improvements to agricultural nutrient management practices."

They were then told, "The costs of the program will be shared between households, businesses, and industry in proportion to their share of total nutrient discharges. The share of the cost for each Utah household will be an additional $YY per month." The $YY dollars ranged from $2 to $50 based on the pretests described in Section 3.1.4.

Respondents were then shown either Figure 3-2 or Figure 3-3, depending on whether they received the Maintain or Improve version of the survey, and were asked if they would pay the increase in their monthly water bill for the Nutrient Reduction Program versus staying with the current regulations at no additional cost. They were then instructed to choose one of these two options. The questionnaire was limited to showing only one of the two future scenarios for several reasons. First, the need to preserve statistical power—the ability to reject the null hypothesis when the null is false—which is a function of sample size and the magnitude of the effect being tested. Second, the desire to keep the questionnaire to an eight-page booklet, a survey design element that can influence whether a potential respondent will return a completed survey. Thirdly, the project had to balance the data collection effort with cost.

To implement the uncertainty recoding, they were then asked:

"How sure are you of this answer? *(circle your answer)*"

1	2	3	4	5	6	7	8	9
(not sure at all)				(somewhat)				(certain)

3.1.4 Focus Groups and Pretests

The final versions of the survey previously discussed were the result of several focus groups and pretests. The focus groups began early in the study process after the basic issues with nutrient and nutrient reduction were developed by DWQ and visual aids and a completed draft of the key components of the survey were in hand. Three focus group sessions were conducted with the main intent of clarifying the description of the problem (water quality degradation resulting from excess loading of nutrients to surface water) and the valuation scenario (the description of the proposed Nutrient Reduction Program and who would pay for the program). The focus groups also provided helpful suggestions for rewording or reordering certain questions on the survey instrument. Changes were made to the survey instrument after each focus group that reflected the feedback received.

After the research team completed introductions, participants were asked to complete the first section of the draft of the questionnaire as well as an accompanying set of clarifying questions. That was followed by an in-depth discussion of the participants' perceptions and suggestions for improving the survey. The completed survey and accompanying questions were collected before providing the participants with the next section of the survey and a new set of clarifying questions. This process was repeated until the focus group made it through the entire survey. Two of the lead researchers on this project served as the facilitators for the discussions. The focus groups, each about 2 hours in duration, were held in Fort Collins, Colorado, on April 12, 2011; Ogden, Utah, on May 10, 2011; and Logan, Utah, on May 31, 2011. The focus groups were held in a meeting room of a local hotel in the evening. Potential participants were recruited through advertisements in local newspapers serving their respective communities. The final list of participants was selected for demographic diversity based on a short set of screening questions asked of those who responded to the ad by phoning the Wyoming Survey and Analysis Center (WYSAC) toll-free number. Participants were compensated $50 each.

A pretest of the TEV Survey was conducted by volunteers from the CH2M HILL Salt Lake City Office resulting in 81 completed questionnaires. In addition to checking for any additional improvements in question wording, the major purpose of the pretest was to finalize the range of prices to be used in the valuation scenario—the "bid vector." Pretests help to ensure that the bid vector covers an appropriate range of values for the environmental good under consideration. The range of the bid vector in the pretest was from $5 to $25, in $5 dollar increments. The results of the pretest indicated that the potential upper limit of Utahns WTP was not reached. Based on this finding, the final bid vector ranged from $2 to $50 to ensure that bid values encompassed the upper limit of WTP.

3.2 The Recreation Questionnaire

Those who engage in near-water and water-based recreation in Utah are direct beneficiaries of improvements in nutrient loading of surface water. Also, by their direct experience with using the state's surface waters, this group is expected to have more well-formed preferences about water quality than households who do not directly use the lakes, rivers, and streams of the state. The main purpose, therefore, of the Recreation Survey was to collect data on the current recreation decisions of Utah households and analyze the extent to which the current water quality influenced their decisions about which water bodies to visit. Simulations of these recreation demand models for lake, river, and stream destinations in Utah show how households change their destinations in response to water quality improvements at specific water bodies. The recreation demand models are also used to estimate the increase in economic value of recreation opportunities in Utah from implementing numeric nutrient criteria. This study did not attempt to estimate the monetary benefits accruing from visitors to the state. As such, the benefit estimates resulting from Utahns engaging in water-based recreation are considered the lower bound of all potential benefits derived from water-based recreation in the state.

3.2.1 Structure of the Recreation Questionnaire

The Recreation Survey is shown in Appendix C and consisted of four parts. The first part asked respondents to list all-day trips and overnight trips their household took to lakes and rivers in Utah in the last 12 months. Additionally, respondents were asked to give a detailed accounting of the money they spent on their most recent lake trip and river trip in the last 12 months. Data on actual recreation visits "reveal" the choices made under baseline conditions and thus constitute the "revealed preferences" of respondents. These data will be used to estimate a recreation demand model. This study allowed for households who did not engage in water-related recreation, either directly or nearby, to provide answers to demographic questions. The inclusion of nonusers in the dataset allowed for weighting the data to known demographic data on Utah households. See Section 4.3 for a detailed discussion on weighting the recreation data.

Part two is composed of questions about lakes. Respondents were asked about the types of activities they and members of their household engaged in while visiting lakes as well as the primary activity during their lake visits. Next, for the lake site visited most often during the summer, respondents were asked to give the name of the lake and their perceptions of lake water quality. This series of questions was immediately followed by a similar set of water quality-related questions; however, respondents were asked to state the level of water quality at which they would no longer visit the lake they visited most often in the summer. Data on intended visitation—in this case, having zero visits—given hypothetical changes in water quality represent intended behavior and thus are characterized as “stated preferences.”

Part three of the Recreation Survey essentially asked the same series of questions with a focus on rivers. The research team believed the differences in cultural eutrophication as experienced by anglers, boaters, swimmers, and near-water users necessitated questions on both lakes and rivers within the survey.

The final section of the survey asked demographic questions that were believed to influence a household’s recreational choices. Demographic data are also used to ascertain the representativeness of the sample relative to the target population.

3.2.2 The Science Behind the Water Quality Attributes in the Recreation Survey

As described earlier, the Recreation Survey asked respondents to state their preferences for desirable levels of water quality. Specifically, respondents were asked to indicate the level of water quality at which point they would no longer visit the lake or river they visited most often that summer. The difficulty in designing a stated preference scenario linking excess nutrients to degraded water quality is that the biological responses to excess nutrients are site-specific. Therefore, several indicators of water quality were selected. The selected indicators are affected by nutrient concentrations and were considered to influence people’s preferences for site selection. Respondents were asked to evaluate these indicators separately. Further, at least one water quality measure that responded directly to changes in nutrient concentrations, yet resonated with the general public with regard to their preferences for selecting a lake or a river to visit, was needed. This was necessary to link the respondents’ stated preferences for water quality back to actual changes in nutrient concentrations.

The nutrient-sensitive water quality indicators chosen for lakes and rivers were water clarity and benthic algae coverage, respectively. Table 3-1 matches the water clarity depth for lakes to aquatic ecosystem trophic states and the corresponding range of nutrient concentrations in accordance with Carlson (1977). For rivers (Table 3-2), benthic algae type and coverage were more generally associated with benthic chlorophyll a and trophic state of the river in accordance with EPA (2000b). The “brownish green and short” type represents diatomaceous benthic algae and the “dark green and long” type represents filamentous benthic algae. Photos were provided in the survey to show each type. Even extensive coverage of diatomaceous algae can result in relatively low benthic algal density and low trophic state, whereas limited coverage of filamentous algae can result in high algal density and elevated trophic state.

TABLE 3-1
Aquatic Ecosystem Trophic Class vs. Levels of Lake Water Clarity in the Recreation Survey

Trophic Class	Trophic State Index (TSI)	Chlorophyll-A (µg/L)	Total Phosphorus (µg/L)	Water Clarity Depth* (feet)
Oligotrophic	< 40	<7.3	<12	>12
Mesotrophic	40 to 50	2.6 to 7.3	12 to 24	12
Eutrophic	50 to 70	7.3 to 56	24 to 96	6
Hypereutrophic	>70	>56	>96	1

***** Prefatory wording: “Which of the following **water clarity** depths would result in you no longer visiting this lake? You can see at most [depth] deep into the water.”

TABLE 3-2
Aquatic Ecosystem Trophic Class vs. Levels of River Bottom Algae Coverage in the Recreation Survey

Trophic Class	Chlorophyll a (mg/m^2)	Algae Type	Algae River Bottom Coverage*
Oligotrophic	<20	Brownish green and short	Less than 10 percent
Mesotrophic	20 - 60	Dark green and long	10 to 40 percent
Eutrophic	60 - 200	Dark green and long	40 to 75 percent
Hypereutrophic	>200	Dark green and long	More than 75 percent

*Prefatory wording: "Which of the following amounts of **algae (dark green and long in length)** covering the river bottom in **late summer** would result in you no longer visiting this river? Covers [percent] of river bottom."

An answer option to the stated preference questions not presented in Tables 3-1 and 3-2 was that the particular water quality indicator (water clarity/benthic algae coverage) did not play a role in the respondent's decision to visit this site (lake/river). The analyses of these data will be conducted as part of a future effort.

3.2.3 Focus Group and Pretesting

Nelson and Jakus completed a series of three focus groups to test question formats, answer sets, length of the survey, and clarity and believability of the stated preference questions for the Recreation Survey. Each focus group was conducted in the same manner as the TEV Survey focus groups described in Section 2.1.3 including the manner in which participants were recruited and compensated. Focus groups were held May 9, 2011, in Logan, Utah; May 12, 2011, in Salt Lake City, Utah; and June 2, 2011, in Logan, Utah. A pretest of an abbreviated version of the Recreation Survey was completed using volunteers from CH2M HILL's Salt Lake City office on June 30, 2011. After 1 week, a total of seven questionnaires were returned. The intent of the pretest was to check question wording, specifically the instructions for using the enclosed maps to identify sites visited in the last 12 months and revealing a respondent's perception of water quality at the site visited most often.

4.0 Administering the Surveys

4.1 Sampling, Field Period, and Participation Rates for the TEV Survey

The target population for the TEV Survey was all households in Utah. Given the need to obtain responses from those who engage in recreation on or near the state's waters as well as those who don't engage in water-based activities, WYSAC at the University of Wyoming conducted a mail survey using a random sample of mailable addresses that was representative of all Utah households. WYSAC purchased a single address-based sample of 2,700 mailable addresses (based on the U.S. Postal Service Delivery System File) from a national vendor (Marketing Systems Group). This address-based sampling meets the intent of the study's data quality objective (DQO) to represent all households in Utah.

In addition to the address-based sampling frame, the "last birthday" method for within-household selection of one adult respondent was used. Previous research has shown that the birthday method gives an acceptable approximation to pure random selection, as long as children are not part of the target population (see Grandjean et al., 2005). Instructions in the cover letter and also on the questionnaire itself asked that it be completed by "the adult in your household who has most recently had their birthday."

Communication for the mail survey began with a pre-survey contact letter to all addresses in the sample (see Appendix A). These letters went out in batches over several days, with the first batch being mailed on August 8, 2011. A week after each batch of contact letters, the corresponding batch of questionnaires (with cover letters) was mailed. About 2 weeks after sending the questionnaires, reminder postcards went out (in batches) to nonrespondents, excluding cases that had been identified by the Postal Service as undeliverable.

Two to three weeks after the reminder postcard, a second copy of the questionnaire (with a slightly revised cover letter) was sent to each remaining nonrespondent. The mailing of these replacement questionnaires began on August 29, 2011. About 2 weeks after mailing the replacement questionnaire, 590 questionnaires had been received. The targeted completion number for the TEV was 650. Hence, a third mailing of the questionnaire to all nonrespondents was conducted, which commenced on September 23, 2011.

The field period for the TEV Survey ran from July 23, 2011, through November 8, 2011. A summary of the survey effort for the TEV Survey is shown in Table 4-1. As can be seen, the survey effort came within 25 surveys of meeting the target of 650 completed surveys, so for all intents and purposes the DQO for this element of the study is met. Random samples of 625 yield a margin of error of about ±4.0 percentage points with 95 percent confidence.

TABLE 4-1
Survey Effort for the Total Economic Value Survey

Survey Effort	Mailing sequence	N
Initial	Contact letter	--
Minimal	Cover letter + survey, Reminder postcard	399
Ordinary	2nd cover letter + survey	191 (590)
Concerted	3rd cover letter + survey	35 (625)

NOTE:
Totals in parentheses are cumulative.

To calculate response rate, the formula identified by the American Association for Public Opinion Research (AAPOR) as Response Rate 1 (RR1) was used. The formula for RR1 includes the number of completed questionnaires divided by the number of cases of known eligibility plus the cases of unknown eligibility (AAPOR, 2011).

To be eligible for the mail survey, the questionnaire had to reach a private U.S. household, not a business or government office. Further, the questionnaire had to be completed by an adult member of the household with the most recent birthday and who was able to read in English. Because the target population was all Utah households, all addresses regardless of whom the current occupant was sampled, as opposed to a specifically named person.

Of the initial sample of 2,700 mailable addresses, the mailing efforts identified 250 undeliverable addresses. These addresses were considered ineligible. The RR1 for the TEV Survey was 25.3 percent. Since the survey response rate is slightly below the DQO target of 30 percent, a thorough analysis of nonresponse bias and any needed adjustments were made to the statistical analysis (for example, weighting of observations to better match the demographics of the state of Utah) undertaken where necessary. As described in Appendix D on nonresponse bias, survey nonresponse bias was absent. As described in Section 4.3, a weighting of the sample based on three categories of demographic variables was performed to bring the in-sample data into alignment with state demographics.

4.2 Sampling, Field Period, and Participation Rates for the Recreation Survey

The target population for the Recreation Survey was all households in the state of Utah that engage in near-water or water-based recreation. However, the ability to draw a random sample from such a population is not possible because a complete list of all members of this population does not exist. Therefore, a random sample of mailable addresses that was representative of all Utah households was used. A targeted sample of mailable addresses in Utah was also used given the concern with the lower than expected response rate for the TEV Survey (around 25 percent). The targeted sample consisted of households that were believed to engage in water-based recreation with an estimated probability of 70 percent. The 70 percent probability of engaging in water-based recreation was based on past purchasing habits and/or a voluntary response to a survey on recreation and water (M. Fahimi, Marketing Systems, personal communication). The purpose of using a dual-sampling frame was to get the minimum number of returned questionnaires needed for the analysis while remaining within budget.

WYSAC purchased two samples from a national vendor (Marketing Systems Group): (1) an address-based sample (ABS) of 2,000 mailable addresses (based on the U.S. Postal Service Delivery System File); and (2) a targeted sample of 2,600 mailable addresses of households that are known to recreate on Utah's waters. Before drawing the targeted sample, the sample vendor purged the targeted population of any addresses that appeared in the random address-based sample.

In addition to the dual-sampling frame, the "last birthday" method for within-household selection of one adult respondent was used. Instructions in the cover letter and also on the questionnaire itself asked that "the adult in your household who has most recently had their birthday" complete it.

The same communication steps outlined for the TEV Survey in Section 4.1 were implemented for the Recreation Survey. However, a third mailing of the questionnaire was not needed as the target of 1,000 completed surveys after the second mailing was met. The field period for the Recreation Survey ran from September 6, 2011, through January 10, 2012. Random samples of 1,411 yield a margin of error of about ±2.7 percentage points with 95 percent confidence.

TABLE 4-2
Survey Effort for the Recreation Survey

Survey Effort	Mailing Sequence	Address-Based Sample (n)	Target (n)	Combined (n)
Initial	Contact letter	--	--	--
Minimal	Cover letter + survey, reminder postcard	87	193	280
Ordinary	2nd cover letter + survey, reminder postcard	288 (375)*	843 (1036)*	1109 (1411)*

***Totals in parentheses are cumulative.**

By the end of the entire field period for the Recreation Survey, the mailing efforts had identified 264 undeliverable addresses. The RR1 for the targeted sample was 40.9 percent, for the address-based sample it was 20.8 percent, and for the combined sample it was 32.5 percent.

4.3 Weighting

Weighting of survey data is a common practice. Here it was used to bring the distribution of survey respondents into line with known characteristics of the population. Further, for the Recreation Survey, the weighting process was also used as a means of combining the ABS sample with the targeted sample in a statistically defensible fashion. With post-stratification weighting, each sample of respondents should be representative of the entire population of Utah households.

Although the sampling design for the TEV Survey was based on a random sample of all Utah households, a comparison of the demographic data resulting from the survey to 2010 Census data on Utah households indicated notable differences (see Table 4-3). To reduce bias in the subsequent estimation of model parameters, weights were developed using the raking command, *ipfweight*, in Stata Version 12. Raking is an iterative proportional fitting algorithm that performs stepwise adjustment of survey sampling weights until known population margins are achieved. The household characteristics shown in Table 4-3 were the demographic dimensions used for raking.

TABLE 4-3
Differences in Household Characteristics between TEV Survey Data and 2010 Census Data

Household Characteristic	TEV Survey Data	2010 Census Data
Size[a]		
Adult householder living alone	16.1%	18.7%
Households with children	37.7%	43.3%
Racial Composition[a]		
White only	92.5%	91.4%
Income in the past 12 months[b,c]		
Less than $25,000	15.3%	17.8%
$25,000 up to $50,000	25.3%	25.7%
$50,000 up to $75,000	24.7%	22.1%
$75,000 up to $100,000	16.9%	14.4%
$100,000 up to $150,000	11.7%	13.2%
$150,000 up to $200,000	3.4%	3.7%
$200,000 or more	2.7%	3.0%

NOTES:
[a]Source: U.S. Census Bureau, 2010
[b]Source: U.S. Census Bureau, 2006 to 2010 American Community Survey
[c]Only four of the seven income categories were used in the raking procedure: less than $25,000; $50,000 up to $75,000; $75,000 up to $100,000; and $100,000 up to $150,000.

As previously described, the sample design used in the Recreation Demand Survey was a combination of (1) a "targeted" sample of households believed to engage in water-based recreation and (2) a random sample of the general population. The complex nature of the sample design resulted in the research team's decision to use a survey sampling statistician from Marketing Systems to develop the weights. A report describing the approach used is provided in Appendix E. The same set of household characteristics used in developing weights for the TEV Survey data were used to rake the Recreation Survey data. In addition, a geographic-based indicator was included in the raking. The indicator was based on two county-based regions defined as follows:

- **Northern Counties.** Box Elder, Cache, Daggett, Davis, Duchesne, Morgan, Rich, Salt Lake, Summit, Tooele, Uintah, Utah, Wasatch, and Weber
- **Southern Counties.** Beaver, Carbon, Emery, Garfield, Grand, Iron, Juab, Kane, Millard, Piute, San Juan, Sanpete, Sevier, Washington, and Wayne

4.4 Summary

To the best of the research team's ability, the specific protocols for sampling, administering the surveys, and data evaluation and assessment (as presented in Appendix F, the Quality Assurance Project Plan for this project) were followed. The purpose of the QAPP was to establish the DQOs that would ensure that the survey data collected for this study to evaluate the economic benefits of numeric nutrient criteria implementation were of appropriate quality. The desired outcomes from the survey data collection effort described in this section plus the analysis of these data described in forthcoming sections were to (1) ascertain water quality conditions that are deemed undesirable for recreation and (2) assess the benefits to Utahns of nutrient load reductions and the associate improvements in water quality. This section describes when additional measures were undertaken to ensure that the DQOs were met.

For both survey efforts, the goal of the survey was to accurately depict the attitudes, preferences, and/or activities of the study's target population (for example, all households in the state of Utah). A comparison of the demographic composition of the resulting survey sample against that of the state of Utah showed dissimilarities between the two groups. Post-stratification weighting was used to bring the survey samples in line with the known population proportions of key demographic variables for the state (see Section 4.3). Weighting can improve the accuracy of the parameter estimates; however, the cost of weighting is an increase their variance and thus a reduction in their precision (Dorofeev and Grant, 2006). Therefore, all significance tests in the econometric analyses presented in the following sections have been corrected to reflect the inflation in standard errors as a result of weighting (Dorofeev and Grant, 2006; Greene, 1993)

The TEV Survey effort resulted in a significantly lower response rate than anticipated, even after employing considerable survey effort (for example, a third mailing of the cover letter and questionnaire) to engage the household in responding to the survey. The concern with a low survey response rate is the possibility of nonrespondents differing systematically from respondents, which, if present, can introduce bias into the economic estimates of water quality improvements. To ensure this was not the case, an analysis of nonresponse bias was conducted. Results of the analysis of nonresponse bias indicates an apparent lack of correlation between a household's propensity to respond and their WTP suggesting negligible nonresponse bias. Therefore the sample WTP values are generalizable to Utah's population. The methods used in this analysis and the subsequent results are detailed in Appendix D.

5.0 Analysis of Total Economic Value

This section begins with a comparison of those households who visited Utah's waters to households who did not visit Utah's waters. The development and estimation of the econometric models of WTP for improved water quality from the implementation of numeric nutrient criteria follows. Unless otherwise noted, all results in Section 5 are based on data weighted to correspond to the Census demographics of Utah households (as described in Section 4.3). Appendix G provides unweighted frequency counts and percentages for every question in the TEV Survey.

5.1 Demographic Comparison of Users versus Non-Users of Utah's Surface Water Resources

In this study a user of Utah's waters is defined as those households who visited a lake, river and/or stream in the last 12 months. Nearly three-quarters (73.2 percent) of Utah households indicated that they were users (see Table 5-1). Just over half (53.2 percent) of Utah households visited both lakes and rivers in the past year while only 7.5 percent said they visited rivers only and 12.5 percent said they visited lakes only. Table 5-2 presents a demographic comparison of users versus nonusers in Utah. A different set of weights, based on census characteristics of Utah individuals, was applied to the data to generate the values presented in Table 5-2. The individual characteristics used for raking included gender, education and race.

Significant differences were observed between users and nonusers for gender and age. Users were significantly more male and younger than nonusers.

TABLE 5-1
Distribution of Utah Households by Water-Based Recreation

Nonuser	26.8%
User	73.2%
Both River and Lake	*53.2%*
River only	*7.5%*
Lake Only	*12.5%*

TABLE 5-2
Demographics of Utah Households by Water-based Recreation

Demographic	Non-user	User
Gender[a]		
Male	44.7%	52.1%
Female	55.3%	47.9%
Education		
Less than high school	7.1%	3.6%
High school graduate or GED	21.3%	18.6%
Some college or technical school	46.7%	47.6%
Undergraduate degree	7.7%	14.3%
Some graduate school	3.0%	3.2%

TABLE 5-2
Demographics of Utah Households by Water-based Recreation

Demographic	Non-user	User
Graduate degree	14.2%	12.7%
Age[b]		
18-24 years	1.8%	8.9%
25-34 years	10.8%	17.5%
35-44 years	9.6%	18.0%
45-54 years	10.2%	18.0%
55-64 years	24.7%	21.6%
65 years and older	42.8%	16.1%

[a] Pearson Chi-square test: p <.001
[b] Pearson Chi-square test: p <.10

Figures 5-1 and 5-2 summarize the importance Utah households assign to water quality-related issues associated with nutrient concentrations. Specifically, Figure 5-1 displays the order of importance that Utah households assign to preventing changes in water quality resulting from excess nutrients. Preventing unfavorable taste and odor of their drinking water, even after treatment, as a result of excess nutrients was of high importance to 86 percent of Utah households. Seventy-one percent of Utah households said preventing reduced water clarity, changes in color, and increased odor was of high importance. Figure 5-2 shows the order of importance when Utahns were asked to consider the quality of water in state. The maintenance of water quality for future generations was of high importance to 84 percent of Utah households.

FIGURE 5-1
Public opinion on the importance of preventing changes to water quality from excess nutrients

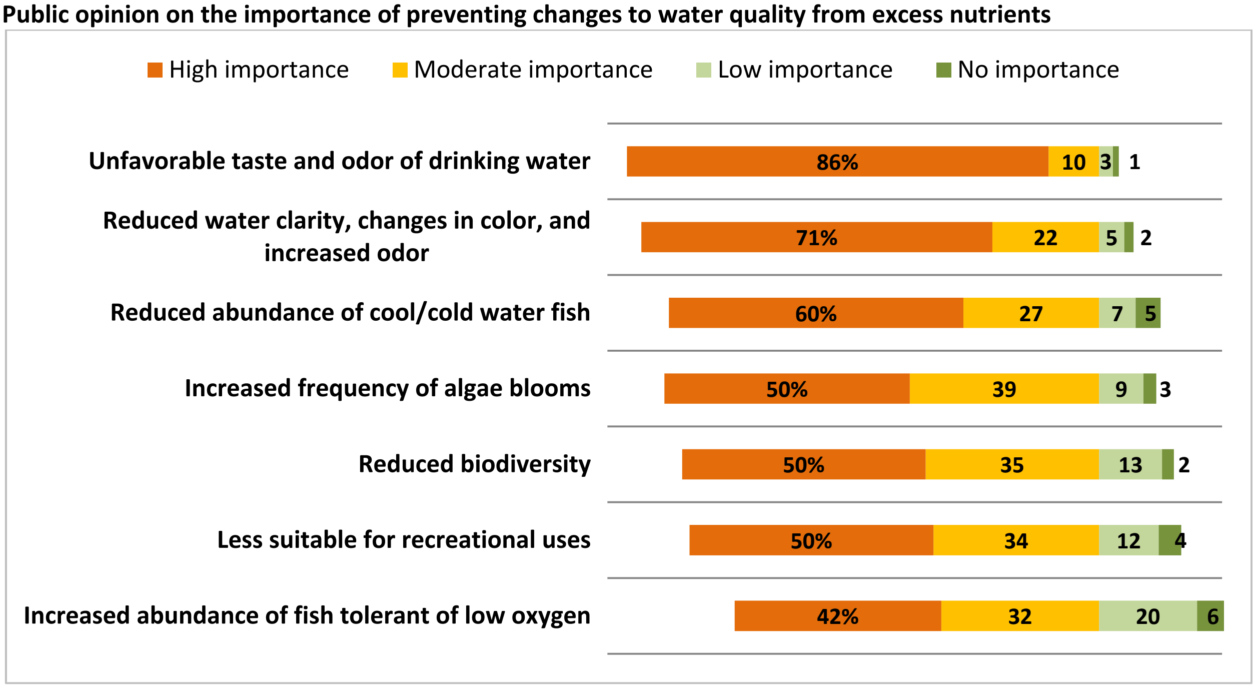
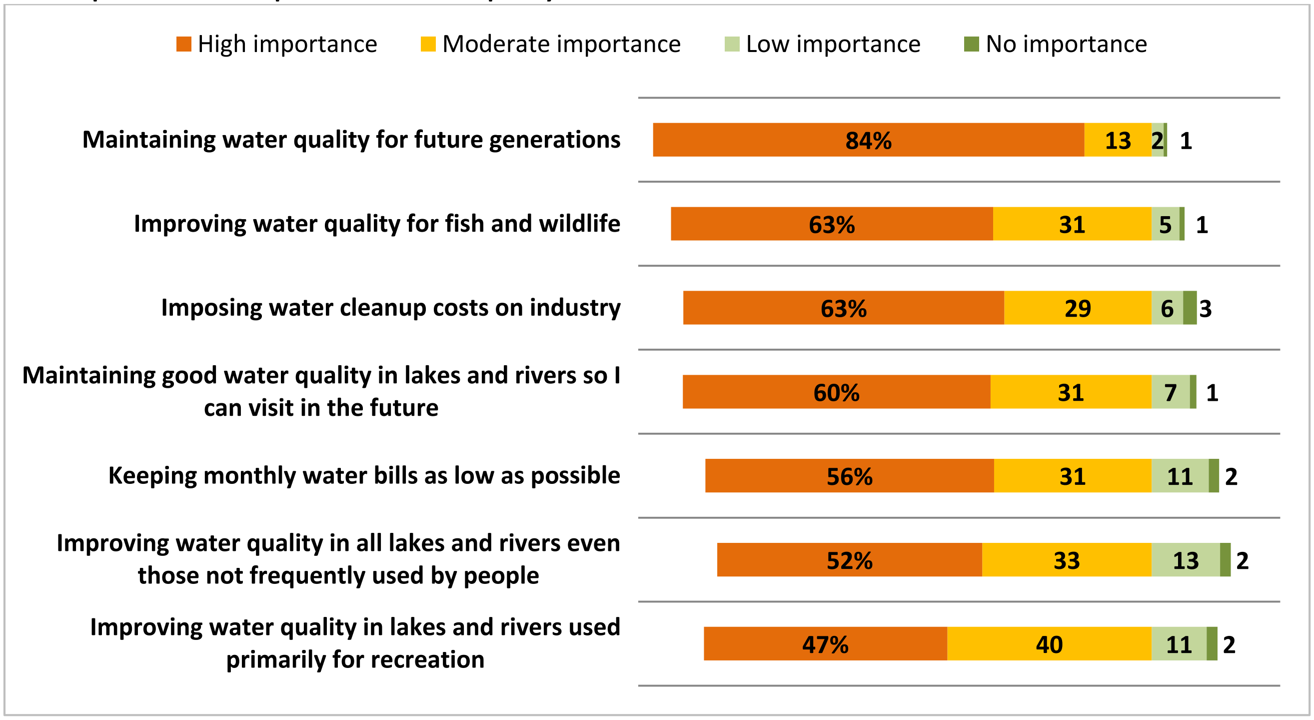


FIGURE 5-2
Public opinion on the importance of water quality-related issues in Utah



5.2 Statistical Model of WTP

Given the referendum format of the WTP scenario—household's respond with a "yes" or "no" vote to a single dollar amount—the probability they would pay a given dollar amount can be estimated using a logit model (Hanemann, 1984). The initial model was defined as:

$$\Pr(NutRedux = 1) = F(\beta_0 + \beta_1 \ln(Bid) + \beta_2 User + \beta_3 Improve + X_i'\beta + \varepsilon_i), \quad (1)$$

where *NutRedux* is the dependent variable and indicates whether a household was (or wasn't) willing to pay the specified bid amount; *Bid* specifies the increase in the household's monthly water and sewer bill; *User* indicates the household's use of lakes and/or rivers in the last 12 months; *Improve* indicates the version of future water quality presented to the household; X_i is a vector of demographic variables; and ε_i is an error term.

The bids respondents were asked to pay were selected at random, with equal probability, from the following bid vector (developed using focus groups and pretests):

Bid = ($2, 5, 7, 10, 12, 15, 20, 30, 40, 50).

Table 5-3 shows the percentage of respondents that accepted the various bids. Given the small sample size at each bid amount, it is not unusual that the percentage responding "yes" does not decline monotonically as the bids increase. Table 5-4 presents the definitions for the dependent and explanatory variables. The mean percentage of respondents accepting the offered bid was 49.8 percent.

TABLE 5-3
Percent Responding "Yes" to Offered Bid by Survey Version

Bid	Maintain % 'Yes'	Improve % 'Yes'
$2	76%	75%
$5	77%	68%
$7	42%	62%
$10	44%	54%
$12	63%	50%
$15	41%	47%
$20	40%	62%
$30	31%	51%
$40	29%	32%
$50	26%	31%

TABLE 5-4
Variable Definitions and Descriptive Statistics

Variable	Definition	Type	N
NutRedux	Voted 'yes' for the Nutrient Reduction Program	D	615
lnBid	Natural log of bid amount chosen from the set {$2, $5, $7, $10, $12, $15, $20, $30, $40, $50}	C	625
Improve	Survey version (coded 1 for Improve; 0 for Maintain)	D	625
Passive	Passive use value	D	618
Female	Gender (coded 1 for female; 0 for male)	D	614
Age	Age of respondent	C	609
College	Undergraduate degree or higher	D	615
Adult	Number of adults in the household	C	617
Child	Number of children (age ≤ 17) in the household	C	613
White	White	D	610
Income	Household income in the last 12 months	C	596

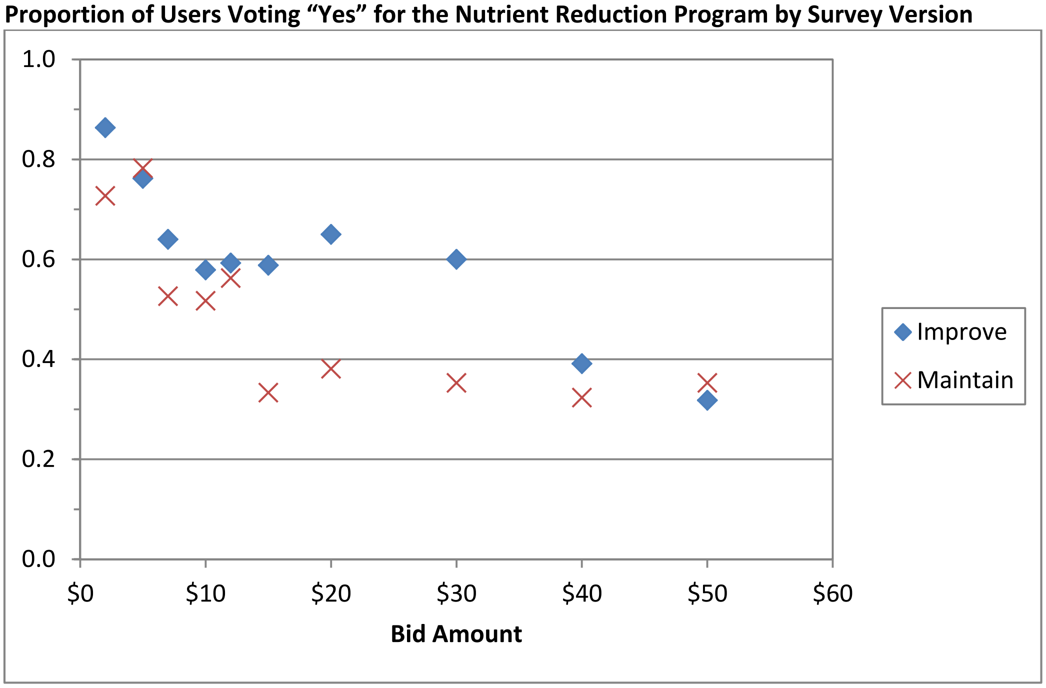
NOTES:
C = Continuous variable
D = Dummy variable. Sample sizes less than N=615 indicate missing data.

All models were estimated using the logit procedure in Stata Version 12 with weights applied. Initial estimation of Equation 1 produced less than ideal results. Specifically, the sign on Improve was negative. The research team expected, a priori, the sign on Improve to be positive. Improve is a dummy variable that captures the version of the questionnaire the household received, either water quality was maintained (Improve = 0) or improved (Improve = 1) as a result of the Nutrient Reduction Program being in effect for 20 years (see Section 3.1.2 for a complete discussion). Economic theory suggests that consumers would have a higher WTP for a larger amount of the good provided (larger improvement in water quality).

Separating the data by whether the household had visited a lake and/or a river in the last 12 months and graphing the proportion of "yes" responses at each bid amount by survey version, provided insight into the problem with the negative sign on Improve. Essentially, nonusers valuation of water quality was independent of the level of water quality improvement (see Figure 5-3), whereas users indicated a higher WTP for a larger provision of water quality (see Figure 5-4). This result is intuitively appealing because one would expect that those who use a resource would have a better grasp of the differences in the amounts being offered.

FIGURE 5-3
Proportions of Nonusers Voting "Yes" for the Nutrient Reduction Program by Survey Version

FIGURE 5-4
Proportion of Users Voting "Yes" for the Nutrient Reduction Program by Survey Version



Given this finding, the initial model was revised, opting to estimate the users separately from the nonusers. The final model fit for users was as follows:

$$\Pr(NutRedux = 1) = F(\beta_0 + \beta_1 \ln(Bid) + \beta_2 Improve + \beta_3 Passive + X_i'\beta + \varepsilon_i), \qquad (2)$$

where the variables have the same definition as in Equation 1 and a new dummy variable, Passive, which captured the degree to which the respondent derived value from clean lakes and rivers for purposes other than recreation, was added. Passive was constructed from three statements about water quality and the level of importance respondents indicated for each statement. A numeric value was assigned each level of importance as follows: high importance = 3, moderate importance = 2, low importance = 1, and no importance = 0. Answers to the three statements were summed resulting in values ranging from 0 to 9. The dummy variable Passive was set equal to 1 for respondents with a sum equal to or greater than 6, and 0 otherwise. Table 5-5 summarizes how Passive was defined.

TABLE 5-5
Construction of the Dummy Variable, *Passive*

Prefatory wording: When you think about water quality in Utah, what importance do you personally place on each of the following?

2c. Maintaining water quality for future generations

2f. Maintaining good water quality in lakes and rivers so I can visit in the future

2g. Improving water quality in all lakes and rivers even those not frequently used by people

Levels of Importance	Numeric value	Algebraic Expression	Coding
High	3	Sum (2c+2f+2g) ≥ 6	1
Moderate	2		
Low	1	Sum (2c+2f+2g) < 6	0
None	0		

In the model estimated for nonusers, the value of the two future states of water quality—Maintain and Improve—was assumed to be equal and thus left out of the model. The final model fit for nonusers was as follows:

$$\Pr(NutRedux = 1) = F(\beta_0 + \beta_1 \ln(Bid) + X_i'\beta + \varepsilon_i) \quad (3)$$

5.3 Statistical Results

Tables 5-6 and 5-7 present the results of the final statistical models for users and nonusers (Equations 2 and 3, respectively). Only the variables that were statistically different than zero are presented.

TABLE 5-6
Results of Logit Regression Model for Users

Variable	Coefficient	z-statistic	Mean
lnBid	-0.658	-5.36[c]	2.51
Improve	0.562	2.4[b]	0.49
Passive	0.631	2.63[c]	0.45
Age	-0.015	-1.92[a]	46.58
Child	-0.137	-1.82[a]	1.14
Income	0.000012	3.82[c]	74948.03

NOTES:
[a] Significant at the 0.10
[b] Significant at the 0.05
[c] Significant at the 0.01

The intercept and model variables Female, College, Adult, and White were not statistically different than zero.

Overall, the WTP model for users performed well with intuitively appealing results. The bid amount (lnBid) is statistically significant at the 1 percent level. The negative sign indicates that the higher the dollar amount the respondent was asked to pay, the less likely the respondent would vote for the Nutrient Reduction Program. This indicates internal validity of the CVM WTP question. The coefficient for Improve is positive denoting a higher WTP for the larger improvement in water quality. This variable is significant at the 5 percent level. Of the demographic variables, age of the respondent, number of children in the household, and household income in the last 12 months were statistically significant at the 10 percent and 1 percent levels, respectively. Older respondents and households with more children were less likely to vote for the Nutrient Reduction Program, whereas households with higher incomes were more likely to vote for the program. Gender, having a college education, number of adults in the household, and racial composition of the household were not significant in predicting the likelihood of voting for the Nutrient Reduction Program.

TABLE 5-7

Results of Logit Regression Model for Nonusers

Variable	Coefficient	z-statistic	Mean
lnBid	-0.780	-3.38[b]	2.65
College	0.964	2.36[a]	0.47

NOTES:
[a] Significant at the 0.05
[b] Significant at the 0.01

The intercept and model variables Female, Age, Adult, Child, White, and Income were not statistically different than zero.

In the model estimated for nonusers, the bid amount was also significant at the 1 percent level. The negative sign on the coefficient indicates a decreasing likelihood for voting for the Nutrient Reduction Program when faced with higher bid amounts. Having a college degree increased the likelihood of voting for the program. None of the remaining demographic characteristics were significant.

Following an approach used by Champ et al. (1997), the lower bound of WTP for improved water quality was estimated using a follow-up question to the WTP referendum question about the respondent's level of certainty with respect to their response. The question read "How sure are you of this answer?" and presented the respondent a 9-point scale ranging from "not sure at all" to "certain." If a respondent indicated a 7 or higher on the certainty scale, their vote for the WTP scenario remained unchanged. A respondent's WTP was changed to "no" if they indicated a 6 or less on the certainty scale. The models for users and nonusers were re-estimated with the revised votes for the Nutrient Reduction Program (see Tables 5-8 and 5-9).

TABLE 5-8

Results of Logit Regression Model for Users to Estimate the Lower Bound of WTP

Variable	Coefficient	z-statistic	Mean
lnBid	-0.574	-4.8 [b]	2.51
Improve	0.547	2.37 [a]	0.49
Passive	0.865	3.68 [b]	0.45
Income	0.000010	3.67 [b]	74948.03

NOTES:
[a] Significant at the 0.05
[b] Significant at the 0.01

The intercept and model variables Female, Age, College, Adult, Child, and White were not statistically different than zero.

TABLE 5-9

Results of Logit Regression Model for Nonusers to Estimate the Lower Bound of WTP

Variable	Coefficient	z-statistic	Mean
lnBid	-0.898	-3.13 [b]	2.57
College	1.318	2.52 [a]	0.25
Income	-0.000018	-2.6 [b]	51184.61

NOTES:
[a] Significant at the 0.05
[b] Significant at the 0.01

The intercept and model variables Female, Age, Adult, Child, and White were not statistically different than zero.

In the user model with WTP votes adjusted for "uncertain" respondents, the coefficients on bid amount, survey version, passive use value, and household income remained significant. The age of the respondent and the number of children in the household were no longer significant in this model. In the corresponding nonuser model, the coefficients on bid amount and education remained significant. Interestingly, the coefficient on household income was significant at the 1 percent level after adjusting the WTP vote for "uncertain" respondents.

5.4 Economic Benefit Estimates

From Equations 2 and 3, the expected value of WTP was calculated using Hanemann's (1989) formula, as long as WTP is nonnegative. By including the natural log of the offered bid amount in the model, the WTP estimates resulting from Equations 2 and 3 are nonnegative. The formula for mean WTP is as follows:

$$\text{Median WTP} = \exp(\beta_{GC}/\beta_1) \quad (4)$$

where β_1 is the coefficient on the bid amount and β_{GC} is the grand constant calculated as the sum of the estimated coefficients times their respective means.

Using Equation 4, mean monthly WTP per household was calculated for the Maintain and Improve water quality scenarios for users. A single value was calculated for nonusers because this group did not appear to differentiate between the two levels of future water quality that were offered; therefore, the economic benefit arising from the two future states of water quality was treated as being equal. In addition, lower bounds for mean monthly WTP per household were calculated as described previously by recoding respondents who were uncertain about their "yes, would pay the increase in water bill" responses to "no, would not pay the increase in water bill." Table 5-10 summarizes these results. The WTP per month of the water bill was multiplied by 12 to yield annual WTP. All monthly WTP figures have been rounded to the nearest penny in order to establish the annual WTP and net present value estimates.

TABLE 5-10

Annual Benefits per Utah Household

Group	Future Water Quality Scenario	Monthly WTP		Annual WTP	
		Lower Bound	Upper Bound	Lower Bound	Upper Bound
User	Improve	$8.11 ($3.91, $14.19)	$31.97 ($19.23, $63.53)	$97.32	$383.64
	Maintain	$3.13 ($1.17, $5.66)	$13.61 ($8.47, $23.80)	$37.56	$163.32
Nonuser	Improve/Maintain	$2.19 ($0.12, $4.94)	$7.05 ($2.11, $12.63)	$26.28	$84.60

NOTES:
Numbers in parentheses are the lower and upper 95 percent confidence intervals.

This annual WTP is only a small fraction of Utah household income. In particular, even the upper bound WTP for the Improve program is about 0.5 percent of state mean household income of $70,375 and is still less than 1 percent of state median household income of $56,330. The lower bound WTP estimates are even a smaller percentage of household income. As such, it is very likely households could afford to pay the amounts they agreed to in the survey.

5.5 Generalizing the Sample WTP to the Utah Population

To apply the sample average WTP to the entire Utah population, the sample WTP must adequately represent the population WTP. To start with, the initial TEV sample to whom the survey was mailed did represent Utah households. To achieve as highest response rate as was cost effective in order to minimize nonresponse bias, repeated mailings were performed. Nonetheless, the majority of the households mailed the TEV survey did not respond. That by itself may not be a problem unless there is a systematic difference in values of water quality between those that responded to the survey and those that did not. As described in detail in Appendix D, a substantial statistical analysis of responding and nonresponding households was completed. Using the household demographics that came with the sample for all households, the team tested for whether there was any sample selection effect with respect to valuation of water quality. The results presented in Appendix D indicate no statistically significant difference. Therefore, the sample WTP was generalized to the Utah population as a whole.

However, because separate WTP estimates for users and nonusers were completed, the Utah population of households was also split into users and nonusers. The research team relied on the questions in the TEV survey whereby the respondent reports whether they visit Utah lakes and rivers for recreation or not. This is the same question that was used to separate users and nonusers for the purpose of estimating separate logit WTP models for each. Roughly 73.2 percent of TEV survey respondents indicated they used Utah lakes and rivers for recreation, while 26.8 percent did not. Therefore of the 73.2 percent of the 893,717 total Utah households were assigned the user WTP, while 26.8 percent of these 893,717 households were assigned the nonuser value per household. Table 5-11 presents the total annual Utah WTP for the Improve and Maintain programs, using both the lower and upper bound estimates for each group and program.

TABLE 5-11
Total Utah Households Annual Benefits (2011 dollars)

Scenario		Annual WTP		Number of Users	Number of Nonusers	Utah Annual WTP
		Users	Nonusers			
Maintain	Lower Bound	$37.56	$26.28	654,201	239,516	$30,866,270
	Upper Bound	$163.32	$84.60	654,201	239,516	$127,107,161
Improve	Lower Bound	$97.32	$26.28	654,201	239,516	$69,961,322
	Upper Bound	$383.64	$84.60	654,201	239,516	$271,240,725

The total Utah household benefits range from a minimum (lower bound) of $30.9 million for the Maintain water quality as it exists today to $271.2 million for improving water quality over the next 20 years. While these dollar values may seem large, even the upper bound of the Improve program represents just 0.2 percent of State of Utah Gross State Product (the state level equivalent of gross domestic product). Viewed in this perspective, while the total benefits of maintaining and improving water quality related to nutrients is substantial, collectively it is well within the economic means of the state of Utah.

5.6 Present Value of Benefits

These annual WTP amounts were converted into a present value (PV) of benefits over 20 years to be comparable to the costs of improving water quality. In particular, the cost of improving wastewater treatment plants to reduce nutrients often has large upfront costs that are incurred in the current or present period. However, the benefits are received continuously over time. In this survey, a 20-year time horizon was adopted for both the Maintain and Improve water quality programs. Thus, to bring the 20-year stream or annual series of benefits of water quality back to the present to compare to costs, a present value was calculated. The present value discounts future benefits because of the fact these future benefits are not received until many years from now. Essentially a dollar of constant dollar (real) benefits that someone has to wait 10 years for is worth less than a dollar's worth of benefits they receive today. This is not due to inflation (as all dollars are in constant 2011 dollars). Rather, it is due to people's time preference to have benefits today rather than in the future and the foregone interest on the investment in the capital tied up in the wastewater treatment plant. For this study, the benefits and any costs occurring in the future (for example, plant operation and maintenance costs) were discounted at a real discount rate of 2.7 percent over 20 years. Table 5-12 presents the present value of the lower bound and upper bound of benefits to Utah residents for the Improve and Maintain water quality programs.

Two PV series are presented: one using the current number of Utah households in 2011 and one using the projected number of Utah households based on forecasted population values from the State of Utah (2005).

TABLE 5-12
Present Value of 20 Years of Benefits (in Millions of 2011 dollars)

Scenario		Present Value	
		Constant Population	**Future Population Growth**
Maintain	Lower Bound	$484.96	$591.71
	Upper Bound	$1,997.07	$2,436.67
Improve	Lower Bound	$1,099.21	$1,341.17
	Upper Bound	$4,261.66	$5,199.75

Considering future population growth, the lower bound of the Maintain scenario has a present value of State of Utah benefits of almost $592 million and the corresponding upper bound is more than $2.43 billion. As expected, households are willing to pay more to improve impaired waters rather than simply prevent further deterioration. The lower bound for the improvement scenario is more than $1.34 billion and the upper bound is $5.2 billion. These results suggest that households are willing to make sizeable investments in water quality in Utah. However, the results also suggest that there are limits to what households will pay. In addition, the payments are contingent upon performance and not just effort. Payments would be lower if fewer water bodies respond to management measures.

5.7 Interpretation of Results in Relation to the Study Objectives

One of the primary objectives of this benefits analysis was to provide "information on the value of clean water to the citizens of Utah and the contribution of water-based recreation spending to the Utah economy."

The estimates of TEV provided in this report relate to the economic value of clean water to Utahns, both for maintaining and improving water quality. As such, these estimates are inclusive of the value of enhanced recreation opportunities due to the higher quality of the state's waters as well as what Utahn households are willing to pay to manage nutrients to protect the quality of life for current and future generations. Missing from these calculations are any costs savings of treating drinking water due to the higher quality of the intake water as well as any increases in lake front property values due to the improved aesthetics of lakes, especially as it relates to the clarity of the water.

5.8 Conclusions

This study estimates the economic values of maintaining and improving water quality related to nutrients for all Utah households. A number of factors contribute to the validity of the results as follows:

- The results have internal validity based of the fact that responses showed an economically sensible inverse relationship between the amount households were asked to pay and their likelihood of paying the increase in their water bill.
- Given the information in the survey booklet, the familiarity Utah households have with paying a water bill, and the fact that nearly three-fourths of Utah households visit Utah lakes and/or rivers, the contingent valuation survey results should be considered well-informed economic values.
- The statistical tests found no evidence of sample selection bias, and weights were applied to the responding household responses in the statistical analysis so that the WTP values represent Utah households as a whole.
- A range of benefits have been provided with an upper bound based on responses by households to the survey and a conservative lower bound to bracket the value that the economic literature indicates will correspond to what households would pay when it comes time to part with real money.

6.0 Analysis of Water-Based Recreation Demand

Section 5 reports the benefits of improved water quality to all citizens of the state regardless of whether they used Utah's lakes and rivers for recreation. The TEV estimated in Section 5 represents the economic value (or WTP) for changes in water quality, including both use and passive use (for example, bequests) values. That is:

Total Economic Value = Use Value + Passive Use Value

The goal of this section is to isolate the contribution of recreational use value to TEV. This was accomplished with a survey of household recreation water-based activity, the basic results of which are described in Section 6.1. Next, Section 6.2 introduces the Travel Cost Model, a model which has been used intensively for more than 40 years to estimate the economic benefits derived from improvements in the quality of water-based recreational activities. An accessible survey of the methodology is provided by Parsons (2003), with a more technical review given by Phaneuf and Smith (2005). The review of the recreation economics literature in Section 6.3 emphasizes studies which have addressed the economic consequences of eutrophication. Section 6.4 presents the water quality data provided by the Utah Division of Water Quality after which the statistical details of the travel cost model are outlined in Section 6.5. The estimated models and discussion of the results appear in Section 6.6, with the economic benefits of alternative nutrient scenarios calculated in Section 6.7. Conclusions appear in Section 6.8.

6.1 Lake and River Recreation in Utah

As noted in Section 4, the recreation survey (Appendix C) was completed by 1,405 people, but after adjusting for households that did not engage in lake or river recreation, 1,067 surveys were completed. Appendix H provides unweighted frequency counts and percentages for every person in the Recreation Survey. A summary of the demographic composition of recreationists in Utah is presented in Table 6-1, where the data have been weighted based on gender, education, race, and age (see Section 4.4). All analysis reported in this section use the weights described in Section 4.4. The population of water-based recreationists is significantly more male, younger, and more educated than the population of Utah adults as a whole. Interestingly, there are also significantly more recreationists that are 75 years of age and older than the adult Utah population in general.

TABLE 6-1
Characteristics of Utahns Who Engage in Water-Based Recreation

Demographic	User	Utah Adults
Gender*		
Male	50.9%	49.1%
Female	49.1%	50.9%
Education*		
High school graduate or GED	32.3%	38.9%
Some college or technical school	36.7%	34.2%
Undergraduate degree	21.9%	18.4%
Graduate degree	9.2%	8.5%
Age*		
18-34 years	44.1%	40.4%
35-44 years	17.3%	17.5%
45-54 years	14.5%	13.9%
55-64 years	11.9%	13.0%
65-74 years	5.8%	9.6%
75 years and older	6.5%	5.6%

*Pearson Chi-square test: $p < .001$

Tables 6-2 and 6-3 describe the activities of Utah households at lakes and rivers within the state. Boating, swimming, fishing for cold-water fish species, and engaging in near-shore activities were the top activities when households visited lakes. Near-shore activities and fishing for cold-water fish species were the top two activities when households visited rivers. The primary activities—those that people spent the most time doing—during a lake trip were fishing for cold-water species, boating, and near-shore activities. The top two primary activities of people during river trips were engaging in near-shore activities and fishing for cold-water fish species. Primary activities by those who visit lakes are more diverse than those for river users: five activities are reported as primary by at least ten percent of lake users whereas only two activities are reported as primary by at least ten percent of river users.

TABLE 6-2
Household Activities While Visiting Lakes and Rivers (All Activities)

Activity	Lakes	Rivers
Boating	64.0%	13.7%
Fishing—warm-water fishery	35.3%	18.4%
Fishing—cold-water fishery	57.1%	47.8%
Swimming	64.6%	31.5%
Near-shore activities	59.6%	73.8%
Hunting—waterfowl	8.9%	7.5%
Hunting/Trapping—other	4.5%	6.4%

TABLE 6-3
Household Activities While Visiting Lakes and Rivers (Primary Activity)

Activity	Lakes	Rivers
Boating	27.8%	5.2%
Fishing—warm-water fishery	10.6%	6.7%
Fishing—cold-water fishery	28.8%	22.2%
Swimming	11.5%	9.4%
Near-shore activities	21.0%	55.3%
Hunting—waterfowl	0.2%	0.1%
Hunting/trapping – other	0.1%	1.0%

Recreationists were asked a multi-part question concerning the lake and/or river they visited most often in the summer and the importance they placed on several water quality attributes, as well as distance traveled, in choosing this site. Figures 6-1 and 6-2 summarize these opinions. For lakes, recreationists ranked no unpleasant odor and proximity to their home as having the greatest importance in choosing the site they visited most often in the summer. Water clarity and having no algae blooms were ranked third and fourth, respectively. For rivers, proximity to home and no unpleasant odor were also most important followed by the absence of long threads of dark green algae and the presence of cold-water fish species. The presence of warm-water fish species was of least importance for choosing to visit both lakes and rivers.

FIGURE 6-1
The Importance of Water Quality Attributes at the Lake Visited Most Often This Summer

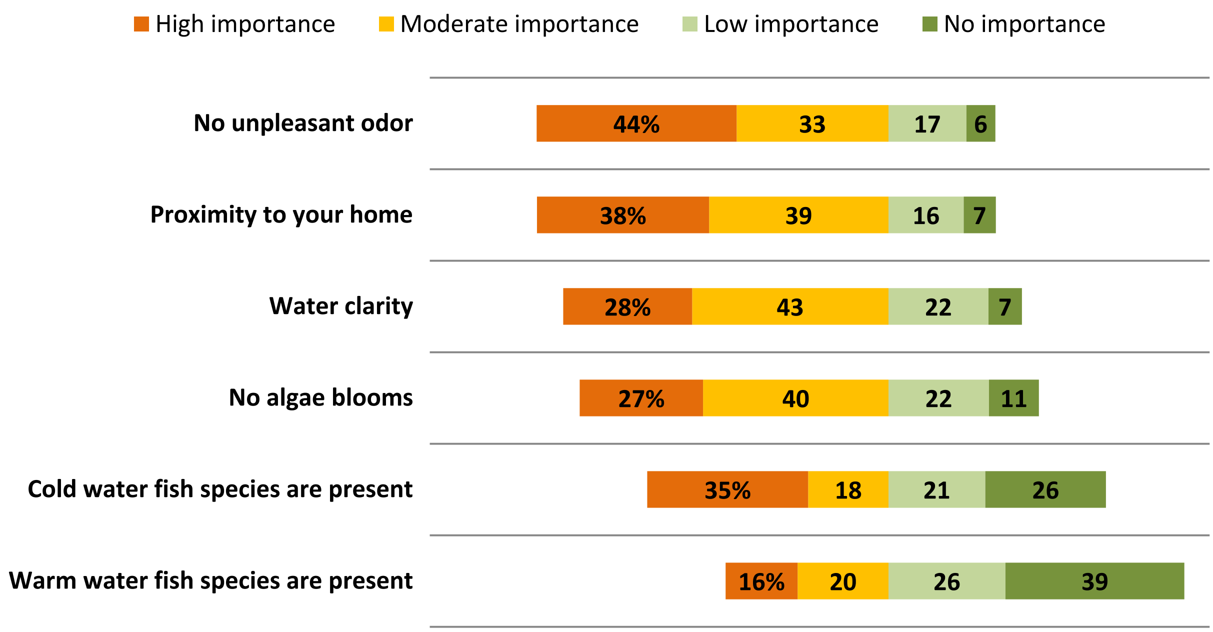
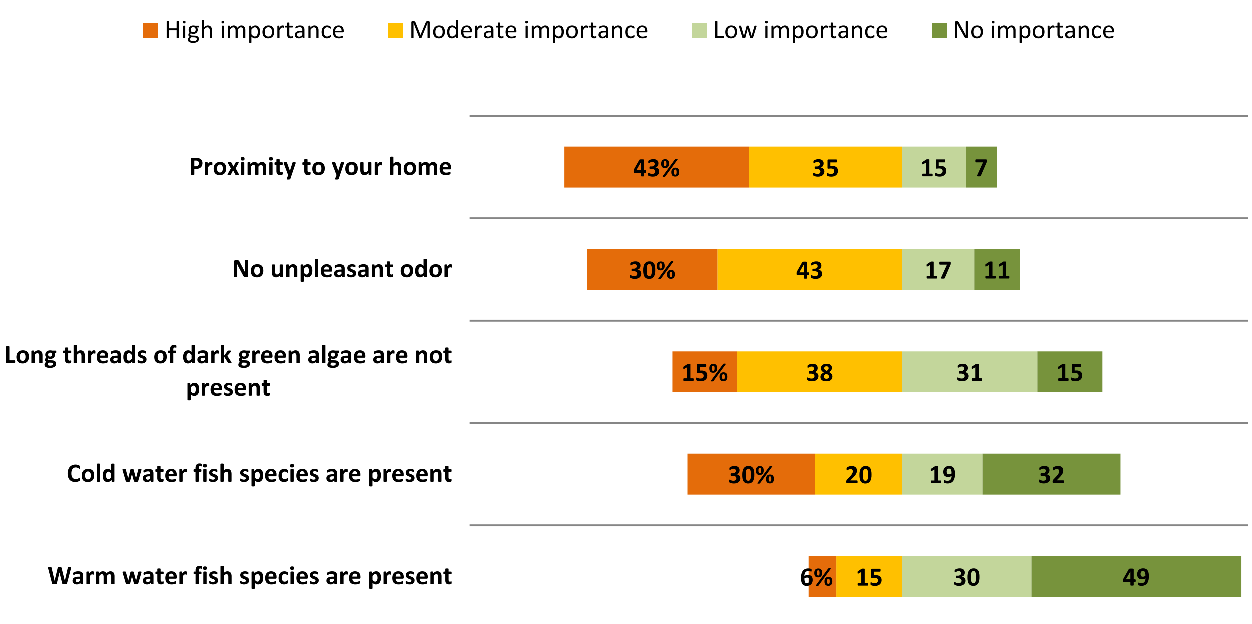


FIGURE 6-2
The Importance of Water quality attributes at the River Visited Most Often This Summer



Recreationists were also asked to indicate whether there were specific lakes and rivers they avoided because the water quality was too poor. If the response was “yes” then they were asked to supply the name of the lake and/or river. These sites are summarized in Tables 6-4 (lakes) and 6-5 (rivers). Just over sixteen percent of lake users and just under six percent of river users said there were sites they did not visit due to poor water quality. Only a subset of these respondents actually listed a poor quality lake (n=144) or river (n=29) by name. Utah Lake was mentioned most frequently as a lake that is not visited because of poor water quality (just over half of those listing a lake mentioned Utah Lake), whereas two segments of the Jordan River (Jordan River-3, from North Temple to 2100 South and Jordan River-1, from Farmington Bay upstream contiguous with the Davis county line) were mentioned most frequently by river users.

TABLE 6-4

List of Lakes Utah Households Did Not Visit Because the Water Quality Was Too Poor (n=144)

Lake Name	AU_ID	Number of Households Listing the Site
Utah Lake	UT-L-16020201-004	78
Mantua Reservoir	UT-L-16010204-033	10
Great Salt Lake—Willard Bay		10
Strawberry Reservoir	UT-L-14060004-001	6
Great Salt Lake—Antelope Island		4
East Canyon Reservoir	UT-L-16020102-020	3
Lake Powell	UT-L-14070006-001	3
Panguitch Lake	UT-L-16030001-006	3
Cutler Reservoir	UT-L-16010202-002	2
Pineview Reservoir	UT-L-16020102-014	2
Echo Reservoir	UT-L-16020101-001	2
Matt Warner Reservoir	UT-L-14040106-033	2
Red Fleet Reservoir	UT-L-14060002-006	2

The sites listed below were mentioned by only one household:

Baker Dam Reservoir, Causey, Reservoir, Donkey Reservoir, Gunlock Reservoir, Gunnison Bend Reservoir, Johnson Valley Reservoir, Kens Lake, Koosharem Reservoir, Minersville Reservoir, Newton Reservoir, Palisade Lake, Rockport Reservoir, Scofield Reservoir, Upper Enterprise Reservoir, and Yankee Meadow Reservoir.

TABLE 6-5

List of Rivers Utah Households Did Not Visit Because the Water Quality was Too Poor (n=29)

River Name	AU Description	AU_ID	Number of Households Listing the Site
Jordan River-3	Jordan River from North Temple to 2100 South	UT16020204-003	6
Jordan River-1	Jordan River from Farmington Bay upstream contiguous with the Davis County line		4
Ogden River	From confluence with Weber River to Pineview Reservoir	UT16020102-005	3
Jordan River-6	Jordan River from 7800 South to Bluffdale at 14600 South	UT16020204-006	3
Logan River-1	Logan River, except Blacksmith Fork drainage, from Cutler Reservoir to Third Dam	UT16010203-005	2
Weber River-8	Weber River from Echo Reservoir to Rockport Reservoir	UT16020101-017	2

The sites listed below were mentioned by only one household:

Bear River-2 (Bear River from Malad River confluence to Cutler Reservoir), East Canyon Creek-1 (from confluence with Weber River to East Canyon Dam), Jordan River-8 (Jordan River from Narrows to Utah Lake), Little Bear River-1 (Little Bear River from Cutler Reservoir to Hyrum Reservoir), Price River-1 (from Price City Water Treatment intake to Scofield Reservoir), Santa Clara River-1 (From Virgin River to Gunlock Reservoir), Spanish Fork-1 (from Utah Lake to Moark diversion), Virgin River-3 (Quail Creek Diversion to North Fork Virgin River), and Weber River-1 (Weber River from Great Salt Lake to Slaterville Diversion).

In calculating the total number of lake and river trips taken by respondents, the decision was made to eliminate all those who said they had a first or second home located on a lake. The rationale is based on a key assumption of the travel cost model: the price of the good (travel cost) is assumed to reflect the recreation access only. If a person has a residence located adjacent to a water body then the satisfaction of a recreational trip is not derived solely from the water body; instead, some of the satisfaction is derived from the residence. Further, construction of the travel cost measure needed for the recreation model requires knowledge of household income, so respondents who elected not to report their income were necessarily dropped from the analysis.

Another concern is the influence of "outlier observations;" that is, some households may report a number of trips that is inconsistent with the bulk of the sample, and strongly influence the subsequent economic benefits modeling. Our "trips" variable could be subject to various recall biases known to affect questions with relatively lengthy recall periods (12 months for the trips question).

The technique of Letter Values was used to identify severe outliers in the data set (Hoaglin, 1983). The idea behind letter values is to calculate an "outer fence" for a variable. Values that lie beyond this fence are severe outliers. The outer fence is located by first determining the interquartile range (IQR, essentially the 25th and 75th percentiles of an ordered dataset). The lower bound for the outer fence is defined by the lower quartile value minus three times IQR, while the upper bound is the upper quartile value plus three times the IQR.

The top portion of Table 6-6 reports on the trip-making activity of 970 respondents for whom complete information is available. These respondents answered the question about household income (needed to calculate the travel cost variable) and did not have a primary or secondary residence at a lake in Utah. Summing lake and river trips, the average household reported a total of 31.7 trips of all kinds to Utah lakes and rivers. Lake users reported making an average of 12.1 day trips and 4.5 overnight trips, for a total of 16.6 trips to lakes during the last 12-month period. River users were also quite active, reporting an average of 13.7 day trips and 1.4 overnight trips, for a total of 15.1 river trips of all kinds.

TABLE 6-6
Number of Day Trips and Overnight Trips to All Lakes and Rivers in Utah (Weighted)

	Mean	Standard Deviation	Minimum	Maximum	Median
All Eligible Observations (n=970)					
All lake and river trips	31.72	69.40	1	794	13
Lakes					
Day trips	12.11	16.77	0	154	6
Overnight trips	4.52	8.37	0	77	1
Total lake trips	16.63	21.61	0	154	10
Rivers					
Day trips	13.74	60.51	0	732	0
Overnight trips	1.35	13.04	0	365	0
Total river trips	15.09	64.40	0	790	1
Drop 33 Outlier Observations (n=937)					
All lake and river trips	20.74	22.73	1	115	12
Lakes					
Day trips	10.28	12.73	0	112	6
Overnight trips	3.99	7.40	0	77	1
Total lake trips	14.26	16.12	0	114	9
Rivers					
Day trips	5.70	12.65	0	100	0
Overnight trips	0.78	2.85	0	42	0
Total river trips	6.48	13.43	0	100	0

*Severe outliers identified using letter value analysis; those households reporting more than 115 trips to all Utah lakes and reservoirs in 12-month period.

Examining the distribution of trips further, one can readily observe that the mean for trips of each kind is likely to be influenced by some rather large values for reported trips. For example, one respondent household reported 732 day trips to different rivers in the past 12 months; whereas another household reported 365 overnight trips to rivers. The survey question does allow for such values because the question asked about trips by all household members. While it is possible that two or three different members of a household could have made a total 732 different trips to different water bodies during a year, this would seem unlikely. Rather, it is possible that some respondents misunderstood the question or that some bias associated with recalling trips over a 12-month period has influenced the response. The concern is that such “outlier” values can have a strong effect on statistical models, so it is desirable to identify the outlier observations and delete them from the data set.

For total trips measure (All Lake and River Trips in the top portion of Table 6-6), the mean was 31.7, with a standard deviation of 69.4 and a median of 13 trips. After ordering the dataset from the minimum number of trips (1) to the maximum (794), the 25th percentile was 7 trips and the 75th percentile was 34 trips, resulting in an IQR of 27. The lower value for the outer fence is zero, whereas the upper value for the outer fence was 34 + (3 × 27) = 115 trips. That is, households reporting more than 115 trips to Utah lakes and rivers are considered severe outliers.

Some 33 households (3.4 percent of respondent households eligible for the travel cost analysis) were identified as outlier observations because more than 115 trips were reported. The lower portion of Table 6-6 shows the effect of outliers on the measures of central tendency. The mean number of trips falls from 31.7 to 20.5 (a 35.5 percent drop) while the median number of trips falls from 13 to 12 (7.7 percent). The relatively smaller effect on the median is expected because the median is much less sensitive to outlier observations than the mean. All subsequent recreation analysis in this report is conducted using data that have had the 33 outlier observations removed. Some 76 percent of all trips are for day recreation whereas 24 percent are for overnight recreation.

The most popular lakes and rivers for both day trips and overnight trips are shown in Table 6-7. The sites included in this analysis are those which have been included in the recreation demand model (with Lake Powell perhaps being the most notable excluded site). Visits were calculated by determining the weighted mean for each site and then multiplying by the sum of the household weights. Utah Lake was the most popular lake in the state for day trips with approximately 492,000 annual visits (despite it being a site that is avoided by many people because of perceived poor water quality). The most popular river for day visits Logan River-1, with 203,000 day visits annually. One will note that the most popular destinations for day trips are close to the population centers of the state. In contrast, the more popular overnight destinations (Flaming Gorge and Green River-4) are located away from population centers.

TABLE 6-7
Top Five Lakes and Rivers, by Total Trips (Weighted)*

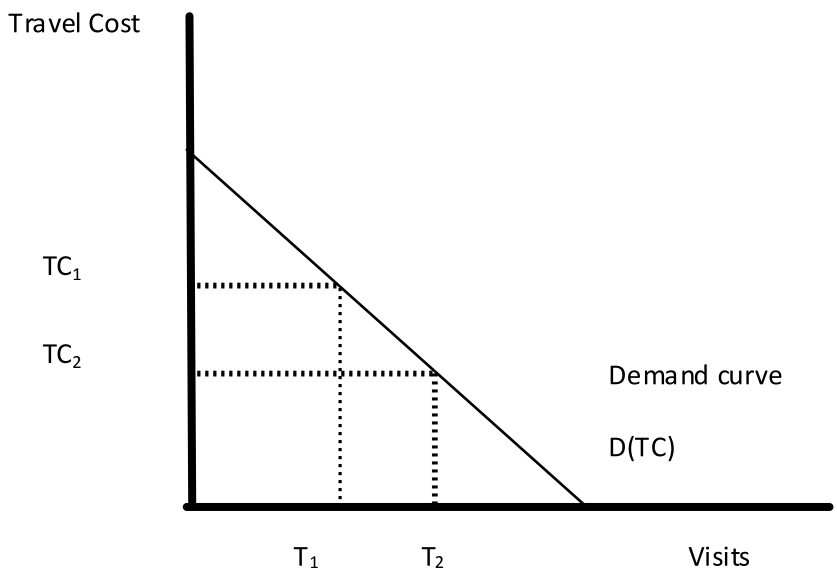
Lake	Number of Trips	River	AU Description	Number of Trips
Day Trips				
Utah Lake	492,000	Logan River-1	Logan River from Cutler Reservoir to Third Dam	203,000
Strawberry Reservoir	271,000	Provo River-1	Provo River from Utah Lake to Murdock Diversion	132,000
Deer Creek Reservoir	240,000	Provo River-3	Provo River from Olmstead Diversion to Deer Creek Reservoir	119,000
Pineview reservoir	206,000	Jordan River-8	Jordan River from Narows to Utah Lake	117,000
Bear Lake	199,000	Chalk Creek-1	Chalk Creek from confluence with Weber River to confluence with South For Chalk Creek	111,000
Overnight Trips				
Flaming Gorge Reservoir	274,000	Green River-4	Green River from San Rafael confluence to Price River confluence	34,000
Strawberry Reservoir	263,000	Provo Deer Creek	Provo Deer Creek from confluence with Provo River to headwaters	29,000
Bear Lake	222,000	Huntington Creek-1	Huntington Creek from confluence with Cottonwood Creek to Highway 10	22,000
Jordanelle Reservoir	52,000	S. Fork Ogden River	From Pineview Reservoir to Causey Reservoir	21,000
Rockport Reservoir	47,000	Ogden River	From confluence with Weber River to Pineview Reservoir	19,000

*Trips estimated only for those sites included in econometric model.

6.2 A Brief Introduction to the Travel Cost Model

The travel cost model treats "visits" to a site as a measure of quantity, while price is measured implicitly as the cost to travel to a site (Parsons, 2003). Intuitively, people will visit recreation sites which are closer to where they live more often than they will visit sites which are further away because it is cheaper in time and vehicle costs to visit sites which are closer (recall the importance of site proximity in Figures 6-1 and 6-2). The travel cost measure includes both "out-of-pocket" costs associated with driving a vehicle and the "opportunity cost" of travel time, typically valued at a fraction of the wage rate. A demand curve showing the relationship between visits and cost can be constructed, all other factors held constant (Figure 6-3). For example, at travel cost TC_1 the person will make T_1 trips, while at a lower travel cost (TC_2) the person will make more (T_2) trips.

FIGURE 6-3
The Travel Cost Demand Curve



The travel cost demand curve measures the marginal benefit for each recreational trip. WTP for each successive trip falls as the person "consumes" more trips because of the assumption of diminishing marginal utility (satisfaction), as encountered with consumption of any good. Let the demand curve in Figure 6-3 represent the demand for recreation at a site by a single person during a given season. Assume that travel cost TC_1 is $50, which includes the costs of travel to and from the site. A person is willing to go on the first trip because the WTP for the marginal (first) trip, say, $150 (as given by the demand curve), is greater than the cost of $50. Indeed, the person received a "surplus" of $100: the person was willing and able to pay $150 for the first trip but only had to pay $50. For the second trip, marginal WTP is lower, say $125, but the cost was only $50, so the person receives a surplus of $75. A person will continue to make trips as long as the benefit of the marginal trip is at least as great as the cost of the trip. Let the T_1 th trip yield a marginal value of $50 and assume that trip travel cost is still $50. If this is the fifth trip, then the fifth recreation trip is worth exactly what it costs, and the recreationist receives no "surplus" from this trip. A sixth trip is not taken because the marginal benefit of the trip would be less than the $50 travel cost.

Economists determine the net economic value of the recreation site by summing the economic surplus obtained from all the trips. One can think of this "consumer's surplus " as being the difference between what a person was willing to pay for all of the trips versus what he or she actually had to pay. Graphically, this is the triangular area under the demand curve and above the travel cost. Though technically it is a measure of the net economic value or the net WTP, this area of consumer's surplus is commonly referred to as WTP.

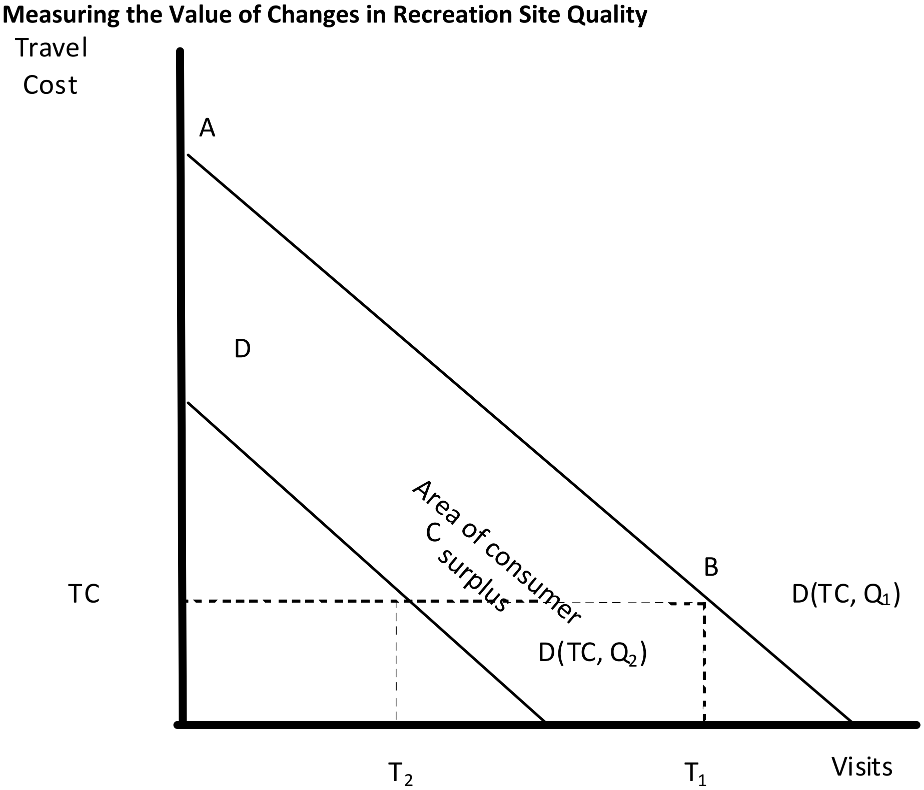
Of course, people often visit more than one site because of differing site qualities or other aspects of the recreational experience; that is, people drive past nearby sites to visit more distant sites of higher quality. Again, recall Figures 6-1 and 6-2, in which odor, water clarity, algae, and fish abundance were identified as important site characteristics. Quality attributes may include measures of water quality (for example, water clarity, nutrient loading, or other pollutants) or access (the number of boat ramps or the length of a river reach). In the case of two sites with the same travel cost but differing qualities, one would expect the higher quality site to be visited more frequently than a lower quality site. Economists can measure the value of changing site quality by examining what happens to the demand for recreation with improvements (or degradations) in site quality.

Travel cost models for a single recreation site are useful in many circumstances and can be easily estimated using straightforward regression techniques, where the number of trips is the dependent variable and cost of travel is one of the explanatory variables. The problem with single-site models is that unless time-series data are available one does not observe the variation in water quality necessary for econometric estimation. While many people will have a favorite lake or river, most recreationists visit more than one site within a given time frame. This behavior means that economists can use visitation data to see if people's site selections are related to water quality. Thus, one can take advantage of variation in both distance and water quality (among the many factors that influence site choice) to isolate the effect of water quality and its value in water-based recreation. The details of the multi-site econometric model used in this study will be laid out in Section 6.5, but economic benefits/losses associated with changes in water quality can be depicted in a graph for a single site.

Consider an initial situation in which site quality is Q_1 and the recreation demand for the site is a function of travel cost and site quality, $D(TC, Q_1)$, as shown in Figure 6-4. One may think of *Q* as measuring the level of water clarity or extent of algae at the site. At travel cost *TC* and initial site quality Q_1, the person would make T_1 trips and receive a consumer's surplus of the triangular area given by *A-B-TC*. Now consider a situation in which the site has received a greater amount of nutrients from upstream sources resulting in decreased water clarity and/or increased algal growth. This lower quality level, Q_2, has the effect of shifting the demand curve for the site to the left—any given trip yields less satisfaction and, hence, a lower marginal benefit—so that at travel cost *TC* the angler now takes only T_2 visits and receives a surplus of the triangular area *D-C-TC*. The difference in consumer's surplus under the two conditions, trapezoidal area *A-B-C-D*, is a measure of the economic loss suffered by the visitor as a result of the reduced water clarity and/or algal growth. Improvements in water quality follow the same conceptual approach: improved water quality will shift the travel cost demand curve to the right and the difference between the consumer surplus triangles yields the economic gain of better quality.

FIGURE 6-4

Measuring the Value of Changes in Recreation Site Quality



Non-economists will often be skeptical of consumer surplus measures because this "money" is not traded for goods in the marketplace. This naturally leads to a question: what is the relationship between consumer surplus and measures of economic impact, such as the net changes in employment, income, and tax revenues commonly reported in the popular press? Referring once again to Figure 6-4, the loss in economic value is given by area *A-B-C-D*. Economic impact analysis, in contrast, is based on the change in expenditures by the person. If one assumes that travel cost consists only of cash expenditures, the net change in expenditures due to a change in water quality would be the travel cost per trip multiplied by the change in trips, in this case, $TC \times (T_1 - T_2)$, or area T_2-B-C-T_1. If TC = $50 and a person made six fewer trips, then $300 is taken out of economic sectors affiliated with water-based recreation and then spent elsewhere. Economic impact analysis traces these expenditures (or lack thereof) throughout the regional economy, including multiplier effects, to estimate changes in employment, income and taxes. Economic impact measures are useful in informing policy decisions, but consumer surplus measures have been identified by the U.S. Water Resources Council (1983) and numerous executive branch agencies as the appropriate measure of changes in angler welfare as a result of changing site quality (for example, EPA, 2000a).

As an intuitive proof of the importance of consumer surplus as a welfare measure, consider the following thought experiment. Think of all the money an angler may have spent on all recreational trips to Utah's waters in the last 12 months—let's assume it was $500. Assume the angler enjoys fishing quality level Q_1, so that the $500 amount corresponds to the rectangular area $TC \times T_1$ in Figure 6-4. Now let nutrient loading and the subsequent algal bloom completely decimate game fish populations in the state but—for the purposes of the thought experiment—all other aquatic ecosystem services (drinking water, habitat for other species, boating, etc.) are left intact. The only thing missing are the game fish. How much would the angler pay to avoid future algal blooms? If it's something more than $500, then clearly the angler has suffered a loss in excess of the market transactions of $500. There are not enough market goods and activities to compensate him for the loss of the fishery. Intuitively, after the fish are gone the angler could spend his $500 on other market goods; however, in fact, the angler would pay even more to have the fishery restored.

6.3 Review of the Relevant Literature

Ribaudo and Piper (1991) provide one of the earliest studies to estimate the effects of nutrients on recreation behavior. Using data on 5,400 respondents to the 1980 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, the authors gauge the influence of water quality on the decision to fish and how often to fish. The recreation sites at which anglers could fish were located within 129 aggregate "residence regions," with several water bodies (both lakes and rivers) aggregated within a given residence region. Water quality for the region was defined as the mean of the two year measurements for total suspended sediments (TSS), total Kjeldahl nitrogen (TKN), and total phosphorus (TP) as measured by all USGS National Stream Quality Assessment Network stations located within the residence region. A zero/one index of water quality was calculated from these measurements: the index took a value of 1 (poor quality) if TSS exceeded 90 mg/L, or if TKN exceeded 0.9 mg/L and TP exceeded 0.1 mg/L.

The authors found that water quality in the "home" region had a negative effect on the decision to fish; whereas, the water quality of an adjacent region did not. That is, all else equal, lower water quality in a home region implied that anglers would be less likely to go fishing. In the regression explaining the number of trips made by anglers, the water quality measure was statistically insignificant, implying that water quality is a hurdle to participation but does not influence the total number of fishing trips. Improving water quality such that 10 percent fewer people would have index value of 1 increases the probability of fishing by a little less than 0.4 percent. On the basis of a fishing age population, the authors predict an additional 750,000 anglers nationally.

More recently Vesterinen et al. (2010) estimated a model that is conceptually similar to that of Ribaudo and Piper. Using data from Finland, the authors estimate separate recreation models for participation in swimming, fishing and boating, gauging the effects of water quality on each activity. Water clarity—as measured by Secchi depth—was highly correlated with "…chlorophyll levels, turbidity, color, total phosphorus, total nitrogen, as well as coliform bacteria levels." Because of collinearity, water clarity was the only measure of water quality used in the study. Water quality data were available for only lakes and coastal areas so the model is restricted to recreation at these types of waters. The number of recreation sites is not reported, but the behavioral data is drawn from a national recreation study. Of the roughly 3,600 people in the full sample, 167 swimming trips, 175 fishing trips, and 89 boating trips were reported. A logit participation model (swim or not, fish or not, boat or not) was linked to a negative binomial model of recreation trips for each activity. Travel cost was not included in the initial trips model whereas water clarity was included as an explanatory variable in both the participation and trips models. Better water clarity was found to positively influence participation in fishing but not swimming or boating; similarly, better water clarity positively influenced the number of swimming and fishing trips, but not boating. Finally, the authors restrict their sample to just those reporting a positive value for swimming, fishing or boating trips so that a negative binomial travel cost model could be estimated. Water clarity was statistically insignificant in the models that included travel cost. The participation/frequency model was not formally linked to the travel cost model, so the Vesternin et al. approach is non-standard and likely does not satisfy the requirements of travel cost demand theory. The study does provide insight into modeling water clarity: the effects are likely to differ by the type of water-based recreation activity.

In a study of more than 1,100 lakes in Wisconsin, Parsons and Kealy (1992) examine the impact of water quality on recreation choices for those who stated their primary activities were boating, fishing, swimming, or viewing. This approach is similar in spirit to that of Vesternin et al. as it models different activities separately. The paper is primarily methodological in nature, focusing on how one can use randomly drawn choice sets to estimate a recreation demand model in a computationally challenging context (more than 1,100 potential choices). The CH2M HILL team focuses on Parson and Kealy’s results for choice sets consisting of 24 alternatives: the site selected for the most recent recreation trip, and 23 other sites randomly selected from among the sites not visited.

Water quality was measured using a set of zero/one dummy variables for dissolved oxygen (DO) and water clarity. The DO variables were coded so that sites with either poor DO levels or high DO levels appeared in the econometric specification. Low DO levels were identified for lakes “…if the entire hypolimnion is devoid of oxygen at critical times during the year.” High DO levels were identified for lakes if measured DO in the hypolimnion was greater than 5 ppm “…at virtually all times.” The water clarity variable took a value of one if the average Secchi depth reading was at least 3 meters and zero otherwise.

The behavioral models of day trips to Wisconsin lakes were based on the 1978 National Survey on Recreation and the Environment (NSRE) data. The authors use a random utility model of site choice. Low levels of DO at a lake negatively affected the decision to boat, fish, swim, or engage in viewing activities at that site. High DO levels positively affected the decision to boat or swim at a site but were statistically insignificant in the fishing and viewing models. Water clarity was not included in either the boating or fishing models; better water clarity positively influenced the decision to swim or engage in viewing activities at a lake.

Two welfare scenarios were posed: (1) improve the DO measures such that no lake in the state has a low DO reading and, (2) improve all lakes in the state to a high quality standard. All lakes would achieve a high DO level and an average Secchi depth in excess of 3 meters. The mean per choice (per trip) WTP estimates for achieving the “low standard” are $0.66 for boating, $1.72 for fishing, $2.86 for swimming, and $0.52 for viewing. For the high standard, similar calculations were made for boating ($14.56), fishing ($3.24), swimming ($20.08), and viewing ($19.08). All values are reported in 2011 dollars; the study did not contain enough information to convert these figures to annual values.

Helm et al. (2004) conducted a similar random draw study to measure the benefits of water quality improvements for almost 21,000 rivers, almost 3,000 lakes, and over 1,200 coastal areas in six northeastern states (Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut.) Water quality at these sites was measured using a pair of zero/one dummy variables designating “high” or “medium” water quality based on measurements of biological oxygen demand (BOD), TSS, DO Saturation, and fecal coliforms. A water body must have satisfied all four criteria to qualify as “high quality” (BOD less than 1.5 milligrams per liter [mg/L], TSS less than10 mg/L, DO greater than 83 percent, and fecal coliform less than 200 most probable number per 100 milliliters [MPN/100mL] or “medium quality” (BOD less than 4 mg/L, TSS less than 100 mg/L, DO greater than 45 percent, and fecal coliform less than 2,000 MPN/100mL). Coastal water quality was inferred from water quality measures at the mouths of nearby rivers.

The behavioral data are from the 1994 NSRE, with 632 people reporting that they had taken at least one day trip. Respondents reported taking an average of between seven and ten trips per year, depending on the primary activity reported (boating, fishing, swimming or viewing). Because of the exceptionally large number of sites, choice sets of 36 sites were constructed via random draw: 35 sites were randomly selected plus the site visited by the respondent. All choice sets consisted of 12 lakes, 12 rivers, and 12 coastal areas. The econometric approach was a random utility model to explain site choices (similar to Parsons and Kealy), followed by a Poisson model explaining total trips (similar to Vesterinen, et al.).

All else equal, high water quality sites were more likely to be visited than low quality sites for all activities (boating, fishing, swimming, and viewing.) Medium quality sites were more likely to be visited than low quality sites for fishing and swimming activities, but not for boating and viewing. At the aggregate trips level, the water quality measures are embedded in the utility index passed from the site choice model. The sign of the index indicates that better water quality will increase the number of recreational trips. Two welfare scenarios are of interest: (1) bringing all 25,000 sites up to at least medium quality and (2) bringing all 25,000 sites up to high quality. Measured in constant 2011 dollars, the annual benefits per person for all sites achieving medium quality are $4.77 for fishing and $8.26 for swimming. If all sites were brought to a high quality level, the annual WTP would be $12.52 for boating, $12.53 for fishing, $106.94 for swimming, and $47.73 for viewing. The authors note that the bulk of these benefits are for coastal waters, and for moving from middle to high water quality. While the parameters of the Poisson model indicate that improvements in water quality will increase the number of recreation trips, the increase in trips is not reported.

Phaneuf (2002) approaches recreational demand at the watershed level, where recreation sites are defined by the eight-digit Hydrologic Unit Code (HUC). Focusing on the 58 eight-digit HUCs in North Carolina, water quality is measured in a variety of ways. First, the pH, ammonia, TP, and DO measurements at monitoring stations within each watershed are evaluated for whether the measure is within the appropriate EPA criteria bound. Water quality within a watershed is gauged by the percentage of measurements outside the bound for each criterion. Second, the author uses the Index of Watershed Indicators (IWI), a six-point index identifying the watershed's current condition and future vulnerability, where low scores indicate better quality/lower vulnerability and higher scores indicate lower quality /greater vulnerability.

Using behavioral data from 394 respondents to the 1994 NSRE, Phaneuf estimates a simple random utility model of watershed choice. Although numerous specifications are estimated for the various activities (fishing, boating, swimming and viewing), the preferred specification uses DO, TP, and ammonia variables (the percentage of measurements exceeding EPA criteria) as explanatory variables for all activities models but viewing. The parameters for the quality variables are constrained to be equal across the three activities. The empirical model indicates that, all else equal, as the percentage of measurements exceeding EPA criteria for pH, DO, TP, and ammonia increases, the less likely a watershed is to be visited for recreation. Similarly, as the IWI index increases (lower water quality and increased vulnerability), the less likely it was for the watershed to be visited.

Phanuef then uses the random utility model to estimate the benefits of improved water quality in each of the 58 eight-digit watersheds. Improvement in water quality is defined as a maximum of 10 percent of measurements being out of EPA criteria for each of the four water quality measures. Across all 58 watersheds, the per trip WTP for improvement of this magnitude range from $0.00 to $2.19 (in 2011 constant dollars). A water quality scenario corresponding to nutrient reductions of 30 to 50 percent were estimated for three river basins, the Neuse (four watersheds), Cape Fear (six watersheds), and Tar-Pamlico (five watersheds). WTP ranged from $0.67 per trip (Tar-Pamlico) to $1.52 per trip (Cape Fear). In the aggregate, the annual benefits of a statewide nutrient reduction (ammonia and phosphorus out of criteria in less than 10 percent of readings) would be between $153 million and $522 million.

Von Haefen (2003) estimates four different versions of the random utility model to compare welfare measures associated with improving water quality. Similar to Ribaudo and Piper's "residence regions" and Phaneuf's HUC-8 approach, von Haefen aggregated 219 destinations (visited by 157 people taking 2,471 trips) into "sub-subbasin" watersheds ranging in size from 100 to 500 square miles, resulting in an 89 site model. Measurements for phosphorus and Secchi depth were converted to a Trophic Status Index (TSI) (Carlson, 1977). A combined phosphorus-Secchi measurement was constructed by calculating the weighted average to the two TSI indices, where the weights were determined by the proportion of total measurements for each measure. A second measurement is a zero/one dummy variable for DO, where the index takes a value of one if DO falls below 6.5 mg/L for cold-water fisheries and below 5.5 mg/L for warm-water fisheries.

The empirical models show that water quality affects the choice of sites for recreation. The weighted TSI index was specified as a quadratic function; in all versions of the site choice model the linear TSI term had a positive coefficient whereas the squared TSI term had a negative coefficient. Evaluated at actual TSI values, the net effect for higher TSI values was negative. Dissolved oxygen also affected site choice: lower DO levels decreased the probability that a site was visited.

Von Haefen reports the welfare estimates of cleaning up eutrophic sites, defining a "clean up" as reducing the weighted TSI index to a level below 50 and raising DO levels to the minimum needed for a healthy fishery (6.5 mg/L and 5.5 mg/L, respectively, for cold and warm-water fisheries). By this definition, 22 of the 89 sites were considered eutrophic. Almost half of the sample visited one of the 22 sites at least once for a total of 347 trips (14 percent of all trips). In the standard form of the site choice model, improving all eutrophic sites yields a per trip WTP measure of $35.58 in 2011 constant dollars. No aggregate annual value was estimated in this paper.

The previous six studies show that economists have adopted a variety of approaches to measuring water quality (Table 6-8). Perhaps the most striking aspect of the economic models is the degree to which economists have *not* used water quality measurements as they were collected and used by water scientists. That is, rather than using the direct measure of dissolved oxygen (either concentration or saturation), economists will convert this measure to a threshold value and then use a dummy variable in the recreation demand model. Indeed, all but Phaneuf's (2002) watershed study used a dummy variable approach (Table 6-8). Phaneuf did not use water quality measures directly either; instead, he converted the data into the percentage of times that a measurement exceeded the corresponding EPA criteria. Though not strictly a dummy variable approach, even this represents a significant departure from the way in which quality variables are collected and used in water management decisions. Von Hafen (2003) began his analysis with Carlson's TSI equations for TP and Secchi depth, but then used a weighted average of both indices with weights derived from the actual number of measurements available for a water body.

TABLE 6-8
Measuring Nutrient-Related Water Quality in Economic Models

Study	Year	"Direct" Measurement	Dummy Variable	"Other" Index
Ribaudo and Piper	1991		TSS, TKN, TP thresholds	
Parsons and Kealy	1992		DO, water clarity (3 meter) thresholds	
Phaneuf	2002			Percentage of "out of criteria" measurements for pH, DO, TP, and Ammonia Index of Watershed Indicators
Von Haefen	2003		DO threshold	Weighted TSI index for TP and Secchi
Helm et al.	2004		Satisfy all thresholds for BOD, TSS, DO, and fecal coliforms	
Vesterinen et.al.	2010		Water clarity threshold (1 meter)	
Egan et al.	2009	Chlorophyll, TN and TP, TSS, Bacteria		

The fact that economists have felt it necessary to convert raw measurements into "something else" is indicative of the difficulty in finding a relationship between water quality and recreation behavior. This difficulty could arise from a number of different sources. For example, people cannot directly observe DO so that relatively small deviations in DO across water bodies may not be enough for people to respond by changing destinations. Put another way, the behavioral model may not align with a model that is desirable from an ecological management perspective. Secondly, with the exception of the Parsons and Kealy (1992) study, all the previous papers dealt with aggregated sites—multiple sites within a region or watershed were combined into a single site, thus losing a level of resolution in both behavioral and physical data.

The recent study by Egan et al. (2009) is notable in that it does not aggregate either recreation sites or physical data, and it carefully tests a number of different ways in which one can include water quality data in the econometric specification. The authors use data collected as part of the 2002 Iowa Lakes Study (a recreation use survey) and data collected by the Iowa State University Limnology Lab. Data were available for 129 lakes in Iowa, about half of which were considered nutrient impaired. An interesting aspect of the Iowa data was the relatively low correlation among Secchi depth and concentrations of chlorophyll, total nitrogen (TN), TP, suspended solids, and bacteria, which the authors state is associated with diversity of land uses across the state. A key contribution of the study is examining the functional form of the econometric model, paying particular attention to the water quality measures. Various linear and log specifications for each of the six water quality measures above were methodically tested with variables added singly and in pairs to gauge the effect on the explanatory power of the model. The authors conclude that direct measures of Secchi depth, inorganic suspended solid concentration, and volatile suspended solid concentrations are preferred along with natural logs of the concentrations of chlorophyll, nitrogen, phosphorus, cyanobacteria, and total phytoplankton.

Similar to von Haefen (2003), Egan et al. estimate a number of different versions of the random utility model, settling on the repeated mixed logit model for their preferred approach, where the models differ in the underlying distribution of the parameters. For welfare analysis, the authors improve water quality in 128 lakes up to the quality observed at the West Okoboji Lake, "…the clearest, least impacted lake in the state." Annual WTP (adjusted to 2011 dollars) is estimated between $114.41 and $191.35 per household per year to bring the other 128 lakes up to the West Okoboji standard. If a single lake is improved in each of nine "zones" in the state (each lake selected by the Iowa Department of Natural Resources as a likely candidate for nutrient improvement), the annual WTP ranges from $14.15 to $24.46 per household. If 65 nutrient impaired lakes are improved up to the median level for each water quality measure, the annual benefits range between $7.40 and $14.40 per household. Thus, a key conclusion of the Iowa lakes study is that the benefits associated with cleaning up a few lakes to a high quality level is greater than cleaning up numerous impaired lakes to a "medium" quality level. This result follows that of Helm et al. (2004). The authors do not provide the number of household recreating at Iowa lakes, so one cannot estimate an aggregate benefit estimate.

6.4 Recreational Site Characteristics

The recreation survey included questions about where and how often people engaged in water-based recreation in Utah. Respondents were asked to consider any and all water bodies in the state, but they were also provided with maps of lakes and rivers as a memory aid. Some 136 lake and reservoir sites were included on one map. Two river maps displayed 252 river segments. Respondents could report trips to these 388 sites or provide the name and number of visits to sites that had not been included on the maps. This portion of the survey followed the basic pattern of the Iowa lakes study reported earlier (Egan et al., 2009).

Empirical estimation of a travel cost model requires information on the characteristics and qualities of each site in the model. For example, the Utah Division of Wildlife Resources (UDWR) provided information on stocking of gamefish at both rivers and lakes (metric tons of fish). Other State of Utah agency websites and physical maps were reviewed to get the area (hectares) of all lakes and the number of improved boat ramps at each lake. Ramps counts are difficult to obtain from agencies as some agency counts include both improved and unimproved boat ramps whereas others include only improved ramps. To obtain a consistent count for boat ramps, the Utah Atlas and Gazetteer (DeLorme) was selected as the reference source. Blue Ribbon Fisheries (BRF) were determined from the Division of Wildlife Resources website.

Several water quality parameters were selected as indicators of impacts associated with excess nutrients in Utah water bodies that would potentially affect recreationists' behavioral choices. In addition to being good indicators of eutrophication, the parameters needed to be readily available from a large number of water bodies in order to be useful for the recreation demand modeling.

For lakes, the two parameters selected were the trophic state index (TSI) for water clarity (secchi depth) [TSI(SD)] and the difference between the trophic state index for Chlorophyll a [TSI(CHL)] and TSI(SD). The TSI was originally developed by Carlson (1977) as an indicator of algal biomass in lakes using three parameters: Secchi depth, Clorophyll a, and total phosphorus.

The TSI(SD) is an indicator of water clarity, which is directly tied to algal concentration; however, in some lakes and reservoirs the water clarity is primarily due to inorganics such as suspended solids or naturally occurring tannins. In order to distinguish between turbidity associated with sediments and turbidity associated with algae, the parameter TSI(CHL) – TSI(SD) was calculated. In general, a positive value of this parameter indicates an algal dominated lake and a negative value indicates a suspended sediment dominated lake.

For rivers and streams, the three parameters selected were total phosphorus (TP), total inorganic nitrogen (TIN) and dissolved oxygen saturation (DOS). Total inorganic nitrogen is ammonia plus nitrate/nitrite and was selected rather than total nitrogen due to the general lack of organic nitrogen monitoring data. Dissolved oxygen saturation, expressed as a percentage, is a response variable that when either too low or too high can be an indicator of eutrophication. In general, a DO fluctuation near saturation is indicative of a healthy stream ecosystem (Wang et al., 2003); therefore, 90 percent to 110 percent was selected as the optimal range of DOS, although in some instances systems not impacted by excess nutrients will naturally fall outside of that range (due to turbulence).

Routine summertime (July-September) monitoring data conducted by UDWQ were used to obtain TSI(SD) and TSI(CHL) for lakes and reservoirs, as well as DOS, TIN, and TP for rivers and streams. Assessment of current conditions of Utah water bodies was based on monitoring data collected by UDWQ from January 1, 2006 to December 31, 2010, the five most recent years of data available at the time of this study. Data from individual monitoring stations were aggregated to the map identification (MAPID) level shown on the recreation demand survey. For calculated statistics (average, minimum, maximum), data from all monitoring stations within the MAPID were included. UDWQ also provided lengths of stream segments. Additional description of the selection and water quality parameters is presented in Appendix I.

Several other water quality characteristics that recreationists may perceive and that may affect their site choice were considered for inclusion in the model. Whether the stream is a cold or warm water fishery, and whether it is listed as impaired for temperature (UDWQ, 2010) were attributes included in the model. Following are other water quality related attributes that were considered but not included in the model for the reason stated. Toxic and bacteriological contaminants are not visible to the recreationist; however, advisories are issued by local health departments or UDWQ that could potentially affect site choice. Bacteria advisories due to elevated E.coli levels were not included in the model due to limited occurrences statewide (less than 5). Fish advisories due to mercury contamination were not included for two reasons: first, the sampling of statewide waters is incomplete; that is, many water bodies were not tested, and second, the most popular angling sites were given priority for testing, that is, the sites tested for mercury were not selected randomly. Direct measures of water column and benthic algal growth in streams were not included due to limited monitoring data. Habitat condition (riparian and instream) was not included due to incomplete assessment data and inconsistent assessment methodology. In addition, degraded habitat conditions often coincide with eutrophication due to agricultural practices and urbanization.

A common problem in recreation demand analysis is that water quality measures are not always available for all the sites people visit. Recreation demand analysis requires characteristics information for all sites to be included in the model. While it is not econometrically necessary for all sites in the model to have been visited (a site could have zero visits and still be included in the site choice set), one must have values for all explanatory variables for a site: for example, if water quality is not monitored at a site visited by one of the sample respondents, that site is necessarily eliminated from the model. Water quality measures were available for 130 of the 136 lake/reservoir sites on the lake map plus one other site that did not appear on the map but was visited (Sand Hollow Reservoir). The number of rivers in the final model was driven primarily by those for which a measure of summer dissolved oxygen saturation was available. The final set of 284 sites to be included in the demand analysis is composed of 131 lakes/reservoirs for which Trophic Status Indices for chlorophyll and Secchi depth were available and 153 river reaches for which summer DOS, TIN, and TP were available. Descriptive statistics for all site characteristics can be found in Table 6-9.

TABLE 6-9
Site Characteristics

	Mean	Std. Dev.	Min	Max
Northern Lakes (n=70)				
Ramps (number)	0.54	0.82	0	5
State Park (1 = yes, 0 = no)	0.19	0.39	0	1
Blue Ribbon Fishery (1 = yes, 0 = no)	0.13	0.33	0	1
Fish Stocked (metric tons)	3.48	11.25	0	91.78
Ln(Area) (hectares)	4.51	2.17	0.69	10.58
Max TSI(SD)	50.32	11.54	32.38	83.19
Max TSI(CHL) – TSI(SD)	-0.54	13.36	-50.25	34.91
Southern Lakes (n-61)				
Ramps (number)	0.46	0.67	0	3
State Park (1 = yes, 0 = no)	0.23	0.42	0	1
Blue Ribbon Fishery (1 = yes, 0 = no)	0.16	0.37	0	1
Fish stocked (metric tons)	2.22	4.53	0	23.00
Ln(area) (hectares)	4.21	1.76	0	8.41
Max TSI(SD)	54.20	14.09	31.16	93.18
Max TSI(CHL) – TSI(SD)	-0.35	14.51	-31.96	36.75
Rivers (n=153)				
Length (km)	31.44	26.09	2.04	151.90
Temperature Impaired (1 = yes, 0 = no)	0.14	0.34	0	1
Cold-water stream (1 = yes, 0 = no)	0.63	0.48	0	1
Blue ribbon fishery (1 = yes, 0 = no)	0.07	0.25	0	1
Fish stocked (1 = yes, 0 = no)[a]	0.33	0.47	0	1
Average DOS (%)	104.23	17.23	60.20	166.00
Average total inorganic nitrogen (mg/L)	0.63	1.01	0.08	8.64
Average total phosphorus (mg/L)	0.19	0.44	0.01	2.69

[a]The total amount of fish stocked in rivers, measured in metric tons, was provided by the Division of Wildlife Resources for each river. Unfortunately we have no record of which particular stream *segment* received the fish; all reaches of a stocked river were thus assigned a value of one, and a zero otherwise.

Based on the survey data, the 131 lakes included in the model represent 67.1 percent of all lake recreation visits. The most important “excluded” sites include Lake Powell, Antelope Island, and Farmington Bay. Secchi depth and chlorophyll readings were not available for these sites. The 153 river segments included in the model capture 67.6 percent of all river recreation trips. The most important excluded sites include Green River-1, Big Cottonwood Creek-2, American Fork-1, Weber River-4, and Strawberry River-2. The Green River and Weber River segments were missing phosphorus data. The remaining segments were missing DOS readings.

6.5 Implementing the Travel Cost Model: Econometric Issues

6.5.1 The Conditional Logit "Site Choice" Model

Complete water quality data were available for 284 sites, yielding a travel cost model in which people may choose from among 284 different sites. The conditional logit model is based on the intuition that people will choose a site to visit based on the attributes of that site relative to the attributes of all other sites. The list of attributes at a given site could be the distance from home (the travel cost), whether the site is designated as a Blue Ribbon fishery (important to anglers), whether it is located in a state park (which conveys information about other site amenities), and water quality (Secchi depth or nutrient concentration). Letting travel cost to site *j* be denoted by TC_j and the set of other attributes for site *j* be denoted by the vector X_j, one can denote the utility, or satisfaction, V_j associated with a trip to site *j* by,

$$V_j + \varepsilon_j = \alpha TC_j + \gamma X_j + \varepsilon_j$$

where V_j is the "deterministic" component of utility obtained from choice *j* and ε_j is the "random" component. The idea behind this formulation is that the analyst knows only a subset of the factors that explain the site choices made by people, so that the random component represents factors known only to the recreationist. The parameters α and γ are to be estimated econometrically, as will be discussed below. In considering any two sites, *j* and *k*, for a recreation trip, the person compares the utility received from each site and will choose the site that yields the greatest level of utility. If site *j* yields more utility than any other site *k*, as in,

$$V_j + \varepsilon_j > V_k + \varepsilon_k$$

then site *j* will be selected. On any given choice occasion a recreationist makes such a comparison for all possible combinations of sites (284 sites in this example) and selects the site yielding the highest level of satisfaction.

Given the random component of the model, the analyst can, at best, only estimate the probability that a particular site is selected on any choice occasion (hence the description of these models as "Random Utility Models," or RUMs). The probabilities are based on an assumption regarding the distribution of the random components, ε. A standard assumption for such models is that the random components associated with site choices are distributed according to the generalized extreme value distribution (Morey, 1999). This assumption yields the standard site choice probabilities,

$$\pi_j = \exp(\alpha TC_j + \gamma X_j) \Big/ \sum_{k=1}^{K} \exp(\alpha TC_k + \gamma X_k) .$$

where π_j is the probability of having chosen site *j*, exp(.) references the exponential operator, *TC* is the travel cost to any site, *X* is a vector of other site attributes, α is the travel cost parameter and γ is a vector of parameters associated with other site attributes, and *K* is the total number of sites. One of the site attributes—namely the cost of travel to the site from the respondent's home—varies across people so that the site choice probabilities vary across respondents even if all other site attributes are identical across people. Econometric estimation of the site choices—as a function of travel cost and other site attributes—yields estimates for α and γ. One would anticipate a negative value for α (sites located further from the respondent's home are visited less frequently than sites located nearby, all else equal) while the sign of any given element of γ would be positive (negative) for site attributes that are considered good (bad).

For any given set parameters α and γ and characteristics TC_i and X_i, the denominator represents the sum of an exponentiated "utility" index across all sites. The numerator includes the characteristics index of only one site, such that the equation is clearly less than 1. Assuming that the numerator is an index of, say, Utah Lake, whereas the numerator sums the index of all 284 sites. The ratio of the numerator to the denominator can then be interpreted as a probability that Utah Lake will be visited on any given choice occasion. Similar probabilities can be calculated for the other 283 water bodies. Given the denominator, the sum of the individual probabilities is assured to be 1.

6.5.2 A Nested Logit Model

In some cases it may be appropriate to "nest" some choices together, thus separating them from other choices in the model. The rationale for doing so could be that the choices in one nest are fundamentally different from the choices in another nest, yet all possible choices should still be included in the same model. In the application to water-based recreation, this could be the case with lake and river recreation. While the data indicate that some people seek out only lakes and others seek out only rivers, a significant portion of the sample enjoys recreating at both rivers and lakes. In this case, the characteristics of lakes and rivers differ from one another, yet one may wish to allow a person to make the choice between lake and river recreation before selecting which lake or which river to visit.

Such a model can be thought of as having two parts: the first part models the "water body type" choice whereas the second part models the "site" choice, which is conditional on having chosen a lake or a river. As an example, Figure 6-5 illustrates a nested site choice model, where the top-level of the choice indicates the decision between lakes and rivers, and the bottom-level indicates the choice of a site, conditional on having chosen to recreate at a lake or a river. The probability of choosing lake *j*, then, is the product of two probabilities: the probability of choosing to recreate at lakes and the probability of choosing lake *j*, conditional on having chosen lakes. That is,

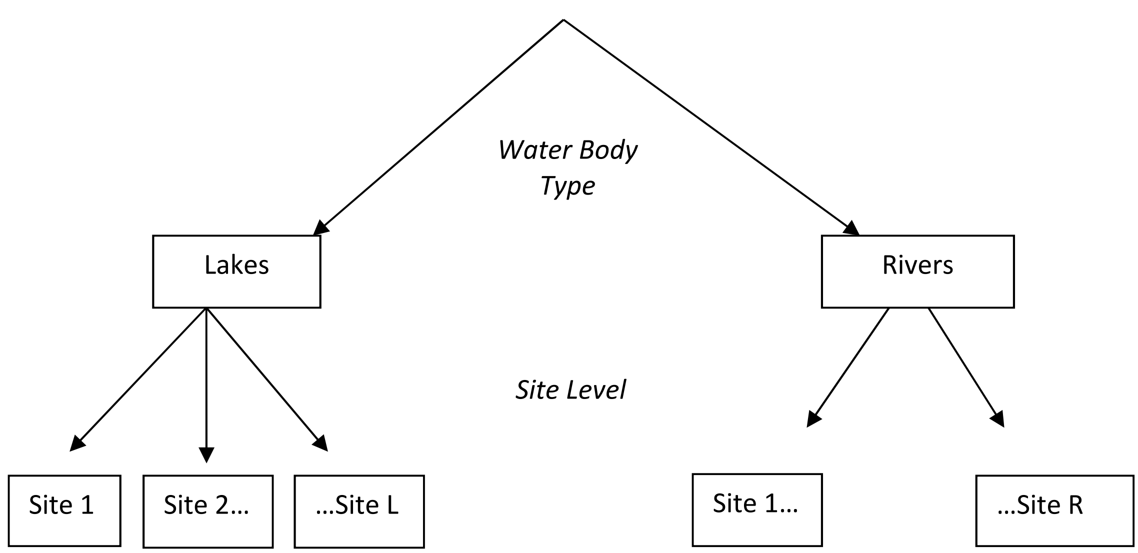
$$\pi(\text{lake } j) = \pi(\text{lake}) \times \pi(j|\text{lake})$$

Again assuming a parametrization of the utility derived from lake *j* identical to that of section 6.5.1, and assuming a generalized extreme value distribution for the random component of utility, the conditional probability of choosing lake *j* is very similar to that appearing above,

$$\pi_{j\ |\ lakes} = \exp((\alpha \text{TC}_j + \gamma \text{X}_j)/\mu) \Big/ \sum_{k=1}^{K} \exp((\alpha \text{TC}_k + \gamma \text{X}_k)/\mu)$$

Here, µ represents a scaling factor needed to estimate the "top" portion of the model (Hensher and Greene, 2002). The scale parameter may differ across all nests, or it may be restricted to be the same across all nests, but all alternatives under a common "branch" must have the same scale parameter. The scale associated with each nest may be estimated at either level of the model (the top or the bottom) depending on where one chooses to normalize. We have followed the tradition of allowing the "free" scale coefficient to be at the bottom level nest (Hensher and Greene, 2002 page 6). In this case, economic theory requires that that $\mu > 1$.

FIGURE 6-5
Example Nested Logit Site/Water Body Type Choice Model



One may summarize the information within any given nest through its *inclusive value*. The inclusive value can be thought of as an index of utility or satisfaction, where higher levels of the index indicate greater levels of satisfaction. The inclusive value for all *J* sites within any nest can be calculated as

$$IV_J = \ln[\sum_{j=1}^{J} \exp((\alpha \mathrm{TC_j} + \gamma \mathrm{X_j}) / \mu)$$

The inclusive value for each nest is then passed to the "upper" portion of the model, the water body choice level. Similar to the lower-level site-choice level, one may estimate the probabilities associated with the choice of any water body type such that the probability of choosing water body type *J* is given by,

$$\pi_J = \exp(\varphi Z_J) \Big/ \sum_{k=1}^{K} \exp(\varphi Z_k)$$

where π_J is the probability of choosing water body type *J*, Z_J is a vector of attributes of explaining the choice of water body type *J*, and φ is a vector of parameters to be estimated. The lower- and upper-levels are linked via the "inclusive value" for each type of water body, where the inclusive value IV_k is included in the vector Z_k at the water body type choice level. The coefficient on the inclusive value is restricted to be μ; hence, the description of μ by some as the "inclusive value parameter." This report will continue to denote μ as a "scale coefficient."

6.5.3 A Poisson "Total Trips" Model

Changes in the water quality of one recreation site (or several sites) will not only change the probability that any given site is selected (the "site substitution" effect), it may also change the total number of trips taken by the household. The idea is simple: if water quality improves, then the utility (or satisfaction) derived from water-based recreation must increase. This increased utility is then compared to the satisfaction derived from alternative activities (for example, recreation away from water, going to the movies, gardening at home, etc.) and, if the change in water quality is sufficiently great, members of the household may choose to engage in more water-based recreation and less in alternative activities. This behavior can be modeled by linking a model of "total trips" to the nested logit site choice model described above (Hausman et al., 1995; Parsons et al., 1999).

Similar to the nested logit model, the "link" between the site choice model and the total trips model is through the inclusive value. That is, one calculates the inclusive value by summing up the utilities associated with all levels and nests of the nested logit model and then uses this value as an explanatory variable in the total trips model. Although one may think of the total trips regression as similar to well-known Ordinary Least Squares (OLS) regression, the (OLS) assumption of continuous dependent variable (and error term) is not appropriate because total trips is a non-negative integer: a person can take two trips or three trips, but she cannot take 2.5 trips. Instead, total trips follow a Poisson distribution, one in which the dependent variable can take on only non-negative integer values. Like the nested logit model, the Poisson model is probabilistic, where one estimates the probability that total trips by person *i*, T_i, will take on its observed value, t_i. The probability is given by,

$$P[T_i = t_i] = \exp(-\lambda_i) \times \lambda_i^{t_i} \Big/ t_i!$$

The model is parameterized by assuming a form for λ_i, namely,

$$\ln \lambda_i = W_i \beta$$

One of the elements of the explanatory vector, *W*, is the inclusive value (the utility index) passed from the nested logit model. The expected sign on the inclusive value in the total trips model is positive: as total utility of recreation increases due to improvements in water quality, one would expect to see more recreation trips.

This study uses a modified version of the Poisson model. The data available are for those households who took at least one water-based recreation trip during the survey time period. As such, the fewest number of trips possible is one. This results in a truncated Poisson distribution, one that does not allow for zero trips (zero being a non-negative integer permissible with the standard Poisson distribution). Further, the standard Poisson model assumes that the mean of the distribution is equal to the variance. In fact, observation of the raw data reveals that the variance of total trips is greater than the mean of total trips (even after adjusting for outliers); the data are considered “overdispersed.” Adjustment for overdispersion is made by estimating the negative binomial form of the Poisson. Thus, the actual form of the Poisson model reported in this study is the “truncated negative binomial” model (Grogger and Carson, 1991).

6.5.4 Summary of the Econometric Model

The linked site-choice/total trips model has properties important to any behavioral model attempting to capture the effects of improvements in water quality. First, the model allows for multiple sites. Whereas people tend to have favorite sites at which to engage in water-based recreation, they also tend to visit more than just that one site. Among the factors influencing the site-choice decision are travel cost and water quality. In particular, after controlling for travel costs and other site attributes, some degree of site substitution would be expected as people alter their behavior to visit higher quality sites more often and lower quality sites less often. Second, the nested site-choice model allows for some heterogeneity in site choice. That is, even after accounting for the site characteristics in the model, there may be some remaining heterogeneity which is not captured. Lakes in the northern portion of the state may not be “the same” as lakes in the southern portion, and the factors that influence choice among lakes may differ from the factors that influence choice among rivers. The nested model allows for attributes in one nest to affect the utility index differently from the same attributes in another nest.

The link from the nested logit site-choice model to the truncated negative binomial “total trips” model allows the utility change associated with improving or degrading water quality to influence the total number of trips taken by a household. Finally, the model allows the analyst to calculate the annual WTP for changes in water quality (net change in consumer surplus), as well as changes in the total number of trips taken during the year. This last measure can be used to estimate the economic impact of improving or degrading water quality (see Section 9).

6.6 Empirical Results

6.6.1 Preliminary Issues

The econometric model described in Section 6.5 provides a structure within which to analyze the recreational choices of Utahns as they relate to nutrient levels in Utah waters. That said, a number of criteria must be assessed when attempting to specify the model—which variables to use, which functional form, how to set up the nests—and how to select the right model to be used in policy analysis. The best model will satisfy the demands of economic theory, the natural sciences, and statistics.

Economic theory imposes restrictions on some model parameters. First, the travel cost parameter must be negative (as cost to visit a site increases the probability of visiting that site decreases). Second, the nested logit site-choice model will be consistent with utility maximization only if the scale parameters for each nest are greater than one. Finally, the parameter estimated for inclusive value passed from the site-choice model to the total trips model must be greater than (or equal to) zero. The intuition is that the inclusive value from the site choice model measures the utility associated with water-based recreation: as utility increases then the total number of trips should increase or, at the least, should not decrease. Unfortunately economic theory does not provide any insight as to the nesting structure of the site-choice model leaving this decision as an empirical matter. Should the nests be defined geographically, such as north or south, or by hydrologic unit? Or should nests instead be defined by type of water, such as nests for lakes, reservoirs, rivers, and streams? Economic theory provides no guidance, and econometric approaches to selecting the best nesting structure are computationally intensive.

Another issue is to decide which water quality variables should be used in the utility index associated with site selection (where the utility index is $\alpha TC + \gamma X$). Ideally one would have measures of water quality that are ecologically meaningful to managers, behaviorally important to recreationists, and statistically satisfying. With the exception of the study by Egan et al., the review of the recreation economics literature in Section 6.3 (and summarized in Table 6-8) shows that economists have struggled with specification of water quality, often inventing their own water quality metrics from measures developed by natural scientists. For example, DWQ managers are concerned about exceeding threshold values for nitrogen and phosphorus concentrations as they can result in ecologically deleterious responses in water bodies. The problem for economists is that households’ recreation behavior may instead respond to the average level of water quality at a site, and not to the extreme values observed at a site, because they visit a site throughout the year. The approach here has been to follow the counsel of DWQ scientists on appropriate water quality measures, thus assuring that the subsequent models are useful for management decisions.

This leads to the second major influence in specifying an appropriate model: the ecology of rivers and lakes. Discussions with natural scientists on the complicated nature of nutrients in water consistently came down to a simple proposition: some amount of nutrient is good for water quality, and a little more may be even better, but at some point a lake or river can get too much nutrient load and water quality is degraded. In effect, this description is one of a nonlinear, quadratic function. As nutrient(s) increase in the water, the health of the ecosystem improves but, past some point (the optimal level of nutrient), health begins to get worse. Some nitrogen is good and some phosphorus is good, but not too much of either nutrient. Rising levels of dissolved oxygen saturation are good, but too little or too much saturation is indicative of eutrophication. Alternatively, if nutrient levels are already very high then a simple linear form of, say, nitrogen concentration, may suffice, with the expectation that the sign of the coefficient is negative (less nitrogen is better).

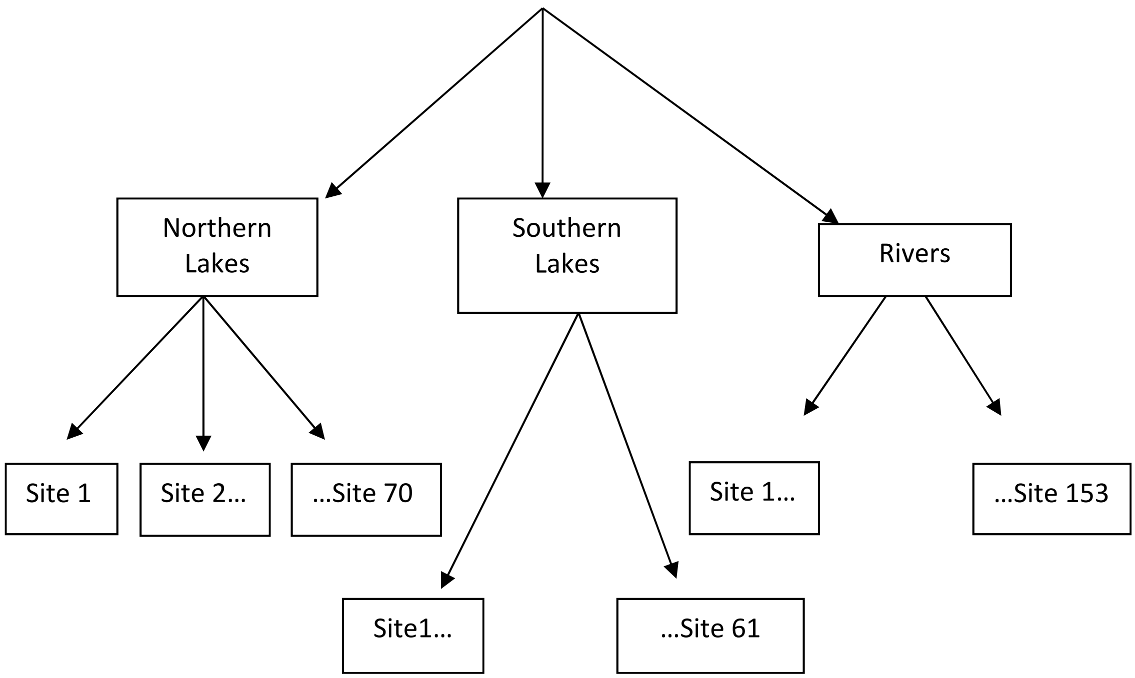
Statistical criteria include significance of parameters at conventional levels, such as two-tailed test of the null hypothesis that the estimated parameter is equal to zero, where the standard probability that one incorrectly rejects the null hypothesis is set at 10 percent (α=0.10), 5 percent (α=0.05), or some more stringent level. For maximum likelihood estimation, one should also examine the overall "goodness-of-fit," using a likelihood ratio test that tests the null hypothesis that all parameters (except for the intercept) are equal to zero. Another measure that one may use is the Akaike Information Criterion, a measure of the relative distance of two alternative models from the true model, with the alternative that is closest to the truth selected as the best model. Akaike's key insight in the development of his criterion was that one did not actually need to know the true model, which can be approximated by a constant (Burnham and Anderson [2002]).

In summary, estimating a model that allows for an ecological optimum and a behavioral optimum, while also satisfying statistical criteria for parameter significance and goodness of fit, is a difficult proposition, and compromises among the three goals must sometimes be made. Indeed, the model specifications reported in the next section are the result of frequent communication between behavioral and natural scientists. Before presenting those results, it is instructive to first examine a model specification with regard to ecological, behavioral and statistical modeling criteria.

6.6.2 Balancing the Tradeoffs: An Initial Model Specification

The analysis begins with the assumption that overnight trips are fundamentally different from day trips. Day trips differ from overnight trips in the amount of time spent onsite and the activities that people do. This violates an assumption of the travel cost model: that the amount of time spent onsite is (relatively) constant. Overnight trips involve more time and are valued more highly than day trips because of the additional time spent onsite. Thus, day trips are separated from overnight trips and models estimated for each. To maintain correspondence with construction of sampling weights (Section 4.4), geographic nests associated with Northern and Southern Utah were defined. See Section 4.4 for the list of counties that comprise the northern and southern portions of the state—water bodies were allocated to the north or south depending upon location within the appropriate set of counties. Initial results indicated that a nested logit model with geographic selection (northern lakes, southern lakes, northern rivers and southern rivers) followed by the site selection within that group was the preferred order of nesting. Further modeling revealed relatively few visits to southern rivers, resulting in statistically unappealing models. All rivers—north and south—were aggregated into a single nest. The structure of the final nested logit portion of the econometric model appears in Figure 6-6. The model consists of 70 sites in the northern lakes nest, 61 sites in the southern lakes nest, and 153 sites in the rivers nest.

FIGURE 6-6
Final Structure of Nested Logit Site-Choice Model



The initial model specification included 10 parameters for the lake site-choice portion of the model, 14 parameters for the river site-choice, a travel cost parameter, scale parameters for each nest, and eight parameters for the total trips models. Here we concentrate on the rivers site-choice portion of the model because it illustrates nicely the tradeoffs among desirable statistical properties, the estimated behavioral implications, and the ecology of rivers (Table 6-10). The initial model specification for rivers incorporates the quadratic relationships in average summer DOS, average summer TIN concentration, and average summer TP concentration; the coefficients in Table 6-10 correspond to the estimated parameters for γ in the utility index. Positive coefficients for a given variable mean that as the value of the variable increases at a site, the utility derived from the site (and, hence, the probability of that site being visited) increases. Thus, longer rivers yield more satisfaction than shorter rivers (the positive coefficient on *Length*). Similarly, if a river is classified as *Cold Water*, the positive coefficient implies that these water bodies are more likely to be visited than warm-water streams. Because the model is highly nonlinear and the explanatory variables are scaled for use in maximum likelihood estimation (for example, income is measured in $1000 increments), one cannot directly interpret the magnitude of any given coefficient to say, for example, variable *X* is more important than variable *Y*.

TABLE 6-10
Rivers Portion of the Initial Site-Choice/Total Trips Model, Day Trips [a]

	Coefficient	**Standard Error (Hessian)**	**Standard Error (White)**
Rivers Variables			
Length (km)	0.012	**0.001**	**0.005**
Temperature Impaired	-0.405	**0.068**	0.280
Cold-water	0.345	**0.057**	0.489
Cold-water×Angler	0.380	**0.114**	0.440
Blue ribbon fishery	0.213	**0.055**	0.295
BRF×Angler	0.937	**0.145**	**0.505**
Fish Stocked (0/1)	0.857	**0.052**	**0.275**

TABLE 6-10
Rivers Portion of the Initial Site-Choice/Total Trips Model, Day Trips [a]

	Coefficient	Standard Error (Hessian)	Standard Error (White)
Stocked×Angler	0.603	**0.122**	0.369
Average DO Sat	0.044	**0.003**	**0.022**
Average DO Sat Squared	-2.29×10^{-4}	$\mathbf{1.8\times10^{-5}}$	$\mathbf{1.3\times10^{-4}}$
Average TIN	0.658	**0.086**	0.664
Average TIN Squared	-0.230	**0.026**	**0.130**
Average TP	-0.036	0.158	1.346
Average TP Squared	-0.022	0.068	0.532
Log likelihood value		-36,281.3	

Bold indicates coefficient is statistically significant at $\alpha<0.10$.

[a]The full set of parameters (for lake site choices, the total trips model, and other ancillary parameters) has been suppressed for clarity of the discussion in Section 6.6.2.

Turning first to a broader statistical issue encountered in the modeling, the standard errors for the coefficients were estimated two different ways: with the standard Hessian variance-covariance matrix and with White's variance-covariance matrix, which is robust to a wide variety of model misspecification issues. One may observe that the standard errors are larger in the White matrix, which is indicative of the misspecification problems, including non-constant variance across observations (heteroscedasticity). Intuitively, the behavioral response to water quality and other site attributes may differ depending upon whether one visits to boat, to fish, or to engage in other activities. The standard errors that are in boldface indicate a coefficient that would be considered as statistically significant (at α less than 0.10). The number of variables that are statistically significant under the White matrix (6 out of 14) is considerably smaller than the number with the Hessian matrix (12 out of 14). This suggests that one should be concerned with model variance that differs across the households on which the model is based. This was controlled for by (1) reporting tests of statistical significance based upon White's robust covariance matrix and (2) allowing the variance to differ according to primary water-based activity (fishing and boating, with all other activities serving as the base).

Of particular interest are the water quality measures in the utility index. As noted above, a quadratic relationship for DOS, TIN, and TP is postulated. One can solve for the "behavioral optimum" for each measure—that is, what are the values of DOS, TIN, and TP that maximize the utility index, and thus maximize the probability that the site is visited? (For the quadratic specification, $y = aX + bX^2$. The maximized value is found by solving $dy/dX = a + 2bX = 0$ for X, with the general solution equal to $-a/2b$.) The DOS behavioral optimum of 96.6 percent is within the ecologically desired range for DOS (between 90 and 110 percent). The TIN optimum of 1.43 mg/L would represent a doubling of the mean concentration currently found at the 153 rivers in the model. The TP optimum of −0.82 mg/L is beyond implausible. Recalling the literature review, Helm et al. (2004) would classify a water body at 97 percent DOS as High quality, whereas the measure for TIN would place these water bodies in Ribaudo and Piper's Poor category. Within the context of the TEV portion of this study, these value of TIN would place the water body in the "poor" category (TP is unclassifiable) so the model in Table 6-10 is unacceptable model from a water quality management perspective. While it is possible that the nutrient levels preferred by recreationists may diverge from the ecological optimum, natural scientists indicated that the water quality optima implied by the model in Table 6-10 would not yield a satisfying recreational experience.

The key to the problem may be in the specifications of nitrogen and phosphorus. Although not immediately evident in Table 6-10, the water quality variables in specifications that included both nitrogen and phosphorus were generally problematic. First, discussions with DWQ personnel indicate that these two measures tend to move together (they are collinear), which is consistent with the results of the econometric model: overall, the models with both nitrogen and phosphorus have a good degree of overall statistical significance, yet individual variables are not statistically significant. Again, recall the literature: Vesterinen et al. report a high degree of correlation amongst their measures of water quality; Egan et al. make special note of the fact that they benefit from a low collinearity. Indeed, a comparison of the Akaike Information Criterion (AIC)—a measure of relative distance of competing models from the true model—suggests that the model from which Table 6-10 is drawn is statistically preferable to the models to be presented in the next section. Second, only one of the six water quality measures in the rivers portion of the model is statistically significant (using White's robust covariance matrix), *and* the parameters imply a behaviorally optimum quality of water that is at odds with the ecological optimum. Clearly the AIC by itself is not an appropriate measure of model quality. In a slightly different context, Burnham and Anderson's (2002, p. 17) discussion of the AIC notes: "If a particular model parametrization [sic] does not make biological sense, this is reason to exclude it from the set of candidate models…"

6.6.3 Model Results: Day Trips

The behavioral models for day trips under four different specifications are shown in Table 6-11 and Table 6-12. The specifications differ only in water quality variables used in the Rivers portion of the models. All significance tests are based on White's robust variance-covariance matrix. The upper two-thirds of each table show the coefficients for the lakes and rivers portions of the nested-logit site-choice model, along with the estimated travel cost and inclusive value parameters. The bottom one-third of each table shows the truncated negative binomial model of total day trips. The parameters describing lake choice were constrained to be equal across northern and southern lakes, yet the scale parameter for each nest allows the effect to differ by geographic region (that is, the influence for boat ramps in Specification 1 is 0.086/1.268 for northern lakes and 0.086/1.435 for southern lakes). As noted above, positive coefficients in the site choice model mean that as the value of the variable increases, the site is more likely to be visited, whereas negative coefficients mean the site is less likely to be visited (as the value of a variable increases).

TABLE 6-11
Day Trips, Lakes and Rivers – 284 sites, n=686; Two-Level Nested Logit with Truncated Negative Binomial

	Specification 1		**Specification 2**	
Site Choice Model	**Coeff**	**t-statistic**	**Coeff**	**t-statistic**
Lakes				
Number of boat ramps	0.086	0.809	0.061	0.660
Ramps×boater	**0.677**	4.528	**0.733**	4.979
State park	**0.576**	3.272	**0.704**	3.403
Blue ribbon fishery	0.255	1.036	**0.552**	2.388
BRF×angler	-0.265	-0.710	-0.313	-0.759
Fish stocked (MT)	**-0.019**	-2.449	**-0.018**	-2.503
Fish stocked×angler	**0.047**	5.197	**0.051**	5.470
Ln(Hectares)	**0.409**	5.859	**0.464**	8.168
Maximum TSI(SD)	**-0.026**	-2.282	**-0.012**	-1.759
Maximum [TSI(CHL) – TSI(SD)]	0.010	1.147	**0.018**	2.516
Rivers				
Length (km)	**0.015**	3.493	**0.010**	2.810
Temperature Impaired	-0.191	-0.693	-0.301	-1.132
Cold-water	0.536	1.093	0.168	0.420
Cold-water×angler	0.014	0.005	0.423	0.972
Blue ribbon fishery	0.238	0.671	0.168	0.570
BRF×angler	1.090	0.896	**0.961**	1.870
Fish stocked (0/1)	**1.006**	3.493	**0.823**	3.128

TABLE 6-11
Day Trips, Lakes and Rivers – 284 sites, n=686; Two-Level Nested Logit with Truncated Negative Binomial

Site Choice Model	Specification 1		Specification 2	
Stocked×angler	0.391	0.442	0.557	1.559
Average DO Sat			**0.054**	3.030
Average DO Sat squared			**-2.66×10^{-4}**	-2.417
Average TIN	-0.036	-0.189	-0.156	-0.679
Average TP	-0.388	-0.753	-0.319	-0.690
Travel Cost and Scale Parameters				
Travel Cost	**-0.068**	-8.654	**-0.070**	-9.310
Scale, northern Lakes	**1.268**	8.912	**1.442**	10.033
Scale, southern Lakes	**1.435**	8.245	**1.656**	8.925
Scale, rivers	**0.855**	4.130	**0.804**	6.587
Total Trips				
Intercept	**1.598**	2.294	**1.395**	1.779
Income	0.004	1.634	**0.004**	1.751
Lake boater	**-0.605**	-2.898	**-0.069**	-2.950
Lake angler	-0.200	-0.908	-0.200	-1.050
River boater	0.433	1.276	0.504	1.633
River angler	**0.566**	2.657	**0.653**	3.874
Inclusive value from nested Logit	0.012	1.138	0.012	1.350
Alpha	**1.468**	6.324	**1.470**	6.486
Heteroscedasticity adjustment				
River boater	0.388	1.559	**0.399**	2.078
River angler	**0.518**	4.984	**0.507**	4.765
Log of likelihood function	-36,537.833		-36,360.252	

TABLE 6-12
Day Trips, Lakes and Rivers—284 sites, n=686; Two-Level Nested Logit with Truncated Negative Binomial

	Specification 3		Specification 4	
Site Choice Model	**Coeff**	**t-statistic**	**Coeff**	**t-statistic**
Lakes Variables				
Number of Boat Ramps	0.060	0.642	0.061	0.661
Ramps×boater	**0.735**	4.943	**0.731**	4.966
State park	**0.708**	3.400	**0.698**	3.375
Blue ribbon fishery	**0.554**	2.388	**0.550**	2.397
BRF×angler	-0.316	-0.764	-0.310	-0.754
Fish stocked (MT)	**-0.018**	-2.480	**-0.018**	-2.515
Fish stocked×angler	**0.051**	5.385	**0.051**	5.515
Ln(hectares)	**0.464**	8.066	**0.464**	8.244

TABLE 6-12
Day Trips, Lakes and Rivers—284 sites, n=686; Two-Level Nested Logit with Truncated Negative Binomial

	Specification 3		Specification 4	
Site Choice Model	**Coeff**	**t-statistic**	**Coeff**	**t-statistic**
Maximum TSI(SD)	**-0.013**	-1.775	**-0.012**	-1.724
Maximum [TSI(CHL) – TSI(SD)]	**0.018**	2.499	**0.018**	2.560
Rivers Variables				
Length (km)	**0.010**	2.773	**0.011**	3.197
Temperature impaired	-0.315	-1.203	-0.284	-1.107
Cold-water	0.190	0.452	0.198	0.549
Cold-water×angler	0.412	0.948	0.439	1.003
Blue ribbon fishery	0.165	0.552	0.182	0.630
BRF×angler	**0.968**	1.869	**0.954**	1.869
Fish stocked (0/1)	**0.820**	3.131	**0.827**	3.189
Stocked×angler	0.547	1.539	0.567	1.592
Average DO Sat	**0.054**	3.038	**0.051**	3.205
Average DO Sat squared	**-2.72×10^{-4}**	-2.471	**-2.50×10^{-4}**	-2.610
Average TIN	**-0.261**	-1.968		
Average TP			**-0.620**	-2.629
Travel Cost and Scale Parameters				
Travel cost	**-0.070**	-9.115	**-0.070**	-9.357
Scale, northern lakes	**1.444**	9.811	**1.438**	10.135
Scale, southern lakes	**1.664**	8.647	**1.645**	8.857
Scale, rivers	**0.808**	6.487	**0.799**	6.629
Total Trips				
Intercept	**1.374**	1.750	**1.434**	1.870
Income	**0.004**	1.765	**0.003**	1.729
Lake boater	**-0.611**	-2.960	**-0.605**	-2.932
Lake angler	-0.200	-1.055	-0.200	-1.050
River boater	0.503	1.632	0.504	1.631
River angler	**0.652**	3.857	**0.654**	3.883
Inclusive value from nested Logit	0.012	1.377	0.011	1.328
Alpha	**1.470**	6.491	**1.471**	6.483
Heteroscedasticity Adjustment				
River boater	**0.411**	2.214	**0.389**	1.960
River angler	**0.502**	4.755	**0.513**	4.768
Log of likelihood function	-36,367.289		-36,369.581	

The models include anywhere from four to six water quality variables (two for lakes and two, three or four for rivers) and 30 other variables. The parameter estimates for these “other” variables are discussed first because they remain relatively constant in magnitude, sign, and statistical significance across all four specifications presented. The remainder of the discussion is then devoted to the water quality variables.

For choice among lakes, boat ramps were a desired attribute for those who reported “boating” as a primary activity at lakes, whereas they were not an important characteristic to others visiting lakes. Designation as a state park was a positive and significant characteristic in all model specifications; designation as a Blue Ribbon Fishery had a positive effects for all lake users (significant in specifications 2, 3, and 4) with no additional effect for anglers (the interaction term is insignificant in all specifications). Anglers are clearly attracted to lakes that are stocked with fish—the more fish the better—but curiously it appears that stocking of fish has a negative effect on nonanglers. Finally, larger lakes are more likely to be visited than smaller lakes, all else equal.

Turning to the river site choice model one can see that the longer the river stretch the more likely it is to be visited. Temperature impairment and whether the river was identified as a cold-water river had no statistical effect on site choice. In contrast to the effect of Blue Ribbon Fishery designation for lakes, the BRF designation for rivers positively influences selection of the site by river anglers (Specifications 2, 3, and 4) but has no significant effect on the site choices of other types of river users. Rivers that are stocked with fish have a positive effect on all river users with no additional effect on anglers.

The travel cost coefficient, which is constant across all site choices, is negative and significant; as the cost of travel to the site increases it is less likely to be visited, all else equal. The scale parameters for two of the three nests are statistically significant and greater than 1, which is consistent with the economic theory of utility maximization. The parameter for the rivers nest is significantly less than one in Specifications 2, 3, and 4.

Five of the eight parameters in the total trips model are statistically significant and have the expected sign. All else equal, one would expect to see a greater number of trips as income goes up and from those who fish on rivers. An unexpected result is the negative (and significant) coefficient on lake boaters; the expectation is that those who have invested in a watercraft would make more water-based recreation trips than those who have not. Another unexpected result is the lack of statistical significance on the inclusive value passed from the nested logit model. (For Specifications 2, 3, and 4, the p-value for a one-tailed test that the parameter is greater than zero is about 0.09; a two-tailed test that the parameter is different from zero has a p-value of 0.19.) Although positive—as utility of recreation increases one would expect more trips—the lack of significance indicates some difficulty in predicting the total number of water-based recreation day trips over the year. Finally, the adjustment for non-constant variance shows that those who boat on rivers (three of the four models) or fish on rivers (all models) have a different variance from all other user types in the model. (The initial specification for the heteroscedasticity adjustment also included those whose primary activities were boating or fishing on lakes. These parameters were consistently insignificant and were dropped from the final variance specification.)

The parameters most relevant to this study are those associated with water quality. The water quality variables in the lake site selection model are constant across all specifications whereas the variables used in the rivers portion of the model vary across all specifications. The lakes variables are the maximum summer measurement for the TSI for Secchi depth [TSI(SD)] and the maximum difference between the TSI for chlorophyll-a and the TSI(SD) at any given reading (see Carlson, 1977, for an explanation of the TSI index). TSI(SD) is a measure of water clarity, higher values indicate poor water clarity and lower values indicate better clarity. The expected sign on this measure is negative. The difference variable attempts to measure people’s preference for water color and to separate clarity issues associated with nutrients from those associated with sediments. A positive value for the difference indicates water that is more green than brown whereas a negative value for the variable indicates water that is browner. The value of the estimate parameter has no expectation and will be determined solely by the preferences of recreationists. A positive value for the parameter indicates a preference for greener water; a negative value indicates a preference for water that is browner.

The river water quality variables are average summer DOS, average summer TIN, and average summer TP). As noted above, when appearing in quadratic form one can calculate an implied “optimum” as determined by the preference model. Given discussions with DWQ personnel one would expect a positive sign on the linear term and a negative sign on the squared term for all three water quality variables. Given the results of the initial specification, TIN and TP are entered into the model only as linear terms. One would expect a negative sign—rising nutrient levels are not preferred.

In the lakes portion of all specifications, the coefficient on the TSI(SD) variable is negative and statistically significant (all specifications) whereas the coefficient on the maximum difference between TSI(CHL) and TSI (Secchi) is positive (Specifications 2, 3, and 4). The positive coefficient suggests that water-based recreationists have a preference for water that is more green than brown. The net effect of water clarity is measured by the net effect of the TSI(SD) variable, which can be determined by subtracting the second coefficient from the first. For example, the net effect of TSI(SD) in Specification 2 is (-0.026 – 0.010), or -0.036. (More generally, with coefficients *a* and *b*, where *y = a TSI(SD) + b [max TSI(CHL) – TSI(SD)]*, then *dy/dTSI(SD) = a – b*. Statistical significance was determined using the appropriate elements of White's covariance matrix, where the variance of the linear combination of random variables, V(*a* − *b*), is given by V(*a*) + V(*b*) − 2×cov(*a*,*b*).) The net effect of TSI(SD) has approximately the same magnitude throughout all specifications. This value is significantly different from zero for all specifications and demonstrates a preference for sites that have greater water clarity. However, if Utah lakes have a clarity problem, recreationists have a preference for greener, rather than browner, water.

The water quality measures used in the rivers site-choice portion of the model varied across all specifications. Specifications 1 and 2 demonstrate the effect of including TIN and TP in the same model. Neither variable is statistically significant. Although the two variables have relatively modest correlation (0.58) across the 153 rivers, DWQ personnel have noted that the variables are collinear, which is consistent with the econometric results.

Specifications 2 (Table 6-11), 3 and 4 (Table 6-12) introduce average Dissolved Oxygen Saturation (DOS) to the rivers site-choice model quadratically. In all specifications the estimated coefficient on the linear term is positive whereas the coefficient on the squared term is negative, consistent with expectations. Evaluating the specifications for their ecological implications, the parameters in the two models suggest utility maximizing levels of average DOS of 101.8 percent (Specification 2), 99.7 percent (Specification 3) and 102.3 percent (Specification 4). These are the levels of DOS that would maximize the probability that the site is selected. Thus, all three specifications place the utility maximizing levels of average DOS within the ecologically optimum range of 90 to 110 percent. The signs of both TIN and TP are negative but insignificant in Specification 2. Each of the two models in Table 6-12 had a linear term for TIN (Specification 3) or TP (Specification 4). In both cases the coefficient was negative and statistically significant; as nutrient concentrations increase, rivers users are less likely to visit that river.

6.6.4 Overnight Trips

Overnight trips were modeled separately from day trips because: (1) an overnight trip is fundamentally different from a day trip in that it involves a different mix of recreation activities that yield utility (for example, a campfire, cooking out, sleeping in a tent or trailer, etc.), and (2) the travel cost model assumes that "time onsite" is relatively constant across all trips. The overnight trips models appear in Tables 6-13 and 6-14. Discussion of these models will follow that of the day trip models: all explanatory variables other than those associated with water quality are discussed first, followed by a focus on the water quality variables.

TABLE 6-13
Overnight Trips, Lakes and Rivers—284 sites, n=459; Two-Level Nested Logit with Truncated Negative Binomial

	Specification 1		Specification 2	
Site Choice Model	**Coeff**	**t-statistic**	**Coeff**	**t-statistic**
Lakes Variables				
Number of boat ramps	**0.553**	1.873	**0.669**	1.948
Ramps×boater	0.046	0.283	0.104	0.584
State park	**0.589**	1.658	0.754	1.471
Blue ribbon fishery	0.099	0.147	0.204	0.238
BRF×angler	0.466	0.647	0.633	0.797
Fish stocked (MT)	0.016	1.431	0.022	1.534

TABLE 6-13
Overnight Trips, Lakes and Rivers—284 sites, n=459; Two-Level Nested Logit with Truncated Negative Binomial

	Specification 1		Specification 2	
Site Choice Model	**Coeff**	**t-statistic**	**Coeff**	**t-statistic**
Fish stocked×angler	0.014	1.271	0.019	1.353
Ln(hectares)	**0.554**	3.661	**0.791**	3.676
Maximum TSI(SD)	**-0.083**	-2.650	**-0.097**	-3.290
Maximum [TSI(CHL) – TSI(SD)]	-0.003	-0.273	0.002	0.120
Rivers Variables				
Length (km)	0.019	2.682	0.017	2.893
Temperature impaired	0.073	0.109	-0.137	-0.253
Cold-water	**-0.897**	-1.623	**-1.176**	-1.876
Cold-water×angler	0.709	0.779	1.075	1.014
Blue ribbon fishery	0.431	0.557	0.426	0.529
BRF×angler	-1.267	-1.072	-1.414	-1.133
Fish stocked (0/1)	0.198	0.345	0.049	0.094
Stocked×angler	0.238	0.306	0.559	0.709
Average DO Sat			**0.079**	2.211
Average DO Sat squared			**-3.9×10^{-4}**	-2.069
Average TIN	**-0.594**	-1.846	**-0.688**	-2.010
Average TP	0.252	0.632	0.244	0.569
Travel Cost and Scale Parameters				
Travel cost	**-0.019**	-4.623	**-0.020**	-5.222
Scale, northern lakes	**1.774**	3.727	**2.430**	4.023
Scale, southern lakes	**2.015**	3.224	**2.840**	3.764
Scale, rivers	**1.312**	3.785	**1.370**	3.628
Total Trips				
Intercept	1.576	0.966	1.530	0.646
Income	-0.001	-0.431	-0.001	-0.395
Lake boater	-0.086	-0.343	-0.087	-0.334
Lake angler	-0.038	-0.157	-0.040	-0.135
River boater	0.778	1.562	0.770	1.551
River angler	**0.588**	2.293	**0.588**	2.248
Inclusive value from nested Logit	9.5×10^{-5}	0.022	1.5×10^{-4}	0.035
Alpha	**1.661**	3.796	**1.661**	3.794
Heteroscedasticity adjustment				
River boater	**-0.311**	-1.668	**-0.432**	-3.481
River angler	0.152	1.394	0.149	1.545
Log of likelihood function	-14,302.276		-14,274.956	

TABLE 6-14
Overnight Trips, Lakes and Rivers – 284 sites, n=459; Two-Level Nested Logit with Truncated Negative Binomial

	Specification 3		Specification 4	
Site Choice Model	**Coeff**	**t-statistic**	**Coeff**	**t-statistic**
Lakes Variables				
Number of Boat Ramps	**0.669**	1.944	**0.675**	1.920
Ramps×boater	0.104	0.584	0.113	0.633
State park	0.755	1.477	0.775	1.468
Blue ribbon fishery	0.206	0.242	0.220	0.249
BRF×angler	0.634	0.797	0.655	0.814
Fish stocked (MT)	0.022	1.533	0.023	1.544
Fish stocked×angler	0.019	1.350	0.020	1.356
Ln(hectares)	**0.793**	3.673	**0.824**	3.686
Maximum TSI(SD)	**-0.097**	-3.287	**-0.098**	-3.248
Maximum [TSI(CHL) – TSI(SD)]	0.002	0.123	0.003	0.172
Rivers Variables				
Length (km)	**0.017**	2.878	**0.020**	2.840
Temperature impaired	-0.122	-0.225	-0.123	-0.229
Cold-water	**-1.209**	-1.978	**-1.038**	-1.705
Cold-water×angler	1.077	1.012	1.120	1.031
Blue ribbon fishery	0.424	0.537	0.448	0.564
BRF×angler	-1.417	-1.158	-1.436	-1.166
Fish stocked (0/1)	0.047	0.081	0.070	0.129
Stocked×angler	0.560	0.696	0.585	0.711
Average DO Sat	**0.079**	2.204	**0.077**	2.133
Average DO Sat squared	**-0.39×10^{-4}**	-2.059	**-3.8×10^{-4}**	-1.971
Average TIN	**-0.614**	-2.464		
Average TP			-0.486	-1.611
Travel Cost and Scale Parameters				
Travel cost	**-0.020**	-5.216	**-0.020**	-5.286
Scale, northern lakes	**2.431**	4.021	**2.508**	4.043
Scale, southern lakes	**2.842**	3.760	**2.931**	3.791
Scale, rivers	**1.371**	3.606	**1.388**	3.535
Total Trips				
Intercept	1.493	0701	1.378	0.596
Income	-0.001	-0.414	-9.5×10^{-4}	-0.372
Lake boater	-0.088	-0.361	-0.090	0.348
Lake angler	-0.042	-0.184	-0.049	-0.171
River boater	0.766	1.602	0.754	1.566
River angler	**0.589**	2.279	**0.591**	2.264
Inclusive value from nested Logit	2.2×10^{-4}	0.056	4.0×10^{-4}	0.101

TABLE 6-14
Overnight Trips, Lakes and Rivers – 284 sites, n=459; Two-Level Nested Logit with Truncated Negative Binomial

	Specification 3		Specification 4	
Site Choice Model	**Coeff**	**t-statistic**	**Coeff**	**t-statistic**
Alpha	**1.661**	3.797	**1.661**	3.796
Heteroscedasticity adjustment				
River boater	**-0.426**	-3.438	**-0.425**	-3.464
River angler	0.149	1.550	0.151	1.598
Log of likelihood function	-14,275.750		-14,293.559	

The specifications of the overnight models were identical to those of the day trip models. Preliminary analysis suggested that developed campgrounds were collinear with other variables (the correlation with developed boat ramps was 0.63) so that this variable could be safely ignored. As with the day trip models the estimated coefficients were quite stable across all specifications. In contrast to the day trip models, though, fewer variables in the site-choice and total trips portion of the model are statistically significant. In the lakes segment of the site-choice model, only two of the non-water quality variables (boat ramps and lake area) are statistically significant in all specifications. Sites that have more boat ramps and/or greater area are more likely to be selected than sites with fewer ramps or smaller area. In the site-choice model for rivers, the length of the river (positive and significant in all specifications) and whether the river was considered a cold-water river (negative and significant in three of the four specifications) are the only non-water quality variables that affect the choice of a river at which to recreate. The travel cost coefficient is negative and significant in all specifications; all scale parameters are significant and consistent with utility maximization.

In the total trips portion of the model the only significant variables are whether or not the primary purpose of river trips was for fishing (River Angler) and the parameter adjustment for overdispersion in the trips data (Alpha). Those who identified their primary river activity as boating had a smaller variance than all other users in five of the six specifications (River Boater in the heteroscedasticity adjustment). A notable shortcoming of the total trips models are the inclusive value parameters which are very small (about 19 to 90 times smaller than the parameter in the corresponding day trip specification) and have relatively large standard errors. This suggests that, while the models do a reasonably good job relating site choices to water quality (discussed in the following text), some difficulty is encountered connecting water quality to the total number of overnight trips.

Focusing on the water quality parameters a similar pattern will be seen as was observed for the day trips models. In the lakes portion of the model, the estimated coefficient on maximum TSI(SD) is negative and significant in all specifications. The sign of the parameter on the difference in chlorophyll and secchi TSIs is negative in Specification 1, and positive in Specifications 2, 3, and 4. It is insignificant in all four specifications. One may conclude, though, that the preference for greater water clarity found in the day trips models also holds for the overnight models: the net coefficient on TSI(SD) ranged between −0.099 and −0.10 in Specifications 2, 3, and 4. All net coefficients (except for Specification 1) were statistically different from zero.

The specifications which include both average summer TIN and average summer TP appear to result in higher standard errors for both variables relative to models in which they appear singly, although TIN is significant in all four specifications and average TP is never significant. The implied optimum level of average DO Saturation (that which maximizes the probability of the site being chosen for recreation) is 101.3 percent in Specification 2, 101.6 percent in Specification 3, and 102.1 percent in Specification 4. Thus, the overnight models show a nice degree of correspondence between the ecologically optimum level of dissolved oxygen concentration and the level which maximizes the probability of visitation.

6.6.5 Model Selection

Having estimated a number of specifications, the key question is which specification(s) should be used to estimate the benefits of potential nutrient reduction policies. It is preferable to choose models which have good statistical properties and satisfy the restrictions of both economics and ecology. Standard statistical criteria include overall measures of "goodness-of-fit"; for maximum likelihood models these include a chi-square test comparing the fitted model to a restricted model in which all parameters except for an intercept are set equal to zero and a pseudo-R-square measure, again compared the restricted intercept-only model. In this model, the variance was also normalized to one by setting the scale parameters in the site-choice model to one, the Alpha in the total trips model to one, and the heteroscedasticity parameters to zero. The results are shown in Table 6-15. Overall, all models are highly significant (the chi-square test) and explain roughly the same amount of variation in the data (the pseudo-R^2). The chi-square test statistics (columns two and four for day and overnight models, respectively) far exceed the critical value for statistical significance (less than 50 for all models) suggesting that the models, on the whole, are significant. Further, there is little distinction across models in the pseudo-R^2 statistic. Thus, neither measure provides much guidance toward selection of the best model.

TABLE 6-15
Model Selection Criteria, Comparison to Restricted Model

	Day Trips		**Overnight Trips**	
Specification	$\chi^2(\beta=0)$	Pseudo-R^2	$\chi^2(\beta=0)$	Pseudo-R^2
1	38,097.9	0.343	9,612.0	0.252
2	38,453.1	0.346	9,666.6	0.253
3	38,439.0	0.346	9,665.0	0.253
4	38,434.4	0.346	9,629.4	0.252
Restricted ln L(β=0, σ=1)	-55,586.8		-19,108.3	

Turning to ecological criteria, Specification 1, the model in which TIN and TP appear in linear form, had no statistical significance in the river water quality measures. It would be difficult to estimate meaningful benefit values for nutrient reduction from models in which the nutrient variables are insignificant. That leaves Specifications 2, 3, and 4 for consideration. The corrected Akaike Information Criterion (AIC_c) statistic is used to rank the models with regard to relative likelihood of best approximating a correctly specified model (Burnham and Anderson, 2002). The statistic is calculated as,

$$AIC_c = -2\ln(L) + 2k + \left(\frac{2k(k+1)}{n-k-1}\right)$$

where ln(L) is the value of the likelihood function for the model, *k* is the number of estimated parameters, and *n* is the sample size. The last term on the right-hand side is the correction term for sample size and the number of estimated parameters in the model.

Table 6-16 shows all four models as ranked according to the AIC_c statistic. Column three of Table 6-16 shows the difference (Δ_i) between the best ranked model (that is, the minimum AIC_c) and subsequent models. While the model with the lowest AIC_c is considered the "best" model—in the sense that it is closest to the "true" model relative to the alternatives—Burnham and Anderson report that Δ_i values of less than 2 suggest "substantial empirical support" for the alternative model. A difference value (Δ_i) between 4 and 7 suggests "considerably less" support, whereas a value in excess of 10 provides "essentially no" support for the alternative. The day trip specification ranked by the AIC_c as best is Specification 2, with no real challenger from the remaining possibilities (Specifications 1, 3, and 4). For overnight specifications, the AIC_c ranks Specification 3 narrowly ahead of Specification 2, whereas Specifications 1 and 4, with difference values in excess of 35, have no support. The final column of Table 6-16 ranks the models according to the relative likelihood, which is calculated as $\exp(-0.5\times\Delta_i)$. For day trips, Specification 2 is clearly the best specification; for overnight trips Specification 3 is 1.5 times more likely to be better than Specification 2 (0.595/0.405). Changes in economic value associated with changes in water quality will be calculated for Specifications 2 and 3 for both day and overnight models. Although Specification 2 suffers from some collinearity between TIN and TP, we estimate WTP for this model due to the AIC criterion for day trips.

TABLE 6-16
Akaike Information Criterion

	AIC_c	$\Delta i = AIC_c - \min AIC_c$	Relative Likelihood of Being "Best" Model
Day Trips Specifications			
2 (minimum AIC_c)	72,796.61	0.000	0.997
3	72,808.46	11.846	0.003
4	72,813.04	16.430	0.000
1	73,147.32	338.867	0.000
Overnight trips specifications			
3 (minimum AIC_c)	28,627.44	0.000	0.595
2	28,628.21	0.766	0.405
4	28,663.06	35.618	0.000
1	28,678.15	49.942	0.000

6.7 Benefits Estimation

Despite its relatively complex likelihood function, the welfare measure derived from the linked site-choice/total trips model has a very simple form:

$$Consumer\ Surplus = \left(pred\ (T_1) - pred\ (T_0)\right) \times {}^{1}\!/\!_{\alpha}$$

where *pred*(T_1) is predicted trips under one set of nutrient conditions, *pred*(T_0) is predicted trips under an alternative set of nutrient conditions, and $1/\alpha$ is the inverse of the inclusive value coefficient in the total trips model.

Three future water quality scenarios were provided by DWQ personnel. A detailed description of the methods used in determining the future scenarios is provided in Appendix I. The first scenario (Status Quo) assumes that current water quality policy remains in place for the next 20 years and captures the effects of current policy on all lakes and rivers in the model. Due to projected population growth, most sites will either maintain their current level of quality or degrade over the 20-year time horizon. However, because of current total maximum daily load (TMDL) management, some sites are anticipated to improve in water quality over the next 20 years. As shown in Table 6-17A, 46 lakes and 73 rivers are expected to degrade in quality if current policies remain in place for the next twenty years, with 23 lakes and 16 rivers improving in water quality.

TABLE 6-17A
Summary of the Effect of Future Water Quality Policies on 131 Lakes and 153 Rivers

	Number that Degrade	Number Held Constant	Number that Somewhat Improve	Number that Greatly Improve
Status Quo: Comparison of Current Water Quality (Current Policy) versus Future Water Quality (Current Policy)				
Lakes	46	62	23	0
Rivers	73	64	16	0
Maintain: Comparison of Future Water Quality (Current Policy) versus Future Water Quality (Maintain Policy)				
Lakes	0	85	46	0
Rivers	0	80	73	0

TABLE 6-17A

Summary of the Effect of Future Water Quality Policies on 131 Lakes and 153 Rivers

	Number that Degrade	Number Held Constant	Number that Somewhat Improve	Number that Greatly Improve
Improve: Comparison of Future Water Quality (Current Policy) versus Future Water Quality (Improve Policy)				
Lakes	0	85	5	41
Rivers	0	80	33	40

Status Quo: Comparison of water quality in twenty years under Current Policy, relative to current 2011 conditions**.**

Maintain: Comparison of water quality in twenty years under a Maintain Water Quality policy that prevents degradation, relative to water quality in twenty years under Current Policy. The 23 lakes and 16 rivers that improved under the Status Quo scenario are now classified as "Constant." The 46 lakes and 73 rivers are returned to the baseline level (2006-2010 average).

Improve: Comparison of water quality in twenty years under an Improve Water Quality policy that prevents degradation and improves water quality, relative to water quality in twenty years under Current Policy. Forty-one lakes and 40 rivers improve to even better quality than under the "Maintain" policy.

The second scenario (Maintain) assumes that all improvements under current policy will still take place and that all other water bodies will be maintained at current levels of water quality (the average water quality readings for the period 2006 to 2010.) This scenario is close to the Maintain scenario valued in the TEV portion of the study in that no waters will degrade, but it also allows for scheduled improvements associated with TMDLs. Under this scenario, the 23 lakes and 16 rivers that improved under current water quality policy are classified as constant; whereas the 46 lakes and 73 rivers that suffered degradation under the Status Quo are returned to the baseline level of water quality (they improve relative to current policy). Finally, the third scenario (Improve) allows for even better water quality at the 41 of the 46 lakes and 40 of the 73 rivers that improve under the Maintain scenario. Thus, the Improve scenario not only prevents degradation, improvements in water quality at 81 sites exceed those of the Maintain scenario.

In considering the results, it is important to note that the "baseline" for the scenario varies. The Status Quo welfare measures compare future water quality 20 years from now under current regulations against water quality as measured in 2011. That is, if we maintain "business as usual" with current regulations, what is the change in welfare relative to today's (2011) water quality? The Maintain and Improve scenarios represent a change in regulatory management (preventing degradation and/or improving quality over 20 years). The WTP measures for these scenarios are compared to the "business as usual" water quality in 20 years.

Table 6-18 shows how each of the future water quality scenarios compares to current water quality. Under the status quo, 46 lakes and 73 rivers will degrade, 23 lakes and 16 rivers will improve and the remainder will remain constant. Under the maintain scenario, no water bodies will degrade relative to current conditions while 23 lakes and 16 rivers will improve. Finally, under the improve scenario, again no water bodies will degrade, and 46 lakes and 73 rivers will improve relative to current conditions.

TABLE 6-18

Summary of the Effect of Future Water Quality Policies on 131 Lakes and 153 Rivers

	Number that Degrade	Number Held Constant	Number that Improve
Status Quo			
Lakes	46	62	23
Rivers	73	64	16
Maintain			
Lakes	0	108	23
Rivers	0	137	16

TABLE 6-18
Summary of the Effect of Future Water Quality Policies on 131 Lakes and 153 Rivers

	Number that Degrade	Number Held Constant	Number that Improve
Improve			
Lakes	0	85	46
Rivers	0	80	73

Status Quo: Comparison of water quality in twenty years under Current Policy, relative to current 2011 conditions**.**

Maintain: Comparison of water quality in twenty years under a Maintain Water Quality Policy, relative to current 2011 conditions.

Improve: Comparison of water quality in twenty years under an Improve Water Quality Policy, relative to current 2011 conditions.

The welfare effects of these policies are shown in Table 6-19 for Specifications 2 and 3 for both day trips and overnight trips models. All models show improvements in the TSI indices, average DOS, average TIN, and average TP, depending up on the specification. Improvements from low average DOS levels were raised to 90 percent (the bottom of the desirable range for DOS) whereas improvements from high average DOS sites meant that average DOS was lowered to 110 percent (the top end of the desirable range). Rivers that were already in the desirable range were left at that value.

TABLE 6-19
Mean Seasonal Welfare Measures

Model	Status Quo	Maintain	Improve
Day Trips			
Specification 2[a]	−$6.37 (−$7.92 to −$5.04)	$9.78 ($8.35 to $11.67)	$17.83 ($15.30 to $21.18)
Predicted baseline trips/HH: 14.79	Predicted mean trips/HH: 14.72	Predicted mean trips/HH: 14.83	Predicted mean trips/HH: 14.92
Specification 3[b]	−$6.71 (−$8.10 to −$5.40)	$10.21 ($8.70 to $11.92)	$18.76 ($15.90 to $22.01)
Predicted baseline trips/HH: 14.79	Predicted mean trips/HH: 14.71	Predicted mean trips/HH: 14.83	Predicted mean trips/HH: 14.93
Overnight Trips			
Specification 2[a]	−$4.82 (−$9.60 to −$1.78)	$29.49 ($21.80 to $43.29)	$89.57 ($65.69 to $134.04)
Predicted baseline trips/HH: 7.17	Predicted mean trips/HH: 7.17	Predicted mean trips/HH: 7.17	Predicted Mean trips/HH: 7.18
Specification 3[b]	−$4.79 (−$9.65 to −$1.78)	$29.47 ($21.17 to $43.00)	$89.73 ($65.72 to $133.91)
Predicted baseline trips/HH: 7.17	Predicted mean trips/HH: 7.17	Predicted mean trips/HH: 7.17	Predicted mean trips/HH: 7.18

[a]Improve TSI measures, Dissolved Oxygen Saturation, Total Inorganic Nitrogen, and Total Phosphorus
[b]Improve TSI measures, Dissolved Oxygen Saturation, and Total Inorganic Nitrogen

For day trips, the status quo of current water quality policy—with improvements at some sites and degradation at many others—results in a loss of about $6.50 per household per year for day trips, and about $4.80 per household per year for overnight trips (Table 6-19, Column 2). The models predict that water based recreation day trips will decline by about 0.5 percent as net overall water quality declines; no change in overnight trips is expected. The Maintain scenario posits the question, "what if all waters with current TMDLs improve but no other sites are allowed to degrade?" The net economic benefit of the Maintain policy is about $10 per household per year for day trips and approximately $29.50 per household per year for overnight trips (column three of Table 6-19). The expected change in water-based recreation trips is very small: about 0.3 percent increase for day trips and no increase for overnight trips. The Improve scenario allows water quality to improve at many sites and degradation at none. The net economic benefit of the Improve policy is about $8.25 per household per year for day trips, and about $89.75 per household per year for overnight trips (Table 6-19, Column 4). The expected change in water-based recreation trips is an increase of about 0.9 percent for day trips and 0.14 percent for overnight trips.

Aggregate welfare measures appear in Table 6-20. Based on the sample weights—which assign to each observation the number households it represents—at least one member of 654,201 Utah households took at least one trip to a lake or river in Utah during the 12 month sample period (Chapter 5, Table 5-9). Of these households, some 625,416 (95.6%) took day trips and 426,539 (65.2%) took overnight trips. The net economic values reported in Table 6-19 are measured as annual benefits per household. Multiplying by the number of households taking day trips and those taking overnight trips yields the aggregate (statewide) economic benefits of different water quality management policies. Relative to the water quality at the time of the data collection (2011), current policy will result in general degradation of water quality (119 lakes and rivers), though a few waters will improve (39 lakes and rivers). Averaging the estimates from the two models the net annual loss once these water quality conditions are in place is estimated to be approximately $6 million per year. Put another way, Utah households would be willing to pay about $6.0 million to avoid these future conditions.

TABLE 6-20
Annual Net Economic Benefits of Future Water Quality Policies ($ millions)

	Status Quo	Maintain	Improve
Specification 2			
Day trips	-$3.91	$6.01	$10.96
Overnight trips	-$2.02	$12.34	$37.49
Total	-$5.93	$18.35	$48.45
Specification 3			
Day trips	-$4.12	$6.27	$11.53
Overnight trips	-$2.01	$12.34	$37.56
Total	-$6.13	$18.61	$49.09

All dollar values measured in millions.

The Maintain water quality policy compares the future effects of current policy in twenty years relative to a policy that keeps the best of current policy (that is, improvements in waters under a TMDL) *and* prevents degradation at 119 lakes and rivers. The aggregate WTP for the Maintain policy is about $18.5 million annually once the targeted water quality conditions have been achieved. Finally, the Improve scenario not only prevents degradation relative to today's conditions, it improves water quality beyond the levels associated with the Maintain policy. The annual aggregate net economic value associated with an Improve policy is estimated to be about $48.8 million when projected future water quality conditions are met.

The benefits reported in Table 6-20 are calculated for water quality that is not expected to be fully achieved until twenty years have passed. For example benefits associated with the Improvement policy will not occur instantaneously, so even if the policy is adopted immediately the benefits in Year 1 will not be $48.8 million. Rather, improvements will take place over time. And although Specifications 2 and 3 produce similar results, it is reasonable to move forward with only one specification to calculate the net present value of water-based recreation demand. To this end, Specification 2 is selected because it performs slightly better than Specification 3 on the basis of the AIC criterion and because it represents a slightly more conservative estimate of recreation demand benefits.

To calculate a net present value for the Maintain and Improve policies, one must assume a "path" for water quality over the twenty year time horizon. We adopt a simple linear path; that is, 1/20 of the water quality change will occur in year 1, 2/20 will have been achieved in year 2, 3/30 in year three, and so on until full benefits (20/20) are achieved in year 20. The net present results are presented in Table 6-21. These results are based on model Specification 2 and are presented both with and without population growth (which is consistent with the population forecasts used in Section 5. The net present value analysis assumes that participation of households in day and overnight recreation trips remains constant across the forecast period, with 95.6 percent of user households taking at least one day trip and 65.2 percent of user households taking at least one overnight trip. Using a 2.7 percent real discount rate (see Section 5), the net present value of the Maintain policy is $141.26 million without population growth and the Improve policy has a net present value of $372.94 million without population growth. If population growth is factored into the calculation, the Maintain policy has a net present value of $183.99 million whereas the Improve policy has a net present value of approximately $485.75 million.

TABLE 6-21
Net Present Value of Water Quality Policies ($ millions)

	Maintain	**Improve**
No population growth	$141.26	$372.94
With population growth	$183.99	$485.75

6.8 Summary

A survey regarding the recreation activities of over 1,400 Utah households was used to gauge the influence of nutrients in recreation choices and to estimate the net economic value of alternative water quality management policies. About 73.2 percent of Utah households participate in outdoor recreation in, on, or adjacent to a river or a lake. Utahns are quite active, reporting a median of 12 trips per household per year, and an adjusted mean of over 20 trips per year. According to statements by survey respondents, the negative effects of nutrients (increased odor, decreased water clarity, and increased algae) are important attributes to consider when choosing a place to recreate.

Rather than rely solely on the stated preferences of Utah residents, water quality data gathered by the UDWQ has been used to estimate a recreation demand model that links the lakes and rivers that people visit (and how often) to objective measures of water quality. The recreation demand model consisted of 131 lakes and 153 river segments in Utah. It is estimated that these 284 sites account for more than two-thirds of all water-based recreation trips in the state. The empirical models demonstrate that Utahns do consider the effects of nutrients when making recreation site choices. Water clarity is a statistically significant determinant of site choice for lakes: as water clarity declines at a lake the probability that lake is selected for recreation declines.

River site selection is related to dissolved oxygen saturation, whereas the relationship to concentration of nitrogen and phosphorus is more complex. The level of dissolved oxygen saturation that maximizes the probability that the river is selected is in accordance with the desirable range as measured by natural scientists. UDWQ personnel noted some degree of collinearity in nitrogen and phosphorus concentrations, and the effects appear to be observed in the models. When appearing alone in the models, though, increasing levels of nitrogen concentration decreased the probability that a site was selected for recreation. Phosphorus had the same negative relationship, but was significant only in the models for day trips. In all the results are consistent with the findings in Chapter 7 whereby survey respondents indicated whether they find stream segments desirable or undesirable for recreation based upon the level of nuisance algae depicted solely in terms of photographs. Survey respondents indicated by their recreation choices and by their opinions that nuisance algae detracts from their recreation experience.

Whereas water quality helped explain where people visit for water-based recreation (the site-choice model), the effect of water quality on the number of recreation trips was very small (the total trips model). People showed a willingness to travel further to reach higher quality destinations rather than forego their favorite water-based recreation activities.

Three future water quality scenarios were posited. The Status Quo policy scenario compared today's water quality to water quality in twenty years under current management policy. The future has a mix of degradation (119 sites), improvements (39 sites), and sites at which water quality will not change (126). The Maintain water quality policy assumed that the improvements at the 39 sites would occur, but that degradation at the 119 sites would not be permitted. Finally the Improve water quality policy would do more than maintain water quality at current levels; no water would degrade and water quality at 81 sites would improve beyond current levels of quality.

Assuming the water quality conditions twenty years hence have been achieved, Utahns would be willing to pay approximately $6.0 million annually to avoid the Status Quo policy. Utahns would be willing to pay approximately $18.5 million annually for the Maintain water quality policy, and approximately $48.8 million annually for the Improve water quality policy. With the gradual reductions in excess nutrient loads over time, the estimated net present value of maintaining water quality for recreation is $184 million and for improving water quality is $486 million. This is a fraction of the total WTP for maintaining and improving water quality that was reported in chapter 5. This substantiates the opinions expressed in Chapter 3. Utahns care about maintaining and improving water quality to protect and enhance the recreation experience. However, they care even more about preserving the quality of life for future residents of Utah.

7.0 Nuisance Algae Threshold for Recreation and Aesthetics

7.1 Background

The Federal Water Pollution Control Act of 1948 was the first major U.S. law to address water pollution. The Water Pollution Control Act was amended in 1972 and the law became commonly known as the Clean Water Act (CWA). The CWA establishes the structure for regulating pollutants and determining water quality standards. Under the CWA, states are authorized and responsible for creating water quality standards to protect the beneficial uses of the state's water bodies. Beneficial uses are the characteristics of a water body that contribute to human values (culinary water supply, fisheries, aesthetics and recreation uses, and agricultural irrigation). States determine the beneficial uses of a water body based on its naturally occurring chemical, physical, geographic and biologic characteristics. The number of uses assigned to a given water body varies from place-to-place, but at a minimum nearly all surface waters are assigned recreation and aquatic life uses in accordance with the CWA's interim goal of providing for the" protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water" (CWA §101(a)(2)). Water quality standards are subsequently established that define specific goals that must be achieved to obtain all of the uses assigned to a water body (EPA 2012).

As described throughout this report, there is extensive documentation that excess nutrients—particularly nitrogen and phosphorus—in water bodies leads to a condition called eutrophication, meaning well-nourished. Eutrophication often leads to undesirable conditions such us nuisance algae, habitat degradation, odors, and low Dissolved Oxygen (DO) all of which harms sensitive aquatic life. Standard toxicological methods developed by EPA and states for developing water quality standards have limited applicability to eutrophication because relatively low levels of nutrients, well below toxic concentrations, can cause nutrient-related problems. Moreover the effects of any given concentrations of nitrogen and phosphorus varies from place-to-place because nutrient responses can be mitigated or exacerbated by site specific factors such as light availability (shading, turbidity), substrate characteristics, groundwater inputs, and adaptations of native fauna to low DO environments. Deleterious effects of excess nutrients also vary temporally and the most severe impacts of different responses sometimes occur at different times of the year. Eutrophication occurs naturally, particularly in depositional areas, so determining the natural—or background—concentration is also difficult, particularly in areas with a long history of human occupation. Such complex linkages between excess nitrogen and phosphorus and the deleterious effects of eutrophication on water bodies result in complications for developing numeric nutrient criteria.

Most of the negative consequences of excess nutrients discussed above are most obviously linked to the protection of aquatic life uses, which DWQ is currently evaluating. However, nutrients can also impact recreation uses in a couple of ways. First, some harmful algal blooms (HABs) are toxic with documented problems that range from rashes to neurological disorders from prolonged exposure. In many places such HABs frequently lead to lake beach closures. HABs are known to occur throughout Utah, although DWQ is just starting to explore the extent of the problem. A second important impact of nutrients is degraded aesthetics—both visually and olfactory. While the effects of most aquatic pollutants are invisible, those associated with eutrophication are obvious to the general public and therefore have the potential to directly impact the recreational uses of water bodies. Developing aesthetics-based recreation criteria is appealing because it would be directly coupled to preferences of Utahns.

Determining what comprises a deleterious effect for a beneficial use of a water body is sometimes somewhat subjective, especially for aesthetic impacts to recreation uses. A study conducted by Hoagland et al. (2006) on the economic impacts of eutrophication determined that harmful algal blooms (HABs) cost $4 million per year to recreation and tourism to coastal Maryland waters. A study calculating the direct losses to fishing and tourism from a single HAB event in Texas in 2000 was estimated at $10 million (Evans and Jones 2001). These studies have shown that there is certainly an economic impact resulting from nuisance algae, although quantifying a threshold where these values are high enough to constitute degradation is more complicated. Dodds and Welch (2000) reviewed literature related to aesthetic impairments of filamentous algae in freshwaters and concluded that nuisance levels of benthic algae occur somewhere between 100 to 200 mg/m^2 (as measured by benthic Chlorophyll a [Chl a]). An earlier study conducted by Horner et al (1983) suggested that a biomass of 150 to 200 mg/m^2 represented a nuisance condition. They were able to able to grow benthic algae in an artificial channel and attain levels of 150-200 mg/m^2 at relatively low phosphorus concentrations (15-25 µg/L soluble reactive phosphorus [SRP]). From these studies and others there is clearly an economic and regulatory need to develop a method to assess and protect recreational and aesthetic uses from nuisance algae. Several states (for example, Montana, Colorado, Vermont) have started incorporating numeric criteria to minimize aesthetic degradation.

In order to determine what levels of benthic algae growth remain protective of the state's recreational beneficial uses (UAC R317-2-6) based on recreation and aesthetics, the Utah DWQ conducted an opinion survey of Utah households to identify the levels of benthic algae that the public finds undesirable.

7.2 Methods

Utah DWQ's approach to developing numeric nutrient criteria for the protection of the recreational beneficial use of Utah's rivers and streams was to develop a nuisance benthic algae standard based on a public opinion survey regarding desirable and undesirable aesthetics associated with benthic algae. The survey question was included as part of the survey intended to estimate Utahn's WTP for protection and improvement of water quality associated with excess nutrients (Designing the Questionnaires, Chapter 3).

In the survey, participants were shown eight color photographs of streams with the stream bottom visible and varying levels of benthic algae. Participants were directed to "Tell us if the level of algae would be desirable or undesirable for YOUR most common uses of rivers, if any." by filling in a bubble next to the option "desirable" or "undesirable" for each photograph. The survey question and photographs are included in Appendix J.

The photographs were selected to represent the range of benthic algae conditions that a user may encounter at a river during summer peak algal growth. The photographs were identical to those used in the Suplee et al (2009) survey. At each site, 10-20 replicate benthic algae samples were taken so that the Chl a concentration for each photograph was known, but not shown to the participants. Chl a concentrations in the photos ranged from <50 mg Chl a/m^2 to 1,276 mg Chl a /m^2 (see Appendix J for photos). Sites and photographs were chosen from sites that varied approximately 50 mg Chl a/m^2 from each other. See Suplee et al (2009) for complete detail on photograph selection and sampling methods.

The relationship among benthic Chl a concentrations and percent desirable condition was analyzed with the Spearman rank correlation and the difference among user and non-user response with the Kruskal-Wallis rank-sum test ($p<0.05$). All analyses were conducted in R (R Development Core Team, 2012).

7.3 Results

The survey showed a strong inverse relationship between benthic Chl a concentrations in the photos and what the public viewed as desirable conditions (Figure 7-1). There was a significant negative correlation among benthic Chl a concentrations and percent desirable responses (Spearman's $r=-0.95$, $p<0.001$), with a distinct threshold between 150 mg/ m^2 (59.8%) and 200 mg/ m^2 (17.5%).

There was no significant difference among the responses of percent desirable condition between users (water based recreationists) and non-users (Figure 7-2). Moreover, there was no significant difference in percent desirable condition among the users and nonusers in the Utah survey and the Montana 2009 survey (Kruskal-Wallis rank-sum test, $p=0.94$, Table 7-1).

7.4 Discussion

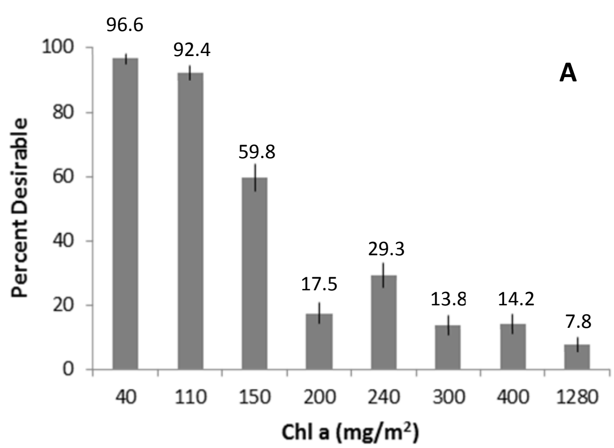
In general, the survey results from water users (water-based recreationists) and non-users show agreement among what Utahns consider a desirable amount of benthic algae. The agreement among these two user types provides confidence that this response is likely one of the larger population of all Utahns. Moreover, the responses on percent desirable condition from user and non-user groups from Utah had no significant difference than the responses from Montana user and non-user groups (Table 7-1). While the public perception of algal concentration is not likely an intrinsic response to algae across the country, there may be consensus to what is desirable within similar regions, such as the intermountain west.

There appears to be a clear threshold at 150 mg Chl a /m^2 that divides sites into desirable and undesirable conditions for a majority of respondents. Sites with < 150 mg/m^2 (n=2) had mean percent desirable condition of 94.5%, while sites with > 150 mg/m^2 (n=5) had a mean percent desirable condition of only 16.5%. The site exactly at 150 mg/m^2 appears to split the difference among these two groups, with percent desirable of 59.8%. The true threshold may lie somewhere between 110 mg/m^2 (94.2%) and 150 mg/m^2 (59.8%); however, it would be difficult to manage for benthic Chl a at very small increments (10 mg/m^2) due to intra-annual variation of weather and temperature that causes variation of algal concentrations beyond this low resolution. Therefore, setting a threshold at 150 mg/m^2 would be a good compromise between over- and under-protective criteria.

The responses from this survey provide a very clear criterion with which to manage the state's rivers and streams for recreation and aesthetic beneficial uses. For some parameters, the criteria for recreation uses are based on protection of human health (*E. coli* concentrations). Parameters affecting recreation demand and aesthetics have more subjective implications, which were objectively defined through the use of the public survey. The threshold of 150 mg Chl a/m^2 can be objectively measured with standard field algal collection techniques and standard lab analyses that Utah routinely collects.

FIGURE 7-1
(A) Percent desirable benthic algae response from all Utah survey participants.

FIGURE 7-2
(B) Percent desirable benthic algae responses from users (black) and non user (grey) groups showing similarity in responses. Error bars indicate 95% confidence interval.



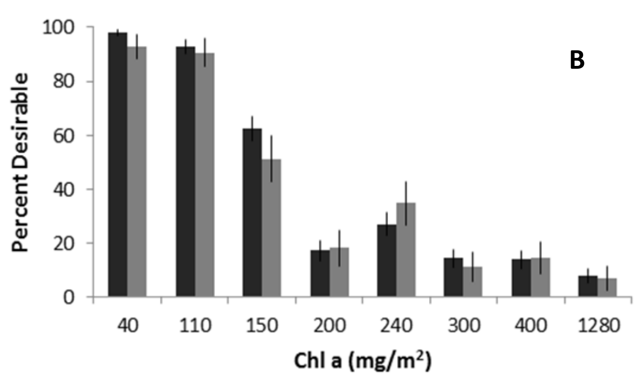


TABLE 7-1

Percent desirable survey responses among two user groups (user and non user) from Utah's survey and the Montana survey (Suplee et al 2009). Responses among users and State did not differ (ANOVA P=0.94).

	Chl a	% Desirable Utah		% Desirable Montana	
Photo #	(mg/m^2)	Non-Users	Users	Non-Users	Users
1	40	92.8	98.0	95.6	98.2
7	110	90.6	92.9	94.9	93.6
6	150	51.2	62.5	69.7	75.8
5	200	18.3	17.4	16.5	31.8
2	240	34.9	27.1	28.8	29.1
8	300	11.4	14.4	12.6	20.2
3	400	14.7	14.1	16.7	11.5
4	1280	7.1	7.8	11.3	9.1

8.0 Analysis of Impacts to Lake-Front Property Values Resulting from Nutrient-Related Changes in Water Clarity

8.1 Introduction

Improvements in surface water quality can increase the visual aesthetics, reduce negative impacts such as odor, and increase or enhance water-based and near-shore recreation opportunities. Waterfront, water-view and water access property owners tend to benefit more than the general public from increases in surface water quality simply because it is convenient for them to take advantage of the waters' amenities. Indeed, the amenity value of clean water tends to get capitalized into property values, reflecting the extra amount that buyers are willing to pay for the clean water amenity. An early study by Dornbush and Barrager (1973) for the U.S. EPA, found that waterfront and near-shore property prices were sensitive to a range in water quality parameters, especially dissolved oxygen concentration, fecal coliform concentrations, clarity, visual pollutants (trash and debris), toxic chemicals, and pH. A second study funded by the U.S. Environmental Protection Agency found that lakefront property values increased when water quality improved from boating/fishing water quality to swimmable and drinkable water quality (d'Arge and Shogren, 1985). Researchers have found that property prices have benefitted from the following:

- Increased pH in streams (Epp and Al-Ani,1979)
- Increased water clarity in lakes (Steinnes, 1992; Poor et al., 2001; Gibbs et al., 2002; Krysel et al., 2003; Ara et al., 2006; Walsh, 2009; Walsh et al., no date)
- Absence of PCB contamination (Mendelsohn et.al., 1992)
- Reductions in fecal coliform (Leggett and Bockstael, 2000; Ara et al., 2006)
- Lower mercury contamination in rivers (Morgan et al., 2010)
- Reductions in total suspended solids and dissolved inorganic nitrogen in the watershed (Poor et al., 2007)

Waterfront property values are most sensitive to changes in water quality (and quantity, especially lake levels) but there is a steep gradient with distance from the water front (Lansford and Jones, 1995; Walsh et al., 2009). Because the change in the value that households and businesses place on the clean water amenity is capitalized into property prices, there can be unanticipated windfall gains and losses when the water quality changes are unexpected at the time of purchase and over the long term. The increments and decrements in property values depend upon whether the changes are perceived as temporary or permanent, as well as the nature and extent of the change.

This chapter explores the likely magnitude of the change in waterfront property values over time because of the implementation of nutrient criteria for managing Utah's surface waters. This analysis is intended to contribute to the weight of evidence of the magnitude of benefits to the public from improving and maintaining water quality. Care must be taken in adding the increments in property values to the estimates of the aggregate WTP of Utahn households for managing nutrients to improve water quality reported in Chapter 5. In some circumstances, adding the property value results to the household WTP results could result in some double counting to the extent that such property owners are represented in the general household and recreation surveys. However, the current general household survey is unlikely to capture a representative sample of waterfront property owners because of the very small number of such households in relation to the TEV survey. As Moore et al. (2011) demonstrated, households most near Green Bay report higher WTP for improvements in water clarity than more distant households. For this reason, a targeted study to estimate waterfront property value changes because of changes in water quality from nutrient load reductions is warranted, while acknowledging that care must be exercised in interpreting results and aggregating benefit estimates. Specifically, this analysis contributes to the weight of evidence of the linkages between implementing nutrient criteria and economic benefits.

As an added benefit of the study, it is important to communicate to property owners that they influence their water quality and their property values. Maine Department of Environmental Protection has used the results from a study of the impacts of eutrophication on lakefront properties in Maine in their local outreach materials to help educate the public (Maine Department of Environmental Protection, 2011). This incentivizes landowners to modify their behavior to help protect their “investment” by preventing run-off of harmful nutrients from their property. It is important to note that higher property values can lead to higher property tax revenue or to reductions in millage rates for all property in the region in order to hold property tax revenue constant. Similarly, reductions in property values resulting from degraded surface waters can have the opposite effect. Finally, the results from this analysis can be used to better understand the expected benefits from improving specific water bodies.

8.2 Empirical Literature Relating Lakefront Property Values to Excess Nutrients

8.2.1 Hedonic Pricing Models

Hedonic pricing models are sometimes used to estimate the WTP for environmental amenities such as improved water quality, cleaner air, unobstructed scenic views, absence of Superfund sites nearby, reduced flood damage, or improved fish and wildlife habitat. These models rely on differentials in housing and property prices within the same market area to determine how much extra people are willing to pay for environmental enhancements compared to similar properties without such enhancements. The applicability of hedonic pricing models depends on the extent to which the alternatives are expected to result in measurable environmental improvements that would be reflected in property values. In addition, the extensive data requirements and significant empirical issues are generally important considerations in choosing this valuation method. One either needs repeat sales within the same market area over a time period when water quality is changing or data on multiple market areas each with different levels of water quality. In this way, it is possible to relate the differences in housing and property values to differences in water quality while controlling for the other factors that affect prices.

8.2.2 Literature Summary

The empirical literature relating changes in waterfront property values to changes in surface water quality, especially water quality measures that are influenced by nutrients involves lakefront properties, but not riverside properties. One early study examined properties in the Lake Okoboji area of Iowa. These glacial lakes offer a relatively unique set of characteristics for experimentation since they are connected and have about the same amenities except water quality. East Okoboji is relatively shallow and suffers from long periods of dense algal blooms during the summer recreation season—primarily because of agricultural run-off. In contrast West Okojobi is typically characterized as clear with low turbidity and rare noticeable algae blooms. The authors found property prices to increase in the range 13 to 23 percent for water quality differentials between the two lakes depending upon the valuation method, including realtors’ opinions, a pooled regression model using a water quality “ladder” or index, and stated preferences of residents.

More recently, New England states (especially, Maine, New Hampshire and Vermont) are well represented in the empirical literature. Young and Teti (1987), Boyle et al. (1998), Michael et al. (1996), Gibbs et al. 2002), Poor et al. (2001) and Ara, et al. (2006) all found water clarity to significantly influence lakefront-housing prices in New England. Steinnes (1992) and Krysel et al. (2003) each examine Minnesota lakes, while Ara et al. (2006) look at Lake Erie. A recent manuscript by Walsh et al., and based on the PhD dissertation by Walsh (2009) involves lakes in Orange County, Florida.

Young and Teti (1987) included a dummy variable for poor water quality and found a significant relationship between the dummy variable and property values. The average property located in polluted areas on St. Alban’s Bay of Lake Champlain, Vermont lost 20 percent of its value as compared to similar properties located in nonpolluted areas. Most of the subsequent studies relied upon specific objective measures of water quality, especially water clarity (Secchi disk readings), which is more useful for the present purpose than a dummy variable. Secchi depth is a measure of surface water clarity (or transparency) obtained when a trained technician lowers a Secchi disk into the water body and records the level at which the disk disappears from sight. Eutrophication from excessive nutrients is one of the primary factors affecting water clarity. Poor et al. (2001) compared the resultant implicit prices derived from the objective Secchi disk readings versus the homeowners' subjective perceptions of water clarity. Their study covered four lakefront real estate markets in Maine and the objective water clarity measures were significant predictors in each of the markets. The implicit prices for the subjective measures of clarity were larger than for the objective measures, but the objective measures were better predictors of property sales prices. Finally, the subjective measures were highly correlated with the Secchi disk readings. In all, this gives some confidence in using the more readily available objective measures that have the added benefit of being more responsive to water quality policies.

Michael et al. (1996) found that a 1-meter (3.3-foot) improvement in lake water clarity increased property prices by anywhere from $11 to $200 per foot of water frontage. Boyle et al. (1998) extended this initial analysis with a two-stage model which added more data and market areas. Boyle et al. (1999) took the estimated hedonic price functions for the four market areas where the estimated coefficient on water clarity was significant and used the results to calculate the implicit prices for water clarity for each of the lakes. In a second stage model they estimate the "demand" for water clarity as a function of the implicit price, size of the lake and other lake characteristics. Boyle and Bouchard (2003) used an updated database for Maine lakefront sales and calculated the property value impacts in percentage terms based upon the current property prices. They found that a 1-meter improvement in clarity increased property values by 2.6 to 6.5 percent depending upon the market. A decrease in clarity by 1 meter depressed prices by 3.1 to 8.5 percent. The average minimum reported water clarity at time of sale for each of the market areas in Maine ranged from 3.88 to 6.09 meters. The hedonic price function is nonlinear with decreasing increments to price with each incremental increase in water clarity. Not surprisingly, properties with greater waterfront frontage showed larger price impacts; however, it was also noted that lake front properties on larger lakes were more sensitive to changes in water quality than similar properties on smaller lakes.

Gibbs et al. (2002) apply an almost identical approach to estimating the contribution of water clarity to lakefront property in New Hampshire. However, they were not anticipating similar results given the differences in market conditions across the two states. New Hampshire has fewer lakefront properties to offer than has Maine, and yet New Hampshire draws upon much larger population centers including Boston and New York. Thus, their lakefront properties have higher market values. Nonetheless, in percentage terms, their results are within range of the Maine results. Gibbs et al. (2002) found that a 1-meter change in water clarity increased average lakefront property values in the range of 0.9 to 6.6 percent. The corresponding average minimum Secchi disk readings across the lakes in each of the real estate markets ranged from 4.18 to 5.88 meters.

Steinnes (1992) studied undeveloped waterfront lots around lakes in northern Minnesota using mean annual Secchi disk readings in the sale year as the objective measure of water clarity. This is a slightly different measure of water clarity than was used in the New England studies. In the latter case, the researchers used the minimum Secchi disk reading for the year of sale. Steinnes (1992) found that the average value of a 1-meter increase in water clarity came to $1.99 per foot of water frontage. Unfortunately, the author did not report the market values for the lots or the percentage of that value attributed to water quality. However, he did calculate the average value of a 1-meter change in water quality for the average lot, which included 121 front feet. Namely $1.99 per foot multiplied by 121 feet produced $240 in the capitalized value of water quality improvement. Using the ratio of the Consumer Price Index (CPI) for 1992 (140.3) relative to the semiannual average CPI for 2011 (223.598), in today's dollars the increment to the value of waterfront lots for a 1-meter increase in water clarity is about $382.00.

A second study of Minnesota lake front property, concentrated on waters located in the Mississippi headwaters. Krysel et al. (2003) followed a similar modeling approach as the Maine and New Hampshire studies. They grouped a sample of the Minnesota lakes into six groups intended to represent the range in real estate markets in the region. Rather than minimum Secchi disk reading as in the Maine work, they used the mean readings for the year of sale to estimate their hedonic price model. They believed that the mean would more closely align with property owners' perceptions. The results show that water clarity has a significant positive relationship with property value for each of the lakes in the study. Mean Secchi disk readings for water clarity ranged from 1.38 to 6.61 meters. With a 1-meter decline in water clarity, across the 37 lakes in their sample, the decrease in property prices per foot of frontage ranged from $1.43 to $594.00. Property prices declined by an average of $70 per frontage foot, which corresponds to $5,250 for a 75-foot frontage property. For a 1-meter increase in water clarity, the increase in property prices ranged from $1.08 to $423.58 with an average of $46 per frontage foot or $3,420 for a 75-foot frontage lot. Most of the properties in the sample were developed, but 13 percent were undeveloped.

The authors did not report their results in terms of the percentage increases or decreases in property values, but they provided the data needed for these calculations, which are summarized in Table 8-1. There was considerable variability within and across the real estate markets. The average property price increase for a 1-meter increase in water clarity ranged from 1 percent for the Brainerd Lake Group to 11.3 percent in the Bemidji Lake Group and the overall mean across all 1,205 lakes was about 5.3 percent. The average decrease in property values for a 1-meter decrease in mean water clarity ranged from 1.4 percent for the Brainerd Lake group to 23 percent for the Austin Lake Group. The average price decrease across all 1,205 lakes was about 8.6 percent. The high end of these ranges is due to the influence of a few large lakes with unique attributes. The average price effects are within the range of the Maine and New Hampshire studies, even as the results for some of the separate lake groups are relatively high.

TABLE 8-1
Summary of Minnesota Lake Property Impacts from a 1-meter Change in Water Clarity

	Number of Parcels	Average Purchase Price ($)	Average Frontage (feet)	Percent Increase Property Prices from a 1-Meter Increase in Clarity	Percent Decrease Property Prices from a 1-meter Decrease in Clarity	Average Clarity (meters)	Lake Area (acres)
Austin Lake group total	174	100,313	139	10.2	23.04	2.77	119,597
Brainerd Lake group total	387	176,461	115	1.04	1.38	3.99	84,995
Grand Rapids Lake Group total	134	135,905	192	1.8	2.37	4	272,962
Walker Lake Group total	216	179,621	143	8.3	11.60	4.29	268,155
Park Rapids Lake Group total	173	124,390	163	4.3	5.77	4.19	50,660
Bemidji Lake Group total	121	142,829	141	11.3	16.11	2.86	66,815
Grand mean	1205	150,669	141	5.27	8.56	3.76	136,971

Source: Constructed from data reported in Krysel et al., 2003

A study of property values along Lake Erie showed sensitivity of property values to both bacteria counts and water clarity (Ara et al. 2006). Although the authors do not report the same statistics as the New England and Minnesota studies, they do assess the welfare effects of raising the level of water clarity from its current condition to 2 meters. Achieving this minimum level of water clarity raised property values by 4 to 5 percent.

Finally, a recent study of water quality benefits as reflected in housing prices in metropolitan Orange County, Florida, finds that estimates of the expected marginal value of a 1-meter increase in Secchi depth translates to about a 4 percent increase in lakefront property values (Walsh, 2009; Walsh et al., no date). Like the Maine, New Hampshire and Minnesota studies, the Florida results indicate that lake size has a small positive effect on the implicit value of water quality. In the Florida case, a tenfold increase in lake size is associated with about a $1,000 (or 20 percent) increase in the marginal implicit price of water clarity. These results relating percentage changes in lakefront property values to water clarity are summarized in Table 8-2.

TABLE 8-2
Summary of Lake Property Impacts of a 1-Meter Change in Secchi Depth

	Number of Parcels	Average Price	Percentage Increase Property Prices/Meter Increase in Secchi Depth	Percentage Decrease Property Prices/ Meter Decrease in Secchi Depth	Average Clarity (meters)	Average Lake Area (Acres)
Grand mean Minnesota lakes	1205	$150,669	5.27	8.56	3.76	8285
Minnesota range	1205	$100,313 to $179,621	1.0% to 11.3	1.4% to 23	4.18 to 5.88	214 to 1,879
New Hampshire range		$132,000 to $175,000	0.9 to 6.6			
Maine range		$70,000 to $107,000	2.6% to 6.5	3.1% to 8.5	3.88 to 6.09	679 to 4,756
Orange County, Florida	146	$ 452,646.	3.94		1.52	520

Sources: Krysel et al., 2003; Boyle and Bouchard, 2003; Gibbs et al., 2002; and Walsh et al., no date

8.3 Empirical Literature Relating River and Stream Edge Property Values to Water Quality

No empirical hedonic property value studies of river and stream edge properties as a function of nutrients in these flowing surface waters were found. An early study of property values along rural streams in Pennsylvania by Epp and Al-Ani (1979) found a positive relationship between pH and stream front property values along streams of relatively good water quality. There was no significant relationship between pH and property values along the more degraded streams. Streiner and Loomis (1996) use the hedonic property value method to estimate the value of restoring streams with associated benefits ranging from reducing flood damages to improving habitat for fish. Cho, Bowker and Park (2006) establish a positive relationship between property values and proximity to rivers and streams, but they do not separately control for water quality parameters. Morgan, Hamilton and Chung (2010) find that riverfront property values are lower for areas with fish advisories resulting from mercury contamination. Using a hedonic property value model of properties within the watershed, and not just river edge properties, Poor et al. (2007) establish a relationship between total suspended solids and dissolved inorganic nitrogen. They find marginal implicit prices associated with a 1 milligram per liter change in total suspended solids and dissolved inorganic nitrogen, to be minus $1,086 and minus $17,642, respectively. They attribute these reductions in property values to nonpoint source pollutants as measured at various monitoring stations in the watershed. These results are encouraging and further substantiate that the value of locating closer to clean water resources does tend to get capitalized into property values. However, they are not useful for the present purpose, which is to consider only waterfront properties in order to avoid double counting of benefits. Also to apply these estimates one would need more data on the spatial relationships between the water resources of varying water quality and the properties that are influenced by changes in water quality. For these reasons, the present analysis is limited to valuing water clarity improvements as reflected in lakefront properties. As an additional point, it is worth noting that this study has not investigated the role that improving the water quality of urban rivers and streams has played in revitalizing urban waterfronts. Standard economic valuation approaches may not apply directly to such situations as revitalization efforts are driven by a multitude of factors, rendering it difficult to parse out the contribution of water quality.

8.4 Methodology

The preferred method of estimating the marginal contribution of environmental attributes to property values is the hedonic property value method. Hedonic pricing models rely on differentials in housing and property prices, while controlling for market conditions, neighborhood effects, and housing attributes, to determine how much more people are willing to pay for properties with environmental enhancements compared to similar properties without such enhancements. The applicability of hedonic pricing models to estimating the value of water quality improvements to property owners depends on the extent to which the improvements are perceptible to and valued by the public. This valuation method is data intensive, especially to achieve coverage for the surface water resources across the entire state. Given the supporting role the results will play in the overall benefit-cost analysis of reducing nutrients loadings to surface waters, a less ambitious but still enlightening approach is adopted for the present purpose. Instead of estimating an original hedonic pricing model, a benefits transfer approach is employed. The benefits transfer method is a practical alternative to valuation methods involving the collection of original data on preferences. This valuation method relies on approaches toward transferring value estimates or WTP functions from existing studies to a different application. The reliability and validity of such transferred values depend on the quality of the original studies as well as the degree of similarity between the original context in which the values were estimated and the new context. Important contextual features can include the type of water quality improvement, baseline and changes in water quality, and preference of the populations.

The benefits transfer method is a practical valuation alternative when direct survey data concerning an identified issue are unavailable, but at best it will produce ball park estimates. As with each of the valuation tools, if the degree of accuracy is not sufficient for supporting a decision, further analysis may be required, for example in the case of a site-specific determination. Benefits transfer applications are heavily reliant upon the existing empirical literature involving the same type of environmental amenity and similar context. The literature review (Section 7.2) demonstrates a strong relationship between water clarity and lakefront property values and the results are summarized in Table 7-2. Using the grand mean for the Minnesota and Florida studies and the ranges for the Maine and New Hampshire studies, the percentage increases in property values for a 1-meter increase in water clarity range from 0.9 to 6.6 percent, with a median of 3.7 percent—which is the estimate used for increases in water clarity for the purpose of this benefit transfer exercise. Similarly, the percentage decreases in property values associated with a 1-meter decrease in water clarity range from 3.1 to 8.56 percent with the midpoint at 5.8 percent—which will serve as the estimate for decreases in property values from any reductions in water clarity projected for Utah's lakes.

8.5 Results

To apply the literature to lakefront properties in Utah, data on the current values of private lakefront parcels, current measures of water clarity (minimum summer Secchi disk reading) and projections for future water quality, were collected by Utah DWQ and summarized in tabular form. Two scenarios are considered. The first scenario considers future conditions under continuation of the current policy relative to a policy of "no degradation." Under this scenario, only lakes that would degrade are evaluated in order to estimate the value of preventing this degradation. The second scenario involves comparing future conditions under a new nutrient reduction policy that would result in improving water clarity as well as preventing degradation. These scenarios are consistent with the water quality scenarios in the recreation demand modeling as well as the assessment of TEV. Only lakes that show changes in water clarity under one or both of these scenarios are carried forward in the analysis. In addition, only lakes with parcels in private ownership are part of the analysis. The state collected ownership data on 125 of the 134 priority lakes. For 66 of these lakes, the entire shoreline is owned by the public, including federal, state and local governments. Of the 59 lakes with private waterfront parcels only a small number, 17, showed changes in water clarity. The list of these 17 lakes with the number of undeveloped lots, developed parcels and, the average prices of each are tabulated in Table 8-3. In total, the seventeen lakes included 549 lots and 819 developed parcels. The developed parcels were concentrated on the waterfronts of three lakes: Bear Lake (419 parcels), Stansbury Lake (284 parcels), and Utah Lake (77 parcels).

Absent a new nutrient policy, the average degradation in the minimum summer Secchi disk reading comes to 0.27 meter and results in an average loss in property values of about $433,000. Summing across all properties gives a total loss of almost $7.4 million across all properties. In present value terms, these future losses would be discounted depending upon when they would occur. If instead, the nutrient criteria were to be implemented, the average water clarity would increase by almost 1 meter. This improvement would increase average property values by about $1.187 million. The total gain across all properties comes to about $20.2 million. Again, this figure would be discounted depending upon when the improvements occur. These gains are not spread evenly. Property owners around Bear Lake would accrue a gain of almost $16.6 million under the improvement scenario. Property owners around Bear Lake would also be the biggest losers under the degradation scenario, where the aggregate lakefront property values would decline by $5.8 million.

8.6 Conclusions

This investigation into the potential impact to lakefront property values in Utah from losses and gains in water clarity resulting from changes in the level of nutrients was intended to fill a potential gap in an otherwise fairly comprehensive assessment of the benefits of implementing nutrient criteria. Waterfront property owners are especially sensitive to changes in surface water quality as the water quality is a factor in their decision about how much they are willing to pay for the property. When the water quality is permitted to degrade, the losses in the aesthetics of the waterfront location tend to get capitalized into the value of the property. Similarly, improvements in water quality attract higher prices for waterfront property. Of Utah's 130+ priority lakes, only a fraction have shorelines in private ownership subject to property tax payments, and only 17 of those water bodies showed changing water clarity conditions from the nutrient control scenarios. The water clarity in these lakes could improve by almost 1 meter by implementing new nutrient criteria versus a continuation of the status quo where water clarity could decline by about 0.27 meter (about 1 foot). In property value terms, the new criteria would produce a gain in property values of $20.2 million. No new action would lead to a loss of around $7.4 million.

TABLE 8-3
Impacts to Lakefront Property Values of Private Parcels from Changes in Water Clarity

							Minimum Summer Secchi Depth (meters)			Maintain	Improve	0.058	0.037
Rec	**County**	**Water Body**	**Mean Value Land Only ($)**	**No. of Parcels**	**Mean Value with Buildings ($)**	**No. of Parcels**	**Current Conditions**	**Future Conditions - Current Policy**	**Future Conditions - Improve Scenario**	**Degrade (meters)**	**Improve (meters)**	**$ Degrade**	**$ Improve**
21	Duchesne	Big Sand Wash Res.	7,162.53	15	0.00	0	2.5	2.0	3.2	-0.48	1.22	-2,961	4,864
31	Emery	Cleveland	359,086.50	2	0.00	0	2.9	2.3	3.8	-0.58	1.50	-24,216	39,959
47	Juab	Mona reservoir	18,858.37	57	528,159.00	2	0.2	0.2	0.2	-0.03	0.07	-3,671	5,808
48	Juab	Yuba Reservoir	7,474.11	9	0.00	0	0.5	0.4	0.6	-0.07	0.16	-258	409
52	Millard	Gunnison Bend Res	28,104.47	19	96,511.80	5	0.3	0.2	0.3	-0.02	0.06	-1,414	2,181
60	Rich	Bear Lake	471,418.41	122	190,154.21	419	5.6	4.9	8.1	-0.73	3.27	-5,797,160	16,593,229
67	San Juan	Dark Canyon Lake	0.00	0	89,900.00	2	3.4	3.3	3.6	-0.12	0.31	-1,277	2,049
78	Sanpete	Ninemile Reservoir	23,164.40	5	0.00	0	2.2	1.7	4.0	-0.51	2.28	-3,397	9,776
79	Sanpete	Palisade Reservoir	25,427.60	5	0.00	0	0.8	0.7	1.1	-0.06	0.32	-478	1,511
89	Summit	Echo Res	133,705.00	2	0.00	0	1.9	1.6	2.9	-0.30	1.33	-4627	13,157
102	Tooele	Rush Lake	58,622.86	14	153,464.33	3	0.3	0.3	0.3	-0.01	0.03	-804	1,291
103	Tooele	Settlement Res.	750.50	2	0.00	0	1.3	1.2	1.8	-0.12	0.62	-10	34
104	Tooele	Stansbury Lake	73,165.00	24	250,501.05	284	0.8	0.7	1.1	-0.08	0.39	-320,364	1,047,197
112	Uintah	Pelican Lake	13,164.50	6	0.00	0	1.9	1.5	2.6	-0.42	1.10	-1,913	3,223
116	Utah	Salem Lake	32,043.23	13	232,877.78	27	0.9	0.7	1.7	-0.22	1.01	-85,964	251,720
119	Utah	Utah Lake	220,535.61	248	429,577.69	77	0.2	0.2	0.4	-0.05	0.25	-279,116	81,7311
125	Washington	Sand Hollow	3,226,173.33	6	0.00	0	7.4	6.7	8.6	-0.75	1.95	-838,346	1,393,436
Total number of parcels				**549**		**819**							
Average change per parcel										**-0.27**	**0.93**	**-433,293**	**1,187,480**

9.0 Analysis of Water-Based Recreation Expenditures in the Utah Economy

9.1 An Introduction to Economic Impact Analysis

The previous sections of this report related to an assessment of the economic benefits of maintaining and improving the state's surface waters by implementing nutrient criteria and thus reducing adverse impacts from nutrient over-enrichment. A second question of considerable importance, which is the subject of this section of the report, involves the role that the state's surface waters play in contributing to the economy of the state. Specifically, this section uses an economic methodology to assess the contribution that annual expenditures on water-based recreation activities have on jobs and net output in the state's economy. This is accomplished using an input-output model of the economy that begins with the direct expenditures on recreation and traces the effects of those expenditures through the economy as those initial dollars get re-spent causing the multiplier effect. As noted in Chapter 6, the dollar values derived from such an impact analysis are measures of local economic activity (for example, employment, net regional output or "value-added," and earnings) which are to be distinguished from measures of net economic value (WTP). Measures of the net change in economic value are the theoretically and policy-appropriate metric for evaluating public projects and programs on the basis of economic efficiency and thus to improve social welfare through the wise use of society's resources. Measures of economic activity, especially employment, are important because a healthy economy is also critical to supporting the quality of life in a region. By providing both types of measures, the relationships between maintaining and improving the quality of the state's surface waters and maintaining quality of life in the region are made transparent.

As shown in Figure 6-4, the net change in economic value associated with a change in water quality is given by area *A-B-C-D*, or the area between the quality-differentiated demand curves and *above* the travel cost. This captures the net value to the public from their recreational use and enjoyment of the surface water resources of the state over and above their out of pocket costs. The rectangular area *below* travel cost and bounded by the origin and the number of trips captures out of pocket expenditures. Economic impact analysis captures how these expenditures benefit the local economy. Assuming that the travel cost consists only of cash expenditures, the total expenditures by a water-based recreation enthusiast would be the travel cost per trip multiplied by the total number of trips. At the initial water quality level (Q_1), total expenditures would be given by the area delineated by $TC \times T_1$. If TC = \$50 and the angler made T_1 = 10 ten trips, then total expenditures would be \$500.

In section 6 we saw that the number of trips under the "Status Quo" scenario fell because, although some sites have better water quality, far more have degraded water quality. Say that the number of trips for a person falls from 10 to, say, T_2 = 6. In this case total expenditures are \$300, or a decline in total expenditures by \$200. Alternatively, under the "Maintain" and "Improve" scenarios the number of recreation trips increased, to say 12 trips. At a cost of \$50 per trip, this would result in additional recreation expenditures of \$100 in the economy. Economic impact analysis traces the multiplier effects of expenditures through the economy as a whole.

Recreation expenditures occur for food, fuel, equipment, rentals, lodging and other goods and services. Firms that cater to recreation activities benefit from recreation expenditures, as do the employees directly employed by firms and the businesses from which firms purchase intermediate goods and services. If a new firm enters a community, or if existing firms expand their operations to satisfy the demands of recreation, the local, regional and state economies benefit. By the same token, the loss of a firm, or contraction of existing firms, can lead to the loss jobs, income and tax revenues. Economic impact analysis is a technique that traces these expenditures (or lack thereof) throughout the regional economy, including multiplier effects, to estimate changes in employment, income and tax revenues.

Economic impact analysis is composed of three types of economic effects: direct effects, indirect effects, and multiplier or ripple effects. Direct effects are those attributable specifically to expenditures by firms to satisfy recreation demands. If a firm receives a \$100 payment for providing goods and services used in recreation, the business will then spend that \$100 in the form of wages, payments to suppliers, proprietor income, etc. For example, the workers employed by a motel represent the direct employment impact of these facilities. Similarly, the firm's expenditures on wages and salaries account for its direct income effect. Direct fiscal effects arise through the property and sales taxes from investment in real and personal property and spending on sales taxable items. In addition, other taxes and fees are paid by businesses which also contribute to direct fiscal effects.

Indirect effects arise from business-to-business activity; these are also known as "backward linkages" in an economy. One firm's expenditures on raw materials, services, supplies, and other operating expenses will help support jobs in other local businesses. For example, a restaurant may see its sales expand as the result of water-based recreation, requiring more purchases from food service wholesalers and potentially greater accounting and legal services from local firms. Note that only the value added via the local production process—the expenditure actually retained by the local vendor, which is not equal to the total retail sale—gives rise to additional economic impacts for the community, (in our case, the state of Utah.) It is for this reason that retail sales, in isolation, represent a poor measure of economic impact. Hence, when firms buy from a wholesaler, much of the proceeds from the sale accrue to the community where the goods were manufactured, which may be from outside the state. Of course, local governments reap the benefits of sales taxes on these sales. Thus, the magnitude of a firm's indirect impact on local incomes depends not only on the dollar value of locally purchased goods and services, but also whether or not these same goods and services are locally produced or imported into the state. In addition, the amount of indirect employment generated by the business will vary with the amount of capacity existing in local businesses. Although a firm's payments to local vendors will increase the amount of local business activity, they will not translate into significant increases in employment and capital investment if local firms are currently experiencing excess capacity. Instead of hiring new workers or expanding production facilities, managers will utilize excess capacity first, thereby resulting in a smaller indirect impact than if local supply firms were operating at full capacity.

Finally, multiplier, or ripple, effects are created as the new income generated by the direct and indirect effects is spent and re-spent within the local economy. These effects are also known synonymously as "forward linkages" or "induced effects". For example, part of the wages received by a firm's employees will be spent on, say, housing in an apartment complex. A portion of the rent payment is used to pay the local employees of the apartment complex. Apartment complex employees will, in turn, spend a portion of their income in the local community on groceries, housing, etc., thus adding to the local economic output and income attributable to the original firm's activities. However, during each subsequent round of spending a portion of the income generated leaks out of the local economy through spending outside the community, savings, and taxes, thereby diminishing the increment to the local economy. The total economic effect is the sum of the direct, indirect, and multiplier effects.

The analysis in this chapter is conducted using most recent (2010) model of the Utah economy developed by the Minnesota IMPLAN Group, which is an outgrowth of an input-output model developed by the US Forest Service (in cooperation with the Federal Emergency Management Agency and the BLM) to assist in land and resource management planning. The IMPLAN package includes (1) estimates of final demands and final payments for counties and states, which is developed each year from government data; and (2) a national average matrix of technical coefficients which measure inter-industry linkages. The software allows the analyst to build a statewide model and conduct impact analysis.

9.2 Expenditures for Water-Based Recreation

Expenditure data was elicited for lake and river recreation. After completing the trips section of the survey, which was described in Section 3, respondents were asked:

> We would like to know how much money you spent on these visits. Please write down your best estimate of what your household spent for each kind of item on the **most recent** visit to a lake and/or a river in Utah that you or members of your household took in the **last 12 months**. If you did not spend any money on an item, please enter a zero for that item. *We realize that some households may have spent a lot of money on their most recent lake or river visit, whereas other households may have spent very little money.* [Italics added.] Answers to this question will allow us to calculate an average household expenditure per visit.

A table with seven expenditure categories followed this paragraph, with each category corresponding to an economic sector in IMPLAN.

The italicized statement was added following the focus groups because participants wished to report expenditures for their most expensive trip, as opposed to expenditures for the most recent trip. Designed in consultation with focus group participants, the intent of the italicized statement was to temper the desire to report expenditures from the trip with the greatest cost.

Initial analysis of the raw data indicated that the question was not fully successful in mitigating this desire. Some extremely high values were reported (for example, $15,000 for cabin rental on the most recent trip, and $3,000 in expenditures at gasoline/convenience stores). The mean total per trip expenditure for lake trips was just under $341, whereas the corresponding measure for river trips was $136 (Table 9-1, Columns 2 and 3). While these figures are valid in principle, in practice the outlier values skew the expenditures greatly. Thus, Letter Value analysis was used to identify the severe outliers. The first step was to assure that the dataset used for the demand analysis was comparable to that used for the expenditure analysis. That is, any observation identified as an outlier in the demand analysis (in excess of 115 total trips) was dropped from the expenditure analysis. Second, expenditures across all categories were totaled separately for lake trips and for river trips. Letter value analysis set the outer fence for total per trip expenditures on lake trips at $1,380 and for river trips at $588. An observation exceeding the outer fence value was dropped when calculating expenditures for lake or river trips. Some 59 observations (6.6 percent) were identified as outliers for the lake expenditures whereas 34 observations (6.5 percent) were outliers for the river expenditures.

TABLE 9-1
Mean per Trip Expenditures for Water-Based Recreation

	Outliers Included		Outliers Dropped		
Category	**Lakes (n=897)**	**Rivers (n=526)**	**Lakes (n=838)**	**Rivers (n=492)**	**Weighted**
Hotels, motels, B&B, etc.	$38.39	$13.14	$16.53	$3.15	$12.35
Cabin or home rental, campground fees	$40.16	$7.09	$16.84	$4.05	$12.84
Gasoline/convenience stores	$124.20	$53.43	$91.63	$34.99	$73.93
Grocery stores	$78.07	$36.93	$59.11	$24.82	$48.40
Restaurants and fast food outlets	$23.28	$14.29	$17.79	$9.14	$15.09
Rental fees and supplies	$29.35	$8.19	$15.36	$3.53	$11.66
Other retail goods	$7.41	$2.93	$4.12	$1.76	$3.38
Total	**$340.86**	**$136.00**	**$221.38**	**$81.44**	**$177.66**

The mean expenditures after dropping the outlier observations appear in columns 3 and 4 of Table 9-1. Total per trip expenditures for lake visits falls by 35.1 percent, to a little more than $221 per trip; for total per trip river expenditures, the value falls by 40.1 percent, to just over $81 per trip. The expenditure analysis will be conducted for all water-based recreation trips, regardless of whether the trip is to lakes or rivers. The final expenditures, by category, were determined by weighting lake and river expenditures according to the proportion of trips taken to lakes (68.8 percent) and to rivers (31.2 percent). The final per trip expenditure is estimated to be $177.66.

Mean per trip expenditures is the appropriate measure for aggregating to the full population and modeling economic impacts by sector. Respondents were asked to report expenditures on their most recent trip because it is easier to recall such details for the most recent trip. In addition, it is assumed that the sample of most recent trip data would be representative of all trips from the population. The distributions shown in Figures 9-1 and 9-2 show a wide range in expenditure patterns, with many visitors reporting modest levels of spending and a few visitors spending a thousand dollars or more.

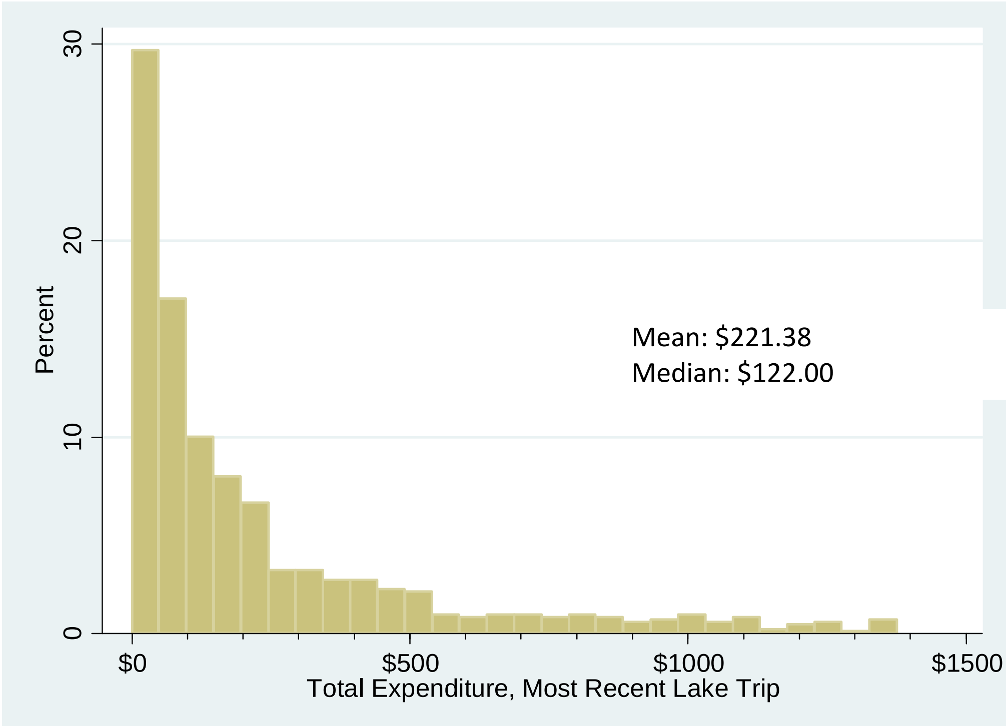


FIGURE 9-1
Distribution of Total Expenditures, Most Recent Lake Trip

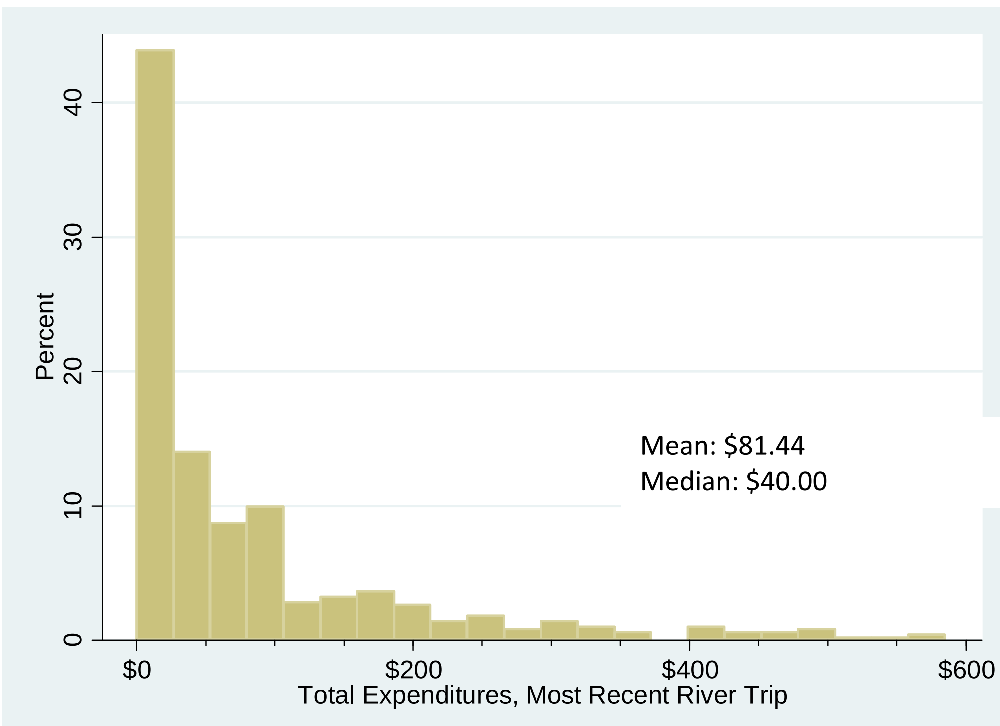


FIGURE 9-2
Distribution of Total Expenditures, Most Recent River Trip

9.3 Aggregate Trips

The next step in the expenditure analysis is to obtain an estimate of the total number of water-based recreation trips in the 12-month period. The simple approach is to use the total number of households choosing to take at least one trip, and multiply by the weighted mean number of trips per household. Before doing so, one must decide what to do with the observations identified as "outliers" for trips (those reporting more than 115 total trips). Three approaches are apparent: (1) assign these households to the weighted mean value that had been calculated after the outliers were dropped, (2) set trips equal to zero for all outliers, or (3) set the household trips equal to the outer fence value of 115 trips. To maintain consistency with Sections 5 and 6, we use the first option. The weighted mean trips per household is 20.47; multiplying this value by the number of recreating households yields a predicted aggregate number of water-based recreation trips of 13.15 million.

The distribution of total trips is highly skewed, as was noted in Chapter 6. An alternative measure of central tendency is the median, the value that is exactly in the middle of the distribution, with half the sample observations reporting more trips and the other half reporting fewer trips. The median of the trips distribution was 12 trips per household. Multiplying by the number of recreating households yields an estimated aggregate number of water-based recreation trips of 7.71 million. These two values—7.71 million and 13.15 million—constitute the lower and upper bounds for the total number of water-based recreation trips.

9.4 The Economic Contribution of Water-Based Recreation in the Utah Economy

Aggregate expenditures were determined by multiplying the per trip expenditures in each category and summing across all categories. Based on aggregate trips calculated from the weighted sample mean (13.15 million trips), a total of almost $2.4 billion in expenditures is predicted (Table 9-2, Row 9). When aggregate trips are based on the median of the trips distribution (7.71 million trips), aggregate expenditures are just under $1.4 billion.

These estimates of aggregate expenditures are based on surveys of Utah households only, and do not include expenditures in Utah by households that do not reside in the state. As such, the income, employment and fiscal effects of changes in water quality across the state are likely to be underestimated. The 2006 National Survey of Hunting, Fishing and Wildlife-Associated Recreation—the most recent comprehensive survey of fishing in the state—indicates that 87,000 out-of-state anglers enjoyed 11 percent of all fishing days in the state, and contributed 20 percent of all trip-related and equipment expenditures in Utah. Similar information for other water-based recreation activities is not available, but the angling survey suggests that the underestimate of the economic effects changing water quality (by including only Utah residents) is likely to be substantial.

Aggregate expenditures by sector (Table 9-2) are used in the economic impact analysis. One may think of the analysis as a snapshot of the contribution of water-based recreation in Utah: given the current structure of the Utah economy and total expenditures for water-based recreation, what is the contribution of water-based recreation to Utah's economy? How much do expenditures contribute in economic output, jobs, income, and tax revenues?

TABLE 9-2
Aggregate Expenditures by Category (millions)

Category	Aggregate Trips based on Median Trips/HH[a]	Aggregate Trips based on Mean Trips/HH[b]
Hotels, motels, B&B, etc.	$95.2	$162.4
Cabin or home rental, campground fees	$99.0	$168.9
Gasoline/convenience stores	$570.0	$972.3
Grocery stores	$373.1	$636.5
Restaurants and fast food outlets	$116.3	$198.4
Rental fees and supplies	$89.9	$153.4
Other retail goods	$26.1	$44.5
Total	**$1,369.7**	**$2,336.4**

[a]12 trips per household, 7.71 million aggregate trips
[b]20.47 trips per household, 13.12 million aggregate trips

The results displayed in Table 9-3 show that expenditures in recreation-related economic sectors have an output multiplier of 1.79. That is, if water-based recreation results in $1.4 billion in direct expenditures (Column 2 of Table 9-3), multiplier effects (the backward and forward linkages in the economy) will generate total sales of just over $2.4 billion in economic output. If expenditures are at the higher value of $2.3 billion, multiplier effects expand the contribution to $4.2 billion (Column 3 of Table 9-3). Value-added nets out the leakages associated with these sales (that is, goods and services imported from out-of-state). Value-added is estimated to range from $1.5 billion to $2.6 billion. Given the most recent estimate of the gross state product ($124.5 billion), the direct and indirect effects of expenditures for water-based recreation constitute somewhere between 1.2 percent and 2.1 percent of the total Utah economy. Water-based recreation is estimated to generate somewhere between 29,500 and 50,000 full and part-time jobs, with employees earning between $0.9 and $1.6 billion in labor income. Local and state entities garner between $248 million and $423 million in fiscal revenues, whereas federal entities gain between $203 million and $356 million.

TABLE 9-3
Economic Contribution of Direct Expenditures for Water-Based Recreation

	Based on Median Trips/HH 7.71 million trips total	**Based on Mean Trips/HH 13.15 million trips total**
Direct Expenditures	$1,369.7	$2,336.4
Multiplier Effects		
Total sales	$2,448.8	$4,177.3
Value-added	$1,547.5	$2,639.8
Labor Income	$922.2	$1,573.1
Jobs (full and part-time)	29,500	50,000
State and local taxes	$247.9	$422.9
Federal taxes	$203.4	$356.4

NOTE: All dollar values measured in millions.

9.5 Changes in Economic Activity under Future Nutrient Management Scenarios

The three water quality management scenarios introduced in Chapter 6 can be evaluated for the effect on economic activity within the State of Utah. The Status Quo scenario allowed current policy to play out over the next 20 years. Relative to current (2011) levels of water quality, some waters would improve in quality because of existing TMDLs, some would remain constant in quality, and a large number would degrade. The recreation demand models predict that the number of day trips for water-based recreation would decrease by about ½ of one percent, as the effect of degrading water bodies outweighs the effect of those (fewer) water bodies which improve in quality. No change in the number of overnight trips was predicted. The Maintain scenario compared the effects of current policy (20 years from now) relative to a policy which did not permit degradation in any water body below its 2011 level of quality. In this case, some waters will improve in quality (those with TMDLs in place in 2011), but no water body would get worse. The recreation demand models predicted a very small increase in the total number of water-based recreation day trips (0.27 percent) and no increase in the number of overnight trips. Finally, relative to the current water policy 20 years from now, the Improve scenario allows numerous water bodies (beyond those with TMDLs) to improve in quality. The recreation demand models predicted larger (though still modest) changes in the number of recreation trips. Day trips were expected to increase by 0.88 percent whereas overnight trips were predicted to increase by 0.14 percent.

Before calculating the net changes in economic activity associated with changing recreation, it is worth recalling that the projections are based on a model of the Utah economy as it was in 2010. The analysis essentially assumes that we will observe no changes in business-to-business connections, no increases in the efficiency of production within a given industry, and that the total money spent on recreation and the categories in which these expenditures are made (hotels, gasoline, restaurants, etc.) will remain constant over 20 years. It also assumes that preferences for water-based recreation (which give rise to the parameters of the economic model) also remain constant. Thus, the estimates represent a snapshot in time rather than a forecast of future conditions. Nonetheless, they provide a reasonable first approximation for expenditures in future years absent any dramatic shift in preferences for water-based outdoor recreation in Utah.

The predicted annual changes in net economic activity associated with the different water quality management scenarios appear in Table 9-4. Under the *Status Quo* scenario—allowing current water policy to continue—the models predict a loss of between 25,100 and 42,800 recreation trips. Assuming current levels of per trip expenditures (about $177 per trip), expenditures for water-based recreation are expected to fall between $4.5 and $7.6 million. The multiplier effects caused the total loss in sales to the Utah economy to be between $8.0 and $13.6 million. The loss in value-added ranges between $5.0 million and $8.6 million. Income is expected to fall by $3.0 to $5.1 million as between 100 and 150 jobs are lost.

TABLE 9-4
Changes in Annual Economic Activity Under Different Water Quality Management Scenarios

	Status Quo		**Maintain**		**Improve**	
	Median Trips/HH	**Mean Trips/HH**	**Median Trips/HH**	**Mean Trips/HH**	**Median Trips/HH**	**Mean Trips/HH**
Change in trips	-25,100	-42,800	14,300	24,500	50,000	85,300
Change in direct expenditures	-$4.5	-$7.6	$2.5	$4.4	$8.9	$15.1
Multiplier Effects						
Change in total sales	-$8.0	-$13.6	$4.6	$7.8	$15.9	$27.1
Change in value-added	-$5.0	-$8.6	$2.9	$4.9	$10.0	$17.1
Change in income	-$3.0	-$5.1	$1.7	$2.9	$6.0	$10.2
Change in full and part time jobs	-100	-150	50	100	200	300

All dollar values measured in millions.

In contrast to the *Status Quo* scenario, the *Maintain* scenario predicts a small increase in the number of day trips. Based on the aggregate number of trips taken, this suggests that between 14,300 and 24,500 more trips may be taken as some waters improve in quality and none degrade. Expenditures on water-based recreation are predicted to increase by $2.5 to $4.4 million. Multiplier effects increase the change in total sales to between $4.6 million and $7.8 million. Value-added by the industries serving water-based recreation ranges between $2.9 million and $4.9 million. Some 50 to 100 additional full and part time jobs are created, with an increase in income of between $1.7 million and $2.9 million. Finally, the *Improve* scenario posits improvements in water quality across the majority of waters in Utah. Day trips are expected to increase by 0.88 percent whereas overnight trips are expected to increase by 0.14 percent, for a weighted net change of 0.65 percent. The total increase in trips is between 50,000 and 85,300, with the resulting increase in recreation expenditures between $8.9 million and $15.1 million. These expenditures multiply through the economy to generate a total change in total sales of between $15.9 million and $27.1 million. Value-added increases by between $10.0 million and $17.1 million. Incomes increase by between $6.0 million and $10.2 million as between 200 and 300 new full and part-time jobs are created.

9.6 Summary

Water-based recreation in Utah is a significant contributor to the Utah economy. Annual expenditures for recreation trips to Utah waters total between $1.4 billion and $2.4 billion. After tracing the multiplier effects through the economy, the total contribution to the Utah economy is approximately $2.4 to $4.2 billion, accounting for about 2 percent percent of the total state economy and from 29,000 to 50,000 jobs. As estimated by The State of Utah Outdoor Recreation Vision (January, 2013) this compares with about $6.87 billion in spending and 124,000 jobs for the outdoor tourism industry as a whole. Changes in water quality are expected to change visitation, but not by very much. Under the *Improve* scenario, total recreation trips are expected to increase by about 0.65 percent, or approximately 50,000 to 85,300 additional trips. Total sales associated with water-based recreation in Utah are expected to grow by up to $27.1 million with an additional 200 to 300 new full and part-time jobs created.

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Appendix A
TEV Survey and Correspondence

APPENDIX A.1

TEV Questionnaire

Thank you for participating in this survey. If you have comments on the survey or water quality in Utah, please use the space below.

____

____

____

____

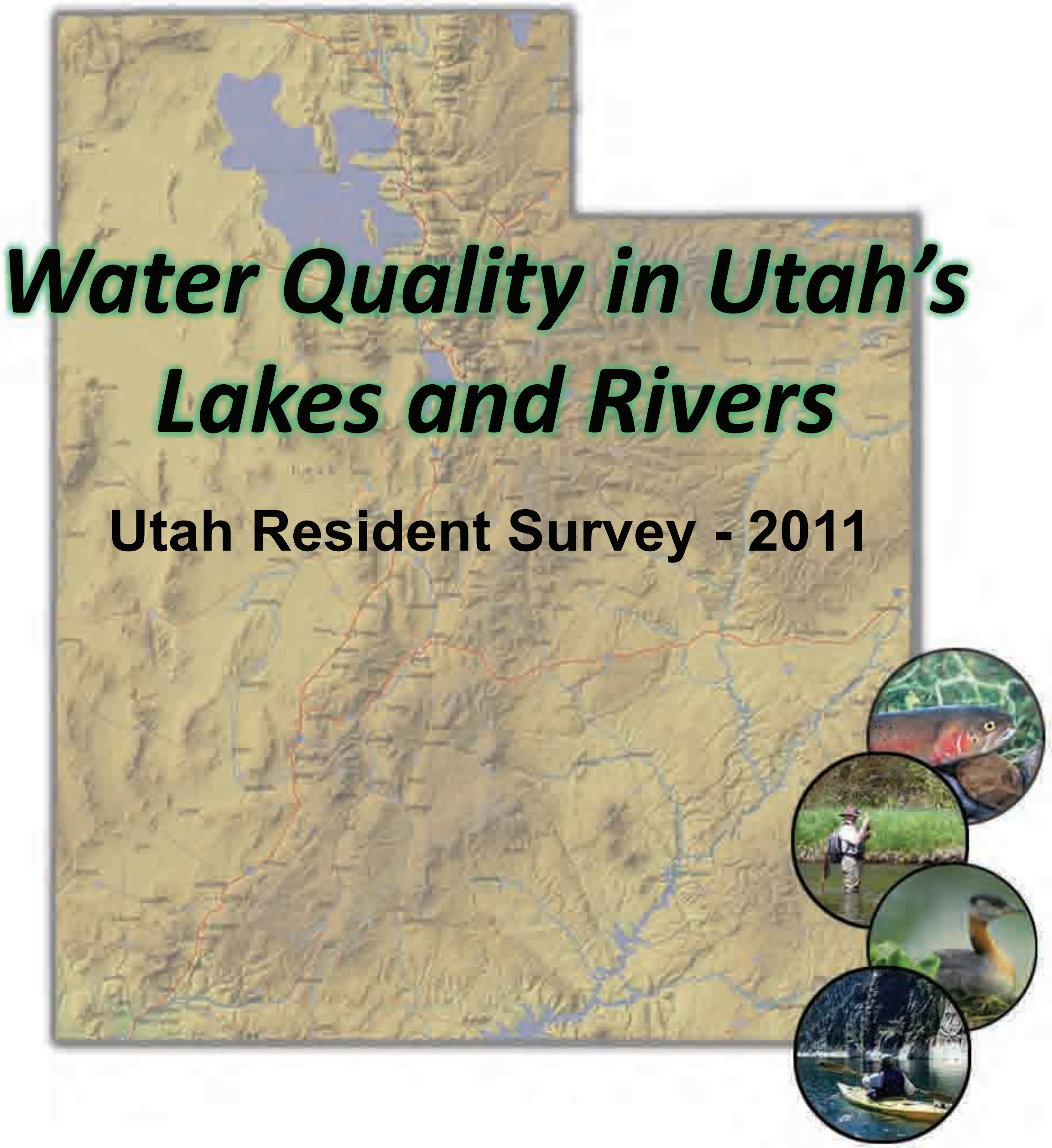
____

____

Please mail your completed questionnaire back in the provided postage-paid envelope to:
University of Wyoming, Dept. 3925, 1000 E. University Avenue, Laramie, WY 82071

If you have questions about your rights as a research subject
please call the University of Wyoming IRB Administrator at (307) 766-5320.

A02



Water Quality in Utah's Lakes and Rivers

Utah Resident Survey - 2011

Introduction

Thank you for taking the time to complete this survey. Your participation in this survey is voluntary. Refusal to participate will have no effect on any benefits to which you are otherwise entitled. This survey should be answered by the **adult in your household** (age 18 or older) **who has most recently had their birthday**.

Fill in bubbles completely using either pencil or pen (blue or black ink), but please do NOT use a felt-tip marker.

Mark Answers Like This ⇨ ● ▮
NOT Like This ⇨ ✗ ✓

Excess Nutrients in Our Water

Nutrients like nitrogen and phosphorus are necessary for all life to live and grow. Nitrogen and phosphorus are important components of the fertilizers we use to help our lawns and crops grow. When too much nitrogen and phosphorous reach our lakes and rivers, these **excess nutrients** cause water quality problems.

The following sources contribute to **excess nutrients** in our water systems throughout the State of Utah:

- Discharge of treated sewage from your home, your neighbors' homes, and businesses statewide
- Water runoff from fertilized lawns
- Leaking septic tanks
- Storm water runoff from urban areas
- Runoff from agricultural fields and waste from animal farms

Excess nutrients pollute our lakes and rivers.

Changes in Water Quality from Excess Nutrients

Excess nutrients result in **Poor** water quality, the consequences of which are:

I. Increased **Algae Blooms** - Algae reproduce rapidly, a situation called an algae bloom, which can lead to low levels of oxygen in the water (which adversely affects some fish species such as trout). Some of these blooms are harmless, but some blooms can contain toxins, other harmful chemicals, or pathogens.

II. Changes in **Fish Species** - Cool or cold water fish species (e.g., trout, walleye, Kokanee salmon) are replaced by other fish species (e.g., carp, green sunfish, channel catfish) that can tolerate low levels of oxygen.

III. Reduced **Biodiversity** - Fewer plant and animal species are found in the water, and some species that are normally present are missing.

IV. Degraded **Aesthetics** - The water turns green, limiting the depth to which one might see. The water may also have a strong and unpleasant odor.

V. Lower Quality **Recreation** - The quality of swimming, fishing or boating experiences will diminish. On rare occasions, people may experience a skin rash after coming into contact with the water.

VI. Degraded **Drinking Water Aesthetics** - Increased chance of municipal drinking water having an earthy or musty taste and/or smell, despite being treated to the standards of the Safe Drinking Water Act.

Not all of our water systems have **excess nutrients**. Some have just the right amount to supply drinking water free of odor and taste issues, support aquatic life, and provide high quality recreation. These systems are classified as having **Good** water quality as opposed to the **Poor** water quality conditions described above.

We use the water quality categories - **Good**, **Fair** and **Poor** - to describe the changes in water quality measures that result from the level of nutrients in the water. See the table on Page 3.

Opinions of Water Quality

10. Please review the photos of algae in rivers on both sides of the one-page insert included in this survey. For each photograph on the insert tell us if the level of algae would be desirable or undesirable for YOUR most common uses of rivers, if any. There are no correct answers; this is your opinion only. ***Fill in one bubble for each number.***

Photograph #	1	2	3	4	5	6	7	8
Desirable	O	O	O	O	O	O	O	O
Undesirable	O	O	O	O	O	O	O	O

Demographics

11. Are you male or female?
- O Male
- O Female

12. In what year were you born?

1 9 ☐ ☐

13. Do you pay a water and sewer bill?
- O Yes
- O No ➔ **skip to question 14**

13a. On average, how much do you pay a month for your water and sewer bill? ***Round to the nearest dollar.***

$ ☐ ☐ ☐

14. What is the highest level of school you have completed?
- O Some high school
- O High school graduate or GED
- O Some college or technical school
- O Undergraduate degree
- O Some graduate school
- O Graduate degree

15. Do you belong to any local, state or national organization whose main purpose is to protect the environment?
- O Yes
- O No

16. Including yourself, how many adults, age 18 or older, currently live in your household?

☐ ☐ # of adults

17. How many children, age 17 or younger, currently live in your household?

☐ ☐ # of children

18. Are you of Hispanic, Latino, or Spanish origin?
- O Yes
- O No

19. Here is a list of racial categories. Please select one or more to describe your race. *(Mark all that apply)*
- ☐ White
- ☐ Black or African American
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Native Hawaiian or other Pacific Islander
- ☐ Some other race

20. Next we'd like to ask about your household income. Your answer will only be used for comparing groups of people. Which of the following income groups best describes your household's total income in 2010, before taxes?
- O Less than $25,000
- O $25,000 up to $50,000
- O $50,000 up to $75,000
- O $75,000 up to $100,000
- O $100,000 up to $150,000
- O $150,000 up to $200,000
- O $200,000 or more

5. **In general, would you say the Nutrient Reduction program is ...?**

- O Not a good use of my money
- O A good use of my money

6. **To help us better understand your answer to Question 3 on the Page 5 please indicate the SINGLE most important reason for your response.**

- O I cannot afford to pay this amount each month
- O The Nutrient Reduction Program is not realistic or is unclear
- O I don't contribute to this problem and I shouldn't have to pay
- O Everyone needs to share in the cost of the Nutrient Reduction Program, even me
- O I believe Utah's lakes and rivers should be protected no matter the cost
- O No one should have the right to damage Utah's lakes and rivers in the first place

Visits to Lakes and Rivers in Utah

7. **In the last 12 months, how many total trips have you and members of your household taken to <u>lakes</u> in Utah?**

[ ][ ] # of lake trips

➔ **If you answered ZERO to Question 7, <u>do not</u> answer Question 9a.**

8. **In the last 12 months, how many total trips have you and members of your household taken to <u>rivers</u> in Utah?**

[ ][ ] # of river trips

➔ **If you answered ZERO to Question 8, <u>do not</u> answer Question 9b.**

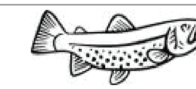
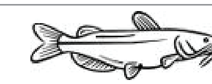
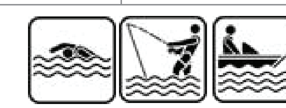
9a. **Which ONE activity do you and members of your household spend the <u>most</u> time doing while visiting LAKES?**

- O Fishing-cold water fishery
- O Fishing-warm water fishery
- O Boating *(e.g., motor-boating, house boating, sailing, canoeing, kayaking, water-skiing, tubing or jet skiing)*
- O Swimming *(e.g., playing in the water, wading or windsurfing)*
- O Near-shore activities *(e.g, walking, biking or running on trails, bird/wildlife/nature viewing, picnicking, or camping)*
- O Hunting

9b. **Which ONE activity do you and members of your household spend the <u>most</u> time doing while visiting RIVERS?**

- O Fishing-cold water fishery
- O Fishing-warm water fishery
- O Boating *(e.g., motor-boating, house boating, sailing, canoeing, kayaking, water-skiing, tubing or jet skiing)*
- O Swimming *(e.g., playing in the water, wading or windsurfing)*
- O Near-shore activities *(e.g, walking, biking or running on trails, bird/wildlife/nature viewing, picnicking, or camping)*
- O Hunting

Summary Table of Water Quality Measures

	Water Quality Measure		Water Quality Category		
			POOR	**FAIR**	**GOOD**
I	Algae Blooms		Frequent and cover a large area of water	Occasional, brief, and do not cover a large area of water	Rare
II	trout  Cool or cold water fish species		Rare	Less Common	Common
II	catfish  Fish species tolerant of low levels of oxygen		Abundant	Common	Less Common
III	Biodiversity		Low	Medium	High
IV	Aesthetics	Water clarity	Not clear at all	Not very clear	Clear
IV	Aesthetics	Color	Often dark green	Greenish tint	No green
IV	Aesthetics	Unpleasant odor	Strong	Faint	None
V	 Recreation		Limited recreation opportunities, swimming advisories may be posted	Most recreation allowed but with diminished quality	All recreation allowed with high quality
VI	 Drinking water aesthetics		Frequent musty or earthy taste and odor	Occasional musty or earthy taste and odor	No taste or odor issues

1. **When you think about changes in water quality resulting from <u>excess nutrients</u>, what importance do you personally place on <u>preventing</u> each of the following?**

	High Importance	Moderate Importance	Low Importance	No Importance	Not Sure
a. Increased frequency of algae blooms	O	O	O	O	O
b. Reduced abundance of cool/cold water fish (e.g., trout, walleye, Kokanee salmon)	O	O	O	O	O
c. Increased abundance of fish tolerant of low oxygen (e.g., carp, green sunfish, channel catfish)	O	O	O	O	O
d. Reduced biodiversity	O	O	O	O	O
e. Reduced water clarity, changes in color, and increased odor	O	O	O	O	O
f. Less suitable for recreational uses	O	O	O	O	O
g. Unfavourable taste and odor of drinking water even after treatment	O	O	O	O	O

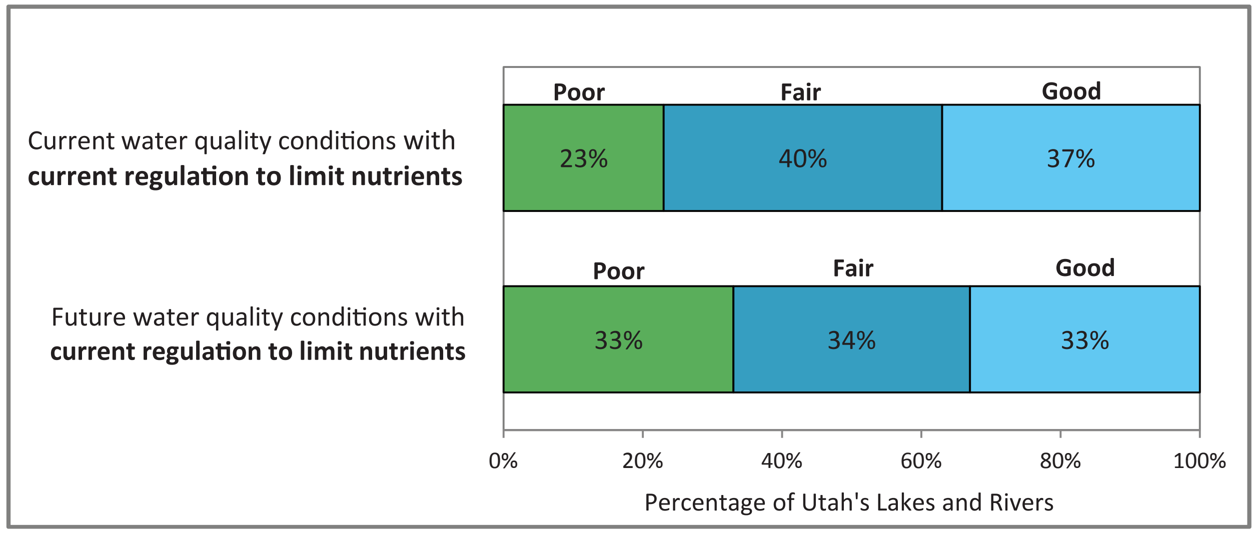
Current and Future Water Quality Conditions

The State of Utah's Division of Water Quality (DWQ) has assessed the current quality of all of Utah's lakes and rivers:

- 23% have **excess nutrients** resulting in **Poor** water quality
- 40% have levels of nutrients that result in **Fair** water quality
- 37% have the optimal amount of nutrients to support aquatic life and recreational uses resulting in **Good** water quality

DWQ already limits the amount of nutrients reaching our lakes and rivers. Nevertheless, as our population grows, nutrient concentrations will increase and the quality of Utah's lakes and rivers will decrease over time. The projected condition of water quality in Utah's lakes and rivers in 20 years is:

- 33% would have **Poor** water quality (an increase of 10 percentage points)
- 34% would have **Fair** water quality (a decrease of 6 percentage points)
- 33% would have **Good** water quality (a decrease of 4 percentage points)



2. When you think about water quality in Utah, what importance do you personally place on each of the following?

	High Importance	Moderate Importance	Low Importance	No Importance	Not Sure
a. Improving water quality for fish and wildlife	O	O	O	O	O
b. Keeping monthly water bills as low as possible	O	O	O	O	O
c. Maintaining water quality for future generations	O	O	O	O	O
d. Imposing water cleanup costs on industry	O	O	O	O	O
e. Improving water quality in lakes and rivers used primarily for recreation	O	O	O	O	O
f. Maintaining good water quality in lakes and rivers so I can visit in the future	O	O	O	O	O
g. Improving water quality in all lakes and rivers even those not frequently used by people	O	O	O	O	O

Nutrient Reduction Program to Improve Water Quality

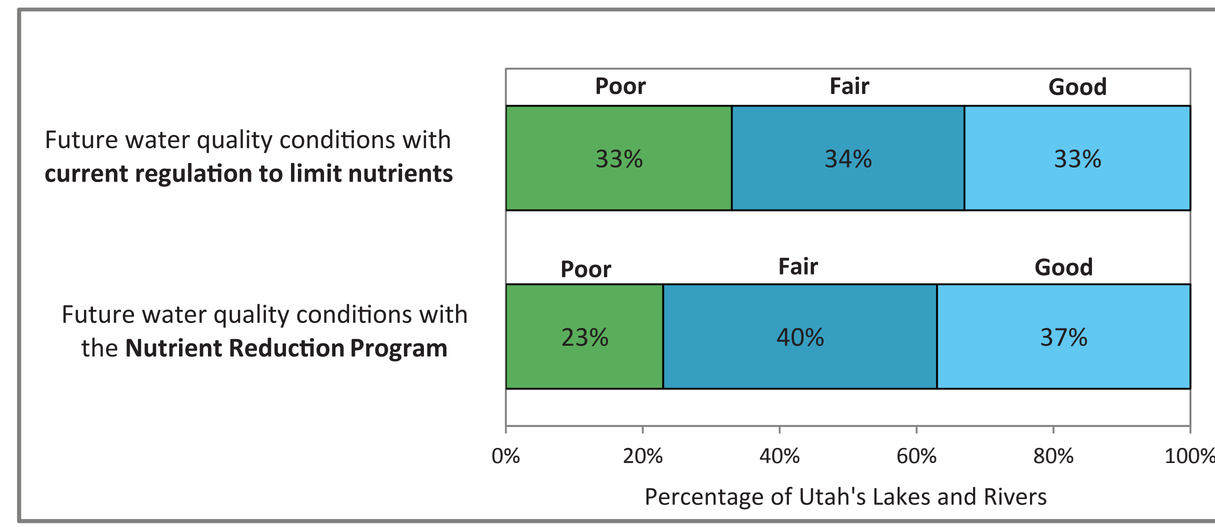
DWQ is considering a new program that will further limit the amount of nutrients that reach lakes and rivers, improving water quality over time.

If a majority of people favor the new program it will be paid for by increasing the amount each household and business will pay for their monthly water and sewer bill. If you do not currently receive a water and sewer bill (e.g., you rent your home or your house is on a septic system) you will receive a separate monthly bill for this program. The funds collected will be used to implement and enforce the **Nutrient Reduction Program**.

The **Nutrient Reduction Program** will require:

- Upgrades in wastewater treatment plants for treating sewage from your home, your neighbors' homes, and businesses statewide
- Programs to encourage proper application of lawn fertilizers and maintenance of septic systems
- Structures to control storm water runoff from streets, parking lots, and roof-tops
- Improvements to agricultural nutrient management practices

The **Nutrient Reduction Program** will reduce the percent of waters in the **Poor** category from 33% down to 23% and increase the percent of waters in **Good** condition from 33% to 37%. Implementation of the program would start next year and be phased in over 20 years. In some cases, complete clean up may take longer than 20 years.



The costs of the program will be shared between households, businesses, and industry in proportion to their share of total nutrient discharges. Based on these proportions, the share of the cost for each Utah household will be an additional $2 per month.

3. Which one of the following two options regarding your household's monthly water and sewer bill would you choose? Please do NOT consider what other people could or could not afford.

Under **current regulations to limit nutrients**	Under the **Nutrient Reduction Program**
$0 increase	**$2 increase**
O	O

4. How sure are you of this answer?

1	2	3	4	5	6	7	8	9
O	O	O	O	O	O	O	O	O
(not sure at all)				(somewhat)				(certain)

APPENDIX A.2

Text of TEV Contact Letter

July 21, 2011

Dear Utah Resident:

The Division of Water Quality (DWQ) needs your help making balanced decisions about how Utah's lakes and rivers are managed. Utah is blessed with spectacular landscapes, lakes, and rivers that are enjoyed in many ways. Lakes, rivers, and reservoirs provide us with drinking water, scenic beauty, and recreational opportunities. The waters of Utah are among our state's greatest assets and it is the mission of the DWQ to protect and enhance them.

In a few days you will receive a short questionnaire in the mail, along with a postage-paid return envelope. We will ask that the survey be answered by the adult in your household (age 18 or older) who has **most recently had their birthday**. If that is not you, please pass this letter along to that person, so that he or she will know to look for the survey in the mail. This helps us ensure our study reflects a broad cross section of Utahns.

Our survey asks how you would like Utah’s lakes, reservoirs, and rivers to be managed now and in the future. Every resident of the state has a stake in our future, so even if you aren’t a regular visitor to any waterways in Utah, please answer the questions that pertain to you and your household. We need your opinions, too. The questionnaire is short, and should only take about 15 minutes to complete.

I hope that your household will take part in this survey to help us understand how you would like our state's waters protected.

If you have any questions, please contact Dr. Paul Jakus at Utah State University either by email (Paul.Jakus@usu.edu) or by telephone (435-797-2309). Thank you for your assistance.

Sincerely,

Walter L. Baker, P.E.
Director

APPENDIX A.2

The text of TEV Cover Letter

July 28, 2011

Dear Utah Resident:

The Division of Water Quality (DWQ) needs your help making balanced decisions about how Utah's lakes and rivers are managed. I hope you can spend a few minutes completing and returning the enclosed survey so we may better understand how you would like our state's waters protected. This survey should only take about **15 minutes** of your time. All of your answers are completely confidential.

Utah is blessed with spectacular landscapes, lakes, and rivers that are enjoyed in many ways. Lakes, rivers, and reservoirs provide us with drinking water, scenic beauty, and recreational opportunities. The waters of Utah are among our state's greatest assets and it is the mission of the DWQ to protect and enhance them.

Our survey asks how you would like Utah's lakes, reservoirs, and rivers to be managed now and in the future. Every resident of the state has a stake in our future, so even if you aren't a regular visitor to any waterways in Utah, please answer the questions that pertain to you and your household. We need your opinions, too. A team of experts assembled by Utah State University will summarize your responses to the enclosed survey and provide the results to DWQ.

This questionnaire is being delivered to a select number of households across the state of Utah by the Wyoming Survey & Analysis Center at the University of Wyoming. To ensure our study reflects a broad cross section of Utahns, we ask that this questionnaire be completed by an adult member of your household (age 18 or older) **who most recently had their birthday**.

- Feel free to write any comments or explanations in the blank space on the last page.
- Do not write your name or address on the questionnaire to insure your privacy.
- As soon as you have finished, please mail back the completed questionnaire in the provided envelope. **No postage is required**.

As one of a small number of Utah residents who are being asked to participate in this survey, the answers you give in this survey are very important.

If you have any questions, please contact Dr. Paul Jakus at Utah State University either by email (Paul.Jakus@usu.edu) or by telephone (435-797-2309). Thank you for your assistance.

Sincerely,

Walter L. Baker, P.E.
Director

APPENDIX A.3

The text of the TEV reminder postcard

August 11, 2011

Dear Utah Resident,

About 10 days ago you should have received a survey in the mail about *Utah's Lakes and Rivers*. We are conducting this survey for the Utah Division of Water Quality. The information we obtain will guide the Division in their management of Utah's lakes, reservoirs, and rivers, now and in the future.

Many Utah residents have already responded with completed surveys and, if this includes you, *thank you*! If not, we hope you will take a few minutes to fill out and return your survey, as your opinions are very important.

Appendix B
Methodology for Evaluating the Nutrient Conditions of Utah's Water Bodies for the TEV Survey

APPENDIX B

Methodology and Results for Evaluation of Nutrient Conditions in Utah Water Bodies for Total Economic Valuation Survey

Current Conditions

Lakes and Reservoirs

The evaluation of the current nutrient condition of Utah's lakes and reservoirs was primarily based on the National Lakes Assessment (NLA) conducted by the EPA (2009). The NLA is a statistical survey of the condition of the nation's lakes, ponds, and reservoirs. Based on the sampling of over 1,000 lakes across the country, the survey results represent the state of nearly 50,000 natural and man-made lakes that are greater than 10 acres in area and over one meter deep. In the summer of 2007, lakes were sampled for their water quality, biological condition, habitat conditions, and recreational suitability. Field crews used the same methods at all lakes to ensure that results were nationally comparable. For many of the indicators, scientists analyzed the results against a reference condition. Reference conditions were derived from a set of lakes that were determined to be the least disturbed lakes for a region.

The NLA assessed the condition of lakes for several physical, biological, and chemical indicators, including total nitrogen (TN), total phosphorus (TP), and chlorophyll A (CHLA). Each indicator for a lake was classified as either "good," "fair," or "poor" relative to the conditions found in reference lakes; "good" denotes an indicator value similar to that found in reference lakes, "poor" denotes conditions definitely different from reference conditions, and "fair" indicates conditions on the borderline of reference conditions. Specifically, thresholds were applied to the results from the target lakes and were classified as follows: lake results above 25 percent of the reference range values are considered "good;" below the 5 percent of the reference range value are "poor;" and those between the 5 percent and 25 percent are "fair" (Figure 1 and Table 1).

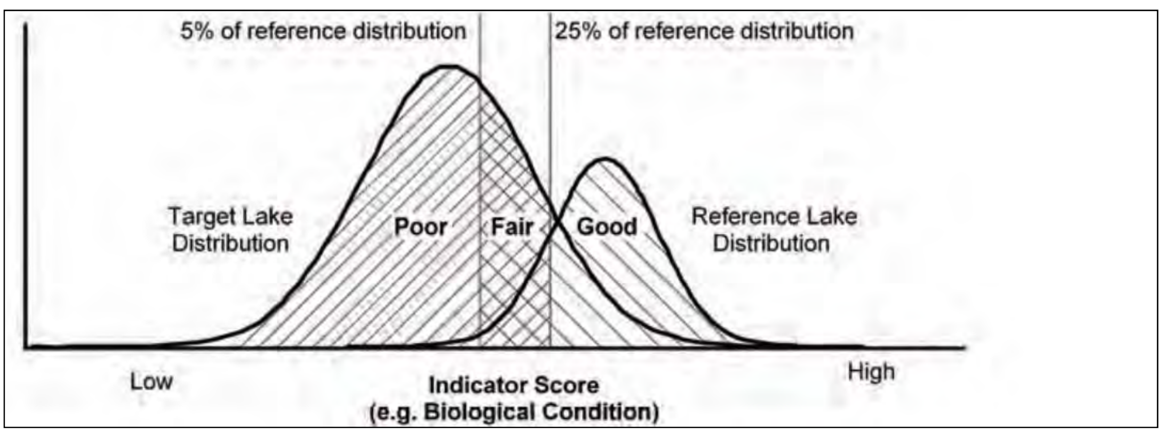


FIGURE 1
Reference condition thresholds used for good, fair, and poor assessment (Source EPA 2009)

TABLE 1
Good/Fair/Poor Condition Class thresholds for total phosphorus (TP), total nitrogen (TN), and Chlophyll a (CHLA)

Nutrient Ecoregion	TP (µg/L)			TN (µg/L)			CHLA (µg/L)		
	Good	Fair	Poor	Good	Fair	Poor	Good	Fair	Poor
II. Western Mts.	<15	15-19	>19	<278	278-380	>380	<1.8	1.8-2.7	>2.7
III. Xeric West	<48	48-130	>130	<514	514-2286	>2286	<7.8	7.8-29.5	>29.5

The classification results for Utah's lakes based on CHLA concentration were extracted from the EPA national data set. Utah's lakes reside in two ecoregions: western forested mountains and xeric west. Good/fair/poor percent ratings were calculated for Utah based on the total surface area of lakes in each classification (Table 2). Note that Great Salt Lake was excluded from the surface area weighting.

TABLE 2
Condition rating for Utah lakes and reservoirs based on chlorophyll A concentration

Nutrient Region	Surface Area (Acre)	Percent in Each Class Based on Chlorophyll A Concentration		
		Good	Fair	Poor
Western Forested Mountains	96,373	9.3%	6.1%	84.6%
Xeric West	286,234	34.4%	65.1%	0.5%
Area-Weighted Total	382,607	28.1%	50.2%	21.7%

Rivers and Streams

Levels of the nutrients nitrogen and phosphorus found in Utah running waters were determined by evaluating 55 probabilistically derived sites sampled from 2000-2004 by EPA's EMAP-West program (US EPA, 2008). Threshold settings for total nitrogen and total phosphorus was set using data from 'least disturbed' sites within the sampled population. Least disturbed ('good' condition) sites were screened by using a variety of chemical (minus TN and TP) and habitat parameters. In addition, to understand differences across ecoregions, these sites were determined separately for both Western Mountain and Xeric ecoregions. 'Poor' condition sites were determined to be those sites above the 95th percentile of values; whereas, 'good' condition sites were those below the 75th percentile. 'Fair' condition was determined to be sites whose values were in between the 75th and 95th percentiles (Table 3).

TABLE 3
Total phosphorus and total nitrogen concentrations describing Utah's river and stream conditions by ecoregion

Nutrient Ecoregion	TP (µg/L)			TN (µg/L)		
	Good	Fair	Poor	Good	Fair	Poor
II. Western Mts.	<11	11-52	>52	<286	286-385	>385
III. Xeric West	<40	40-203	>203	<609	609-1181	>1181

The 55 sampled sites represented 12,091 (+/- 2,287) kilometers of the estimated 13,782 (+/- 3,502) kilometers of perennial flowing waters within Utah. The nutrient stressor thresholds established were used to assign the 'good', 'fair', 'poor' conditions of sites and the length of water body represented (Table 4).

TABLE 4
Percent water body length of nutrient condition classes and total kilometers of Utah's river and streams

Nutrient Condition	TP			TN		
	Good	Fair	Poor	Good	Fair	Poor
Condition Class	40%	36%	24%	50%	25%	25%
Total Kilometers	4796	4325	2970	6102	2916	3073

Combined Water Bodies

The results for the lakes/reservoirs and rivers/streams were averaged in order to estimate statewide condition of combined water bodies.

Future Conditions with Current Regulatory Framework

Future conditions were predicted based on extrapolating historical trends to 20 years in the future.

Lakes and Reservoirs

For future conditions under the current regulatory framework, it was assumed that the lakes/reservoirs would track along with the tributary rivers and streams; therefore, the trend analysis used for the rivers and streams was applied to the lakes and reservoirs.

Rivers and Streams

The evaluation of the future nutrient condition of Utah's rivers and streams under current nutrient protections was primarily based on a study conducted by the USGS (Sprague et al. 2009). Trends in concentrations and loads of total phosphorus, total nitrogen, and nitrate were determined for the period from 1993 to 2003 in selected streams and rivers of the United States. Flow-adjusted trends in concentration (the trends that would have occurred in the absence of natural changes in streamflow), non-flow-adjusted trends in concentration (the trends resulting from both natural and human factors), and trends in load (trends in the nutrient mass transported downstream) were determined, and the results were examined spatially to determine whether a consistent pattern of trends occurred across groups of sites at multiple locations.

Sites in the Rio Grande, Colorado and Great Basin Watershed were extracted from the USGS data files. The trend results for TP, TN and NO3 are summarized in Tables B-1, B-2 and B-3 attached. There was wide variation in the trend results for both the entire region and the Utah specific sites, including both positive (improving) and negative (degrading) trends.

Due to the high variability in the historical trends, a reasonable estimate of the range of potential future conditions was considered + or – 25%; that is, in the best case scenario average conditions would improve 25 percent (from poor to good) and in the worst case scenario average conditions would degrade 25 percent (from good to poor).

Future Conditions with Nutrient Criteria Implementation

Future conditions were predicted for Utah's water bodies assuming full implementation of nutrient criteria (referred to as the Nutrient Reduction Program in the Total Economic Valuation Survey) (Table 5). No time limit was placed on fully implementing the program. It was assumed that the majority of impaired waters (poor condition) would be improved to remove the impairment (fair condition) as part of the Assessment and TMDL programs. In addition, a portion of the fair waters would be improved to good as part of the NPDES and Watershed Protection programs.

TABLE 5
Utah nutrient condition classes of current and predicted scenarios.

Nutrient Criteria Implementation Scenarios	**Condition Class Based on Current and Future Nutrient Scenarios**		
	Good	**Fair**	**Poor**
Current Conditions	37%	40%	23%
Future Trends (No Action-best)	41%	42%	18%
Future Trends (No Action-worst)	33%	34%	33%
Future Trends (New Plan-best)	49%	50%	1%
Future Trends (New Plan-worst)	37%	40%	23%

References

Sprague, L.A., Mueller, D.K., Schwarz, G.E., and Lorenz, D.L., 2009, Nutrient trends in streams and rivers of the United States, 1993–2003: U.S. Geological Survey Scientific Investigations Report 2008–5202, 196 p.

U.S. Environmental Protection Agency (USEPA). 2009. National Lakes Assessment: A Collaborative Survey of the Nation's Lakes. EPA 841-R-09-001. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, D.C.

U.S. Environmental Protection Agency (USEPA), 2008. An Ecological Assessment of USEPA Region 8 Streams and Rivers (14 Chapters). http://www.epa.gov/region08/water/emap/

TABLE B-1

Trends in TP from 1993 to 2003 in Rio Grande, Colorado and Great Basin Watersheds

Site Number	Station number	Station name	TP Reference Concentration (mg/L)	Trend, in percent from 1993 to 2003			
				Modeled estimate	Upper 95% CL	Lower 95% CL	p-value
173	8251500	Rio Grande near Lobatos, Colo.	0.079	52.9	96.9	18.6	**0.002**
177	9217010	Green River below Green River, Wyo.	0.026	51.1	186.1	-20.2	0.210
178	9261000	Green River at Dinosaur National Monument Utah 149 Crossing, Utah	0.062	-34.8	55.5	-72.6	0.338
180	9403600	Kanab Creek at U.S. 89 Crossing, Utah	0.035	232.7	656.8	46.2	**0.005**
182	9415000	Virgin River at Littlefield, Ariz.	0.106	463.4	1200.6	144	**<0.001**
183	9448500	Gila River at Head of Safford Valley, near Solomon, Ariz.	0.122	216	730	20.3	**0.024**
184	9498500	Salt River near Roosevelt, Ariz.	0.013	4678.5	14832.1	1428.8	**<0.001**
185	9508500	Verde River below Tangle Creek, above Horseshoe Dam, Ariz.	0.023	166.7	493.8	19.8	**0.019**
186	9522000	Colorado River at N. International Boundary, above Morelos Dam, Ariz.	0.28	-85.9	-65.2	-94.3	**<0.001**
188	10126000	Bear River near Corinne at Utah 83 Crossing, Utah	0.188	-50.7	-29.9	-65.3	**<0.001**
193	10189000	East Fork Sevier River at Utah 62 Crossing East of Kingston, Utah	0.085	-3.4	37.7	-32.2	0.849
		Average - Rio Grande, Colorado, and Great Basin	*0.093*	*517.0*	*1654.0*	*126.6*	
		Average - All Utah	*0.093*	*36.0*	*180.0*	*-31.0*	
		Average - Utah Significant Trend Only	*0.093*	*91.0*	*313.5*	*-9.6*	
	Green shading – Utah sites with trends with statistical significance.						
	Orange shading – Utah sites with trends without statistical significance.						

Source: Sprague et al. 2009

TABLE B-2

Trends in TN from 1993 to 2003 in Rio Grande, Colorado and Great Basin Watersheds

Site Number	Station number	Station name	TP Reference Concentration (mg/L)	Trend, in percent from 1993 to 2003			
				Modeled estimate	Upper 95% CL	Lower 95% CL	p-value
173	8251500	Rio Grande near Lobatos, Colo.	0.440	14.3	46.8	-11.0	0.298
176	9211200	Green River below Fontenelle Reservoir, Wyo.	0.230	28.9	76.9	-6.1	0.119
179	9380000	Colorado River at Lees Ferry, Ariz.	0.368	5.6	40.6	-20.8	0.713
182	9415000	Virgin River at Littlefield, Ariz.	0.841	194.4	382.6	79.6	**<0.001**
196	10336610	Upper Truckee River at South Lake Tahoe, Calif.	0.210	8.0	30.0	-10.3	0.418
199	1.03E+08	Incline Creek at Highway 28 at Incline Village, Nev.	0.304	-4.8	23.6	-26.7	0.713
201	10336740	Logan House Creek near Glenbrook, Nev.	0.313	-21.3	-1.5	-37.2	**0.038**
202	10336760	Edgewood Creek at Stateline, Nev.	0.328	-34.6	-20.9	-46.0	**<0.001**
		Average - Rio Grande, Colorado, and Great Basin	*0.379*	*23.8*	*72.3*	*-9.8*	
		Average - Rio Grande, Colorado, and Great Basin Significant Trend Only	*0.379*	*46.2*	*120.1*	*-1.2*	

Source: Sprague et al. 2009

TABLE B-3

Trends in NO3 from 1993 to 2003 in Rio Grande, Colorado and Great Basin Watersheds

Site Number	Station number	Station name	TP Reference Concentration (mg/L)	Trend, in percent from 1993 to 2003			
				Modeled estimate	Upper 95% CL	Lower 95% CL	p-value
174	9058000	Colorado River near Kremmling, Colo.	0.121	-0.2	49.5	-33.3	0.994
175	9163500	Colorado River near Colorado-Utah State Line	0.579	-9.2	10.7	-25.5	0.343
177	9217010	Green River below Green River, Wyo.	0.070	-10.1	32.5	-38.9	0.594
181	9413500	Virgin River below First Narrows, Utah	0.901	29.8	84.3	-8.6	0.148
187	10038000	Bear River below Smiths Fork, near Cokeville, Wyo.	0.089	-39.3	-10.9	-58.7	**0.013**
189	10131000	Chalk Creek at U.S. 189 Crossing, Utah	0.253	-17.9	19.3	-43.5	0.303
190	10154200	Provo River above Woodland at U.S. Geological Survey Gage Number 10154200, Utah	0.112	98.6	207.9	28.1	**0.003**
191	10155000	Provo River at Bridge 2.5 miles East of Hailstone Junction, Utah	0.039	301.6	649.6	115.1	**<0.001**
192	10155500	Provo River above Confluence with Snake Creek at McKeller Bridge, Utah	0.463	-54.8	-36.5	-67.8	**<0.001**
194	10336580	Upper Truckee River at South Upper Truckee Road near Meyers, Calif.	0.009	2.1	39.2	-25.1	0.894
195	1.03E+08	Upper Truckee River at Highway 50 above Meyers, Calif.	0.014	-21.3	-2.2	-36.7	**0.032**
197	10336698	Third Creek near Crystal Bay, Nev.	0.017	-67.9	-56.7	-76.2	**<0.001**
198	1.03E+08	Incline Creek above Tyrol Village near Incline Village, Nev.	0.013	10.3	45.9	-16.6	0.491
199	1.03E+08	Incline Creek at Highway 28 at Incline Village, Nev.	0.019	2.4	26.6	-17.2	0.829
200	10336700	Incline Creek near Crystal Bay, Nev.	0.021	-0.7	21.7	-18.9	0.949
201	10336740	Logan House Creek near Glenbrook, Nev.	0.004	70.7	396.2	-41.3	0.328
		Average - Rio Grande, Colorado, and Great Basin	*0.170*	*18.4*	*92.3*	*-22.8*	
		Average - All Utah	*0.354*	*71.5*	*184.9*	*4.7*	
		Average - Utah Significant Trend Only	*0.205*	*115.1*	*273.7*	*25.1*	
	Green shading – Utah sites with trends with statistical significance.						
	Orange shading – Utah sites with trends without statistical significance.						

Source: Sprague et al. 2009

Appendix C
Recreation Survey and Correspondence

APPENDIX C.1

Recreation Survey

37. Do you belong to any local, state or national organization whose main purpose is to protect the environment?
- ○ Yes
- ○ No

38. How many years have you lived at your current residence or within 50 miles of your current residence?

☐☐ # of years

39. Which of the following applies to your household? *(Mark all that apply.)*
- ☐ Primary residence is on a lake
- ☐ Own a second home on a lake
- ☐ Pay a moorage or slip fee for your boat
- ☐ Primary residence is on a river
- ☐ Own a second home on a river
- ☐ Pay dues/fees for a water-based club
- ☐ None of the above

Thank you for participating in this survey. If you have comments on the survey or water quality in Utah, please use the space below.

____

____

____

____

	ID Number	# Single Day Visits in last 12 months	# Overnight Visits in last 12 months	*Unlisted lake/river name and nearest town*
#1				#1
#2				#2
#3				#3
#4				#4
#5				#5
#6				#6
#7				#7
#8				#8

Please mail your completed questionnaire back in the provided postage-paid envelope to:
University of Wyoming, Dept. 3925, 1000 E. University Avenue, Laramie, WY 82071

If you have questions about your rights as a research subject
please call the University of Wyoming IRB Administrator at (307) 766-5320.

UTAH'S LAKES & RIVERS RECREATION SURVEY 2011

Thank you for taking the time to complete this survey. Your participation in this survey is voluntary. Refusal to participate will have no effect on any benefits to which you are otherwise entitled. This survey should be answered by the **adult in your household** (age 18 or older) **who has most recently had their birthday**.

Fill in bubbles completely using either pencil or pen (blue or black ink), but please do NOT use a felt-tip marker.

Mark Answers Like This ⇨ ● ■
NOT Like This ⇨ ✗ ✓

Visits to Utah's Lakes and Rivers

This survey concerns the management of Utah's lakes, reservoirs, and rivers. For the purposes of this survey, please think of lakes and reservoirs as the same thing. Similarly, consider rivers to include streams.

To start, we would like to know whether or not your household visits lakes or rivers and if so, which lakes and rivers you visit and what activities you do there. By "visit" we mean any trip you or members of your household take for the purpose of viewing or using a lake or river. Also, if you or members of your household bike, walk, or jog along a river or on the shores of a lake, include that as a visit as well. If you live on a lake or river, even for part of the year, each day equals 1 visit.

If neither you nor members of your household have visited any lakes or rivers in Utah in the last 12 months we still need your responses.

1a. Did you or members of your household visit any <u>**lakes in Utah**</u> in the <u>**last 12 months**</u>?

○ Yes ○ No ➔ *If you answered no, skip to Question 2a*

1b. Please identify <u>**all**</u> the lakes you or members of your household visited and how many times in the <u>**last 12 months**</u>. To assist you, we have included a map showing many of Utah's popular lakes. Each lake on the map has an ID number. Both the name of the lake and its ID are listed in a table next to the map. If you do not see a lake listed in the table, please write in the name of the lake and the nearest town in the space provided to the right of the table below. If you need additional space please go to the last page of this survey.

	Lake ID Number	# Single Day Visits in last 12 months	# Overnight Visits in last 12 months	*Unlisted lake name and nearest town*
#1				#1
#2				#2
#3				#3
#4				#4
#5				#5
#6				#6
#7				#7
#8				#8
#9				#9
#10				#10
#11				#11
#12				#12

27a. Currently is there a river that you don't visit in the summer because the water quality is too poor?

○ Yes ○ No ➔ *If you answered no, skip to Question 28*

27b. If yes, which river? River ID Number ☐☐☐ Or the name of the river and the nearest town ________

Trips Out-of-State

28. **In the last 12 months**, how many trips did you or members of your household take to lakes and rivers out of state?

# of Lake Visits not in Utah	☐☐	Did not visit any lakes outside of Utah ○
# of River Visits not in Utah	☐☐	Did not visit any rivers outside of Utah ○

Demographics

Finally, we have a few questions about you and your household needed for statistical purposes. Your responses are completely confidential.

29. Are you male or female?
- ○ Male
- ○ Female

30. In what year were you born?

1 9 ☐☐

31. What is the highest level of school you have completed?
- ○ Some high school
- ○ High school graduate or GED
- ○ Some college or technical school
- ○ Undergraduate degree
- ○ Some graduate school
- ○ Graduate degree

32. Including yourself, how many adults, age 18 or older, currently live in your household?

☐☐ # of adults

33. How many children, age 17 or younger, currently live in your household?

☐☐ # of children

34. Are you of Hispanic, Latino, or Spanish origin?

○ Yes ○ No

35. Here is a list of racial categories. Please select one or more to describe your race. *(Mark all that apply.)*
- ☐ White
- ☐ Black or African American
- ☐ American Indian or Alaska Native
- ☐ Native Hawaiian or other Pacific Islander
- ☐ Asian
- ☐ Some other race

36. Next we'd like to ask about your household income. Your answer will only be used for comparing groups of people. Which of the following income groups best describes your household's total income in 2010, before taxes?
- ○ Less than $25,000
- ○ $25,000 up to $50,000
- ○ $50,000 up to $75,000
- ○ $75,000 up to $100,000
- ○ $100,000 up to $150,000
- ○ $150,000 up to $200,000
- ○ $200,000 or more

Potential Changes to River Water Quality in the Summer

Water quality in rivers can change with the seasons. Changes in water quality may or may not affect the number of visits you make to a river.

25. When you think about the river you visited **most often this summer**, what importance do you personally place on each of the following attributes in choosing to visit this river?

	No Importance	Low Importance	Moderate Importance	High Importance
No unpleasant odor	O	O	O	O
Cold water fish species are present	O	O	O	O
Warm water fish species are present	O	O	O	O
Long threads of dark green algae are not present	O	O	O	O
Proximity to your home	O	O	O	O
Other (describe ___________________________)	O	O	O	O

For questions 26a - 26c, please tell us the level of water quality at which you would **STOP** visiting the river you visited **most often this summer**.

26a. Which of the following **unpleasant odor** conditions coming from the water would result in you no longer visiting this river?
- O Faint unpleasant odor
- O Noticeable unpleasant odor
- O Strong unpleasant odor
- O Unpleasant odor plays no role in my decision to visit this river

26b. Which of the following **abundance levels** for each fish type would result in you no longer visiting this river?

Cold water species (trout, whitefish, or salmon)	Warm water species (bass, sunfish, or catfish)
O Common	O Common
O Less common	O Less common
O Rare	O Rare
O No longer present	O No longer present
O Fishing for cold water species plays no role in my decision to visit this river	O Fishing for cold water species plays no role in my decision to visit this river
O Not applicable	O Not applicable

26c. Which of the following amounts of **algae (dark green and long in length)** covering the river bottom in **late summer** would result in you no longer visiting this river?
- O Covers 10 - 40% of river bottom
- O Covers 40 -75% of river bottom
- O Covers more than 75% of river bottom
- O Algae covering the river bottom play no role in my decision to visit this river

2a. Did you or members of your household visit any **rivers in Utah** in the **last 12 months**?
O Yes   O No ➔ *If you answered no, skip to Question 3*
➔ *If you answered no to both Questions 1a and 2a, skip to Question 29*

2b. Please identify **all** the rivers you or members of your household visited and how often in the **last 12 months**. To assist you, we have included two maps showing many of Utah's popular rivers. Each river on the map has an ID number with the larger rivers having multiple ID numbers for various sections. Both the name of the river and its ID are listed in a table next to the map. If you do not see a river listed in the table, please write in the name of the river and the nearest town in the space provided to the right of the table below. If you need additional space please go to the last page of this survey.

	River ID Number	# Single Day Visits in last 12 months	# Overnight Visits in last 12 months	Unlisted river name and nearest town
#1				#1
#2				#2
#3				#3
#4				#4
#5				#5
#6				#6
#7				#7
#8				#8
#9				#9
#10				#10
#11				#11
#12				#12

3. Now think about the **most recent visit to a lake** in Utah that you or members of your household took in the **last 12 months**. Please tell us which lake that was and how many members of your household including yourself were on that visit.

Lake ID Number	Or the name of the lake and the nearest town	Number of household members on visit	Not applicable
	______________		O

4. Now think about the **most recent visit to a river** in Utah that you or members of your household took in the **last 12 months**. Please tell us which river that was and how many members of your household including yourself were on that visit.

River ID Number	Or the name of the river and the nearest town	Number of household members on visit	Not applicable
	______________		O

5. We would like to know how much money you spent on these visits. Please write down your best estimate of what your household spent for each kind of item on the **most recent** visit to a lake and/or a river in Utah that you or members of your household took in the **last 12 months**. If you did not spend any money on an item, please enter a zero for that item. We realize that some households may have spent a lot of money on their most recent lake or river visit, whereas other households may have spent very little money. Answers to this question will allow us to calculate an average household expenditure per visit.

	Most Recent LAKE Trip	Most Recent RIVER Trip
Lodging in hotels, motels, or bed/breakfasts	$ ________ .00	$ ________ .00
Lodging in cabin or home rentals, or public or private campgrounds	$ ________ .00	$ ________ .00
Gasoline, food and beverages purchased at gasoline stations and/or convenience stores	$ ________ .00	$ ________ .00
Food and beverages purchased at grocery stores	$ ________ .00	$ ________ .00
Food and beverages purchased at restaurants or fast food outlets	$ ________ .00	$ ________ .00
Rental fees and supplies (including rental cars, RVs, trailers, boats, and fishing and hunting supplies)	$ ________ .00	$ ________ .00
Other retail goods such as souvenirs (e.g., t-shirts, mugs, postcards)	$ ________ .00	$ ________ .00
Not applicable, no such visit in last 12 months	○	○

Lakes Section

The questions in the next three sections of this survey - Questions 6 through 17 - have to do with **lakes in Utah**. If neither you nor members of your household visited any lakes in Utah in the **last 12 months** please fill in this circle and skip to page 8 ➔ ○

Lake Recreation

6. In the **last 12 months** which types of activities did you or members of your household typically participate in during your lake visits? *(Mark all that apply.)*

- ☐ Boating (includes motor-boating, house boating, sailing, canoeing, kayaking, jet skiing)
- ☐ Fishing for warm water fish species (for example, bass, perch, catfish, crappie, sunfish)
- ☐ Fishing for cold water fish species (for example, trout, whitefish, salmon)
- ☐ Swimming (includes playing in the water, wading, windsurfing, water-skiing, tubing)
- ☐ Near-shore activities (includes walking, biking or running on trails, bird/wildlife/nature viewing, picnicking, camping)
- ☐ Hunting – waterfowl
- ☐ Hunting/Trapping – other

7. In the **last 12 months** which **ONE** activity did **YOU** spend the most time doing during your lake visits? *(Choose only one.)*

- ○ Boating (includes motor-boating, house boating, sailing, canoeing, kayaking, jet skiing)
- ○ Fishing – warm water fish species (for example, bass, perch, catfish, crappie, sunfish)
- ○ Fishing – cold water fish species (for example, trout, whitefish, salmon)
- ○ Swimming (includes playing in the water, wading, windsurfing, water-skiing, tubing)
- ○ Near-shore activities (includes walking, biking or running on trails, bird/wildlife/nature viewing, picnicking, camping)
- ○ Hunting – waterfowl
- ○ Hunting/Trapping – other

22. Which of the following **unpleasant odor** conditions coming from the water did you usually experience at this river this summer?

- ○ No unpleasant odor
- ○ Faint unpleasant odor
- ○ Noticeable unpleasant odor
- ○ Strong unpleasant odor
- ○ Don't know

23. Which of the following **abundance levels** for each fish type did you expect to be present at this river this summer?

Cold water species (trout, whitefish, or salmon)	Warm water species (bass, sunfish, or catfish)
○ Abundant	○ Abundant
○ Common	○ Common
○ Less common	○ Less common
○ Rare	○ Rare
○ Don't know	○ Don't know
○ Not applicable	○ Not applicable

Algae conditions in rivers typically change from May through September (see photos for what we mean by algae conditions). For Question 24a and 24b think about the algae condition as it would appear in **late summer** (e.g., August and September).

Algae are brownish green and short in length

Algae are dark green and long in length

24a. Which of the following **algae** conditions did you usually see in **late summer** at this river?

- ○ Present algae are brownish green and short
- ○ Present algae are dark green and long
- ○ Algae are not present
- ○ Can not see river bottom
- ○ Don't know

24b. How much of the river bottom appeared covered by **algae** in **late summer** at this river?

- ○ Less than 10%
- ○ From 10 - 40%
- ○ From 40 -75%
- ○ More than 75%
- ○ Don't know

Rivers Section

The questions in the next three sections of this survey - Questions 18 through 27 - have to do with **rivers in Utah**. If neither you nor members of your household visited any rivers in Utah in the **last 12 months** please fill in this circle and skip to Question 28 on page 11 ➔ ○

River Recreation

18. In the **last 12 months** which types of activities did you or members of your household typically participate in during your river visits? *(Mark all that apply.)*

- ☐ Boating (includes boats with motors, oar-powered boats, canoeing, kayaking)
- ☐ Fishing for warm water fish species (for example, bass, perch, catfish, crappie, sunfish)
- ☐ Fishing for cold water fish species (for example, trout, whitefish, salmon)
- ☐ Swimming (includes playing in the water, wading, windsurfing)
- ☐ Near-shore activities (includes walking, biking or running on trails, bird/wildlife/nature viewing, picnicking, camping)
- ☐ Hunting – waterfowl
- ☐ Hunting/Trapping – other

19. In the **last 12 months** which **ONE** activity did **YOU** spend the most time doing during your river visits? *(Choose only one.)*

- ○ Boating (includes boats with motors, oar-powered boats, canoeing, kayaking)
- ○ Fishing – warm water fish species (for example, bass, perch, catfish, crappie, sunfish)
- ○ Fishing – cold water fish species (for example, trout, whitefish, salmon)
- ○ Swimming (includes playing in the water, wading, windsurfing)
- ○ Near-shore activities (includes walking, biking or running on trails, bird/wildlife/nature viewing, picnicking, camping)
- ○ Hunting – waterfowl
- ○ Hunting/Trapping – other

Perceptions of River Water Quality in the Summer

We are interested in your **personal** perceptions of river water quality in Utah. Please answer all of the questions in this section - Questions 20 through 26 - for the river that **you** visited **most often this summer**. By summer we mean May through September.

20. Which river in Utah did you visit **most often this summer**? Please record the river ID number (or if the river does not have an ID number then write in the name of the river and the nearest town) and how long you have been going to this river.

River ID Number ☐☐☐ Or the name of the river and the nearest town ________ Number of years visiting this river ☐☐

21. For each of the months listed below, how many visits did you make to this river? For the month of September (post-Labor Day) please estimate the total number of visits you will make.

May	June	July	August (including Labor Day)	September (post-Labor Day)
☐☐	☐☐	☐☐	☐☐	☐☐

Perceptions of Lake Water Quality in the Summer

We are interested in your **personal** perceptions of lake water quality in Utah. Please answer all of the questions in this section - Questions 8 through 16 - for the lake that **you** visited **most often this summer**. By summer we mean May through September.

8. Which lake in Utah did you visit **most often this summer**? Please record the lake ID number (or if the lake does not have an ID number then write in the name of the lake and the nearest town) and how long you have been going to this lake.

Lake ID Number ☐☐☐ Or the name of the lake and the nearest town ________ Number of years visiting this lake ☐☐

9. For each of the months listed below, how many visits did you make to this lake? For the month of September (post-Labor Day) please estimate the total number of visits you will make.

May	June	July	August (including Labor Day)	September (post-Labor Day)
☐☐	☐☐	☐☐	☐☐	☐☐

10. Which of the following best describes the **water clarity** you usually experienced at this lake this summer?

- ○ You can see 12 or more feet deep into the water
- ○ You can see 6 to 12 feet deep into the water
- ○ You can see 1 to 6 feet deep into the water
- ○ You can see at most 1 foot deep into the water
- ○ Don't know

11. Which of the following **shades of green** did the water usually have at this lake this summer?

- ○ No green tint
- ○ Slight greenish tint
- ○ Dark greenish tint
- ○ Don't know

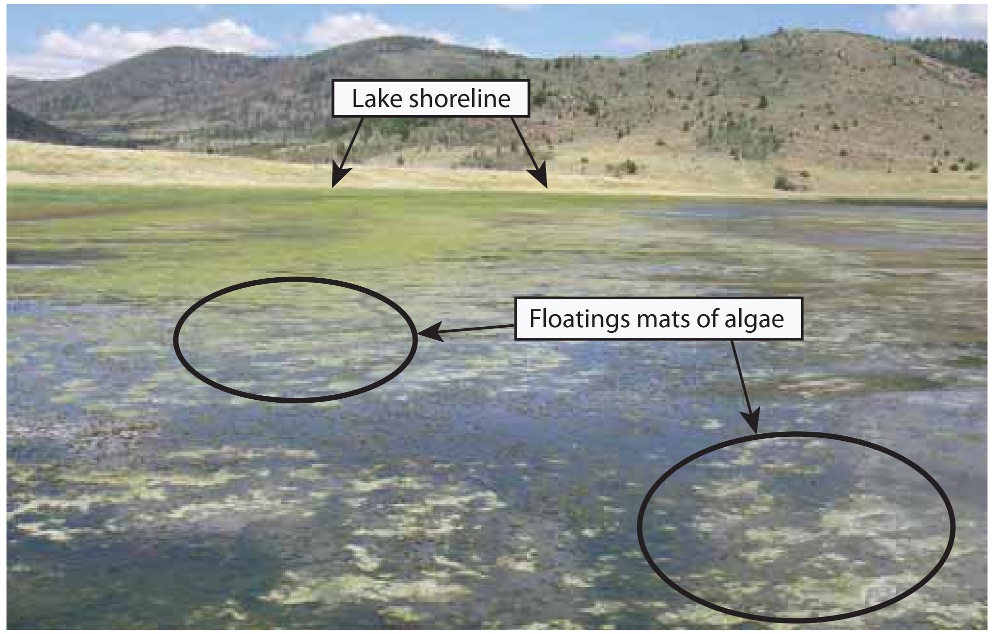
12. Which of the following **unpleasant odor** conditions coming from the water - particularly if the mud on the bottom were disturbed - did you usually experience at this lake this summer?

- ○ No unpleasant odor
- ○ Faint unpleasant odor
- ○ Noticeable unpleasant odor
- ○ Strong unpleasant odor
- ○ Don't know

13. Which of the following **abundance levels** for each fish type did you expect to be present at this lake this summer?

Cold water species (trout, whitefish, or salmon)	**Warm water species** (bass, sunfish, or catfish)
○ Abundant	○ Abundant
○ Common	○ Common
○ Less common	○ Less common
○ Rare	○ Rare
○ Don't know	○ Don't know
○ Not applicable	○ Not applicable

Please examine this photograph which shows an algae bloom covering over 50% of the lake.



14. Which of the following **algae bloom** conditions did you usually find at this lake this summer?
- O Algae bloom would not be present
- O Algae bloom covers less than 10% of the lake
- O Algae bloom covers 10 – 25% of the lake
- O Algae bloom covers 25 – 50% of the lake
- O Algae bloom covers over 50% of the lake
- O Don't know

Potential Changes to Lake Water Quality in the Summer

Water quality in lakes can change with the seasons. Changes in water quality may or may not affect the number of visits you make to a lake.

15. When you think about the lake you visited **most often this summer**, what importance do you personally place on each of the following attributes in choosing to visit this lake?

	No Importance	Low Importance	Moderate Importance	High Importance
Water clarity	O	O	O	O
No unpleasant odor	O	O	O	O
Cold water fish species are present	O	O	O	O
Warm water fish species are present	O	O	O	O
No algae blooms	O	O	O	O
Proximity to your home	O	O	O	O
Other (describe ____________________________)	O	O	O	O

For questions 16a - 16d, please tell us the level of water quality at which you would **STOP** visiting the lake you visited **most often this summer**.

16a. Which of the following **water clarity** depths would result in you no longer visiting this lake?
- O You can see at most 12 feet deep into the water
- O You can see at most 6 feet deep into the water
- O You can see at most 1 foot deep into the water
- O Water clarity plays no role in my decision to visit this lake

16b. Which of the following **unpleasant odor** conditions coming from the water would result in you no longer visiting this lake?
- O Faint unpleasant odor
- O Noticeable unpleasant odor
- O Strong unpleasant odor
- O Unpleasant odor plays no role in my decision to visit this lake

16c. Which of the following **abundance levels** for each fish type would result in you no longer visiting this lake?

Cold water species (trout, whitefish, or salmon)	Warm water species (bass, sunfish, or catfish)
O Common	O Common
O Less common	O Less common
O Rare	O Rare
O No longer present	O No longer present
O Fishing for cold water species plays no role in my decision to visit this lake	O Fishing for cold water species plays no role in my decision to visit this lake
O Not applicable	O Not applicable

16d. Which of the following **algae bloom** conditions would result in you no longer visiting this lake?
- O Algae bloom covers less than 10% of the lake
- O Algae bloom covers 10 – 25% of the lake
- O Algae bloom covers 25 – 50% of the lake
- O Algae bloom covers over 50% of the lake
- O Algae blooms play no role in my decision to visit this lake

17a. Currently is there a lake that you don't visit in the summer because the water quality is too poor?

O Yes O No ➔ *If you answered no, skip to Question 18*

17b. If yes, which lake? Lake ID Number [| |] Or the name of the lake and the nearest town ______________________

APPENDIX C.2

The text of Recreation Survey Contact Letter

September 6, 2011

Dear Utah Resident:

The Division of Water Quality (DWQ) needs your help making balanced decisions about how Utah's lakes and rivers are managed. Utah is blessed with spectacular landscapes, lakes, and rivers that are enjoyed in many ways. Lakes, rivers, and reservoirs provide us with drinking water, scenic beauty, and recreational opportunities. The waters of Utah are among our state's greatest assets and it is the mission of the DWQ to protect and enhance them.

In a few days you will receive a short questionnaire in the mail, along with a postage-paid return envelope. We will ask that the survey be answered by the adult in your household (age 18 or older) who has **most recently had their birthday**. If that is not you, please pass this letter along to that person, so that he or she will know to look for the survey in the mail. This helps us ensure our study reflects a broad cross section of Utahns.

Our survey asks about the lakes, reservoirs, and rivers you visit in Utah and what you do there. Every resident of the state has a stake in our future, so even if you aren't a regular visitor to any of Utah's waterways, please answer the questions that pertain to you and your household. We need your opinions, too. The questionnaire is short, and should only take about 20 minutes to complete.

I hope that your household will take part in this survey to help us understand how you would like our state's waters protected.

If you have any questions, please contact Dr. Paul Jakus at Utah State University either by email (Paul.Jakus@usu.edu) or by telephone (435-797-2309). Thank you for your assistance.

Sincerely,

Walter L. Baker, P.E.
Director

APPENDIX C.3

The text of Recreation Survey Cover Letter

September 27, 2011

Dear Utah Resident:

The Division of Water Quality (DWQ) needs your help making balanced decisions about how Utah's lakes and rivers are managed. I hope you can spend a few minutes completing and returning the enclosed survey so we may better understand how you would like our state's waters protected. This survey should only take about **20 minutes** of your time.

Utah is blessed with spectacular landscapes, lakes, and rivers that are enjoyed in many ways. Lakes, rivers, and reservoirs provide us with drinking water, scenic beauty, and recreational opportunities. The waters of Utah are among our state's greatest assets and it is the mission of the DWQ to protect and enhance them.

Our survey asks about the lakes, reservoirs, and rivers you visit in Utah and what you do there. Every resident of the state has a stake in our future, so even if you aren't a regular visitor to any of Utah's waterways, please answer the questions that pertain to you and your household. We need your opinions, too. A team of experts assembled by Utah State University will summarize your responses to the enclosed survey and provide the results to DWQ.

This questionnaire is being delivered to a select number of households across the state of Utah by the Wyoming Survey & Analysis Center at the University of Wyoming. To ensure our study reflects a broad cross section of Utahns, we ask that this questionnaire be completed by an adult member of your household (age 18 or older) **who most recently had their birthday**.

- Feel free to write any comments or explanations in the blank space on the last page.
- As soon as you have finished, please mail back the completed questionnaire in the provided envelope, and drop it in the mail. **No postage is required**.
- Do not write your name or address on the questionnaire to insure your privacy.
- All of your answers are completely confidential.

As one of a small number of Utah residents who are being asked to participate in this survey, the answers you give in this survey are very important. By completing the questionnaire, you can help ensure that all residents who hold similar opinions to yours are represented.

If you have any questions, please contact Dr. Paul Jakus at Utah State University either by email (Paul.Jakus@usu.edu) or by telephone (435-797-2309). Thank you for your assistance.

Sincerely,

Walter L. Baker, P.E.
Director

APPENDIX C.3

The text of Recreation Survey reminder postcard

October 12, 2011

Dear Utah Resident,

About 10 days ago you should have received a survey in the mail about *Utah's Lakes and Rivers*. We are conducting this survey for the Utah Division of Water Quality. The information we obtain will guide the Division in their management of Utah's lakes, reservoirs, and rivers, now and in the future.

Many Utah residents have already responded with completed surveys and, if this includes you, *thank you*! If not, we hope you will take a few minutes to fill out and return your survey, as your opinions are very important.

Appendix D
Evaluation of Nonresponsive Bias in the TEV Survey Sample

APPENDIX D
Test of Nonresponse Bias

There are two types of nonresponse in survey research: (1) item nonresponse, where respondents fail to answer individual questions or parts of the survey; and (2) unit nonresponse, where the household fails to return the questionnaire. In this appendix, the latter—when households fail to return the questionnaire even after repeated attempts to engage them in participating in the survey—is discussed. The concern with unit nonresponse is when those households who chose not to respond to the survey systematically differ from the households that do return the survey in a way that is relevant to their economic values. This is referred to as nonresponse bias, and for this study it was important to test if nonrespondents differ systematically from respondents in their WTP for cleaner water from reductions in nutrient loading.

The most common approach for minimizing nonresponse bias has been to minimize nonresponse rates. Indeed, WYSAC followed Dillman's Total Design Method to maximize the response rate for this study (Dillman, 2000). However, a review of research studies that presented estimates of nonresponse bias found that empirically there is no simple relationship between nonresponse rates and nonresponse biases (Groves, 2006). In the current environment of declining response rates, this finding offers some assurance that the survey researcher can accurately depict the attitudes, preferences, economic values, and/or activities of a target population. This finding also implies there is no minimum response rate whereby nonresponse biases can be ruled out; hence the survey researcher must assess their data for nonresponse bias regardless of the survey response rate. The Office of Management and Budget (OMB) requires the assessment of nonresponse biases for all survey research that is funded by the U.S. federal government (OMB, 2006).

To test for nonresponse bias the propensity scores method, a two-stage approach entailing the estimation of a selection model in the first stage and a response model in the second stage, was used. The first stage selection model estimates the probability of a household completing and returning the questionnaire. Using demographic data that accompanied the random sample of Utah households that was purchased for the study, the following logistic model was estimated:

$$\ln\left(\frac{\pi_i}{1-\pi_i}\right) = \beta_0 + \beta_1 lnBidAll + \beta_2 NumberOfAdults + \beta_3 Married + \beta_4 HomeOwner + \beta_5 IncomeInSample + \beta_6 AgeInSample + \epsilon \quad \text{(D-1)}$$

where π_i denotes the probability that the i^{th} individual completed and returned the survey.

The dependent variable is a dichotomous variable, in this case whether a household returned the survey or not. The predictor variables include the log of the bid amount that was randomly assigned to the household, plus the household demographic data. Further, these variables are thought to influence whether a household would respond to the survey. A summary of the variables used in the selection model is presented in Table D-1.

TABLE D-1
Definitions of Variables Included in the Selection Model

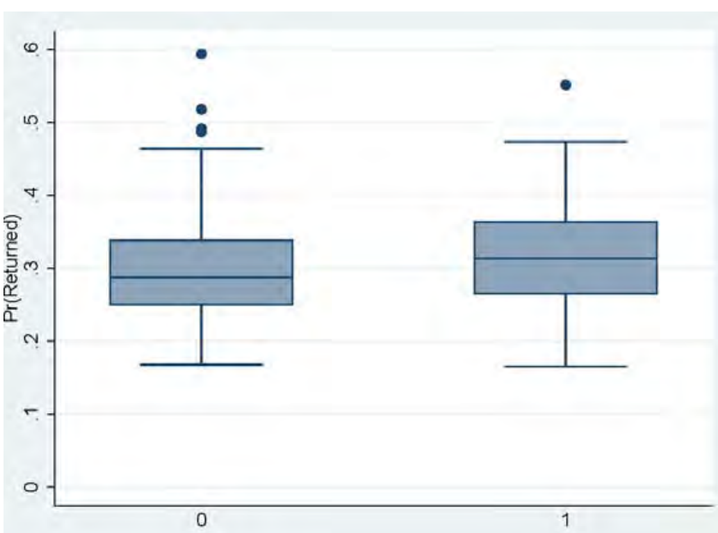
Variable	Definition	Type	N
Returned	A completed questionnaire was returned (coded 1 for yes and 0 for no)	D	2450
lnBidAll	Log of the bid amount chosen from the set {$2, $5, $7, $10, $12, $15, $20, $30, $40, $50}	C	2450
NumberOfAdults	Number of adults in the household	C	2173
Married	Household includes a married couple (coded 1 for married and 0 otherwise)	D	1897
HomeOwner	The home is owned versus rented (coded 1 for owned and 0 otherwise)	D	2070
IncomeInSample	The annual household income	C	2175
AgeInSample	Age of the individual in the sample	C	1742

NOTES:
C = Continuous variable
D = Dummy variable. Sample sizes less than N=615 indicate missing data.

Using these variables in the logit model of the decision to return the survey allows us to predict the probabilities of success (the survey was completed and returned). These are calculated from the selection model and are called propensity scores. The survey response model, estimated in the second stage, incorporates the propensity scores as an explanatory variable in the dichotomous choice WTP logit model.

To observe whether or not the households who returned the questionnaire can be distinguished from the households who did not return the questionnaire, a boxplot was constructed of the predicted probabilities of returning the survey (see Figure D-1). Note that there is a great deal of overlap in the data suggesting the two groups—responders and nonresponders—are similar with regard to the demographic variables used in the response model (household size, married couples, home ownership, household income, and age).

FIGURE D-1
Boxplot of Predicted Probabilities to Return the Survey



Notes:
Returned=1 and did not return=0
Solid circles are outliers.

For this study, it is important that the estimates of economic value for improved water quality are not biased by a household's propensity to complete and return the questionnaire. Therefore, the response model is based on the model to estimate WTP for the nonuser group.

The survey response model is given by the following dichotomous choice CVM logistic model:

$$\Pr(NutRedux = 1) = F(\beta_0 + \beta_1 \ln(Bid) + X_i'\beta + \varepsilon_i) \quad \text{(D-2)}$$

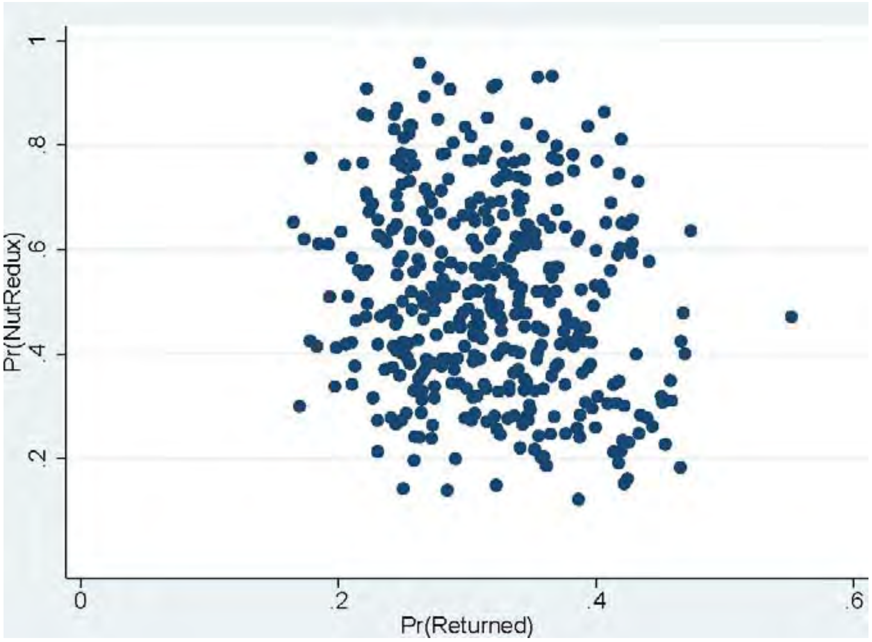
The results of the response model are presented in Table D-2. Given the lack of statistical significance of the propensity score variable – *PrReturn* – there appears to be negligible nonresponse bias and therefore the sample WTP values were generalizable to Utah's population.

TABLE D-2
Results of Logistic Regression with Propensity to Return the Survey

	Response Model	
Variable	**coef.**	**p-value**
Intercept	0.9504	0.252
LnBid	-0.6454	<0.001
Female	0.4666	0.086
Age	-0.0069	0.412
College	0.2241	0.245
Adult	-0.1061	0.513
Child	-0.1138	0.285
White	0.1735	0.698
Income	0.000014	<0.001
PrReturn	0.1316	0.958

As an additional check on whether the probability of returning a survey influenced the WTP estimates, the predicted survey response probabilities were graphed against the predicted probabilities of voting for the nutrient reduction program (see Figure D-2). The apparent lack of correlation between the response propensity and the outcome variable (WTP) also suggests that there is negligible nonresponse bias.

FIGURE D-2
Predicted Probability of Returning the Survey vs. Predicted Probability of Voting for the Nutrient Reduction Program



Appendix E
Weighting Methodology for Recreation Survey from Marketing Systems

APPENDIX E

Weighting Methodology Recreation Demand Survey 2011

This survey has secured a total of 1,405 completed questionnaires with adults residing in Utah. In order to provide a probability-based sample from the entire state, the method of address-based sampling (ABS) was used to select a random sample of 2,000 residential addresses. Moreover, a supplemental (Targeted) sample of 2,601 addresses was selected from listed households expected to be recreationists to increase the number of lake and river users in the state.

Given the highly disproportional sample allocation used for this survey, it was decided to weight the resulting data using a special methodology as detailed next. The needed population figures were obtained from the latest CPS estimates and all weighting adjustments were carried out using the *WgtAdjust*[1] procedure of SUDAAN. It should be noted that survey data for a number of demographic questions, such as race, age, and education, included missing values. All such missing values were first imputed using a hot-deck procedure before construction of the survey weights. As such, respondent counts reflected in all tables in this report correspond to the post-imputation step.

Estimation of the Number of Users and Nonusers

The above 1,405 completed surveys were comprised of 374 from the ABS and the remaining 1,031 from the Targeted components, respectively. In the first step, the 374 ABS respondents were combined with 625 respondents from another ABS survey that was conducted independently in the state using a similar questionnaire. Collectively, the resulting 999 respondents were then weighted to the demographic characteristics of adults in Utah. The following tables provide the number of theses respondents and the corresponding total counts of all adults along the demographic dimensions used for weighting (raking).

TABLE 1
Distribution of ABS respondents from combined surveys and all adults by gender and age

Age	Respondents			Utah Adults		
	Male	Female	Total	Male	Female	Total
18 - 34	81	109	**190**	390,416	396,334	**786,750**
35 - 44	88	72	**160**	170,899	170,393	**341,292**
45 - 54	112	67	**179**	131,404	139,097	**270,501**
55 - 64	128	85	**213**	118,994	134,201	**253,195**
65 - 74	103	51	**154**	93,690	93,849	**187,539**
75 +	67	36	**103**	51,614	57,309	**108,923**
Total	**579**	**420**	**999**	**957,017**	**991,183**	**1,948,200**

TABLE 2
Distribution of ABS respondents from combined surveys and all adults by gender and education

Education	Respondents			Utah Adults		
	Male	Female	Total	Male	Female	Total
Up to High School Diploma	77	73	**150**	375,694	382,358	**758,052**
Some College or Technical School	179	142	**321**	292,230	374,686	**666,916**
Under Graduate Degree	160	124	**284**	176,780	181,778	**358,558**
Graduate Degree	163	81	**244**	112,313	52,361	**164,674**
Total	**579**	**420**	**999**	**957,017**	**991,183**	**1,948,200**

1. Folsom, R. and Singh, A. (2000). The Generalized Exponential Model for Sampling Weight Calibration. *Proceedings of the American Statistical Association, Section on Survey Research*.

TABLE 3

Distribution of ABS respondents from combined surveys and all adults by gender and race

Race	Respondents			Utah Adults		
	Male	Female	Total	Male	Female	Total
White	521	376	**897**	826,805	857,064	**1,683,869**
Other	58	44	**102**	130,212	134,119	**264,331**
Total	**579**	**420**	**999**	**957,017**	**991,183**	**1,948,200**

With a final weight computed for each of the 999 respondents of the random (ABS) samples, it was then possible to generate the distribution of adults who were users and nonusers of lakes and rivers in Utah. The following tables provide weighted estimates of such adults along several demographic characteristics.

TABLE 4

Distribution of respondents and estimated counts of all adults by gender and user status

Gender	Respondents			Utah Adults		
	Nonusers	Users	Total	Nonusers	Users	Total
Male	146	433	**579**	211,351	745,666	**957,017**
Female	138	282	**420**	311,488	679,695	**991,183**
Total	**284**	**715**	**999**	**522,838**	**1,425,362**	**1,948,200**

TABLE 5

Distribution of respondents and estimated counts of all adults by age and user status

Age	Respondents			Utah Adults		
	Nonusers	Users	Total	Nonusers	Users	Total
18 - 34	31	159	**190**	155,221	631,529	**786,750**
35 - 44	28	132	**160**	63,067	278,225	**341,292**
45 - 54	31	148	**179**	68,207	202,294	**270,501**
55 - 64	67	146	**213**	80,023	173,172	**253,195**
65 - 74	71	83	**154**	90,696	96,843	**187,539**
75 +	56	47	**103**	65,623	43,300	**108,923**
Total	**284**	**715**	**999**	**957,017**	**991,183**	**1,948,200**

TABLE 6

Distribution of respondents and estimated counts of all adults by race and user status

Race	Respondents			Utah Adults		
	Nonusers	Users	Total	Nonusers	Users	Total
White	255	642	**897**	454,963	1,228,906	**1,683,869**
Other	29	73	**102**	67,875	196,456	**264,331**
Total	**284**	**715**	**999**	**522,838**	**1,425,362**	**1,948,200**

TABLE 7

Distribution of respondents and estimated counts of all adults by education and user status

Education	Respondents			Utah Adults		
	Nonusers	Users	Total	Nonusers	Users	Total
Up to High School Diploma	55	95	**150**	252,040	506,013	**758,052**
Some College or Technical School	98	223	**321**	170,910	496,006	**666,916**
Under Graduate Degree	59	225	**284**	58,544	300,014	**358,558**
Graduate Degree	72	172	**244**	41,345	123,330	**164,674**
Total	**284**	**715**	**999**	**522,838**	**1,425,362**	**1,948,200**

Calibration of the Targeted Sample

Before combining the Targeted sample of 1,031 respondents with the 374 respondents from the ABS component of the RDS survey, adjustments had to be made to compensate for the fact that respondents from the Targeted component had a higher propensity for being users. This calibration was carried out using the methodology developed by Fahimi (1994)[2]. In the first step, respondents were weighted to the synthesized distribution of user and nonuser adults as obtained from tables 4 to 7. Subsequently, the resulting weights were adjusted so that weighted total for each component would add up to the estimated effective sample size for the given component. For this purpose the design effect for the Targeted component was estimated to be 3.7, while for the ABS component this effect was estimated to be 2.2. That is, the base weights for the Targeted respondents were forced to add up to 279 = 1031/3.7 while for the ABS respondents this total was 171 = 374/2.2.

Computation of the Final Weights

Using the weights obtained from the above steps as base weights, calibrated to the effective sample size of each component, the resulting weights were then raked one last time to the household characteristic in Utah residents, including the ABS-estimated counts of users and nonusers. For this step the entire state was partitioned into two county-defined regions as defined below:

Northern Counties: Box Elder, Cache, Daggett, Davis, Duchesne, Morgan, Rich, Salt Lake, Summit, Tooele, Uintah, Utah, Wasatch, and Weber.

Southern Counties: Beaver, Carbon, Emery, Garfield, Grand, Iron, Juab, Kane, Millard, Piute, San Juan, Sanpete, Sevier, Washington, and Wayne.

The summary counts of respondents and their corresponding household totals for this round of weighting are provided in the following tables.

TABLE 8
Distribution of the RDS respondents and counts of all households by region and race

Region	Race	Respondents	Households
North	White	1,140	69,1782
	Non-White	81	10,0161
South	White	171	10,6053
	Non-White	13	1,0896
Total		**1,405**	**908,892**

TABLE 9
Distribution of the RDS respondents and counts of all households by region and household size

Region	Household Size	Respondents	Households
North	1 Person	136	140,050
	2 Persons	552	221,673
	3 Persons	242	138,492
	4 Persons	132	128,041
	5+ Persons	159	163,687
South	1 Person	28	22,625
	2 Persons	87	40,744
	3 Persons	23	17,060
	4 Persons	17	15,725
	5+ Persons	29	20,795
Total		**1,405**	**908,892**

2. Fahimi, M. (1994). "Post-stratification of Pooled Survey Data." Proceedings of the American Statistical Association, Survey Research Methods Section, Toronto, Canada.

TABLE 10

Distribution of the RDS respondents and counts of all households by regions and child status

Region	Child Status	Respondents	Households
North	With Children	376	343,864
	Without Children	845	448,079
South	With Children	55	45,242
	Without Children	129	71,707
Total		**1,405**	**908,892**

TABLE 11

Distribution of the RDS respondents and counts of all households by region and income

Region	Household Size	Respondents	Households
North	Less than $25,000	109	132,070
	$25,000 up to $50,000	313	215,379
	$50,000 up to $75,000	287	182,412
	$75,000 up to $100,000	213	111,500
	$100,000 up to $150,000	179	102,152
	$150,000 and up	120	48,430
South	Less than $25,000	23	30,111
	$25,000 up to $50,000	56	38,671
	$50,000 up to $75,000	40	23,734
	$75,000 up to $100,000	35	12,496
	$100,000 up to $150,000	23	8,566
	$150,000 and up	7	3,371
Total		**1,405**	**908,892**

TABLE 12

Distribution of the RDS respondents and counts of all households by user status

User Status	Respondents	Households
No-User	338	243,920
User	1,607	664,972
Total	**1,405**	**908,892**

Variance Estimation for Weighted Data

Survey estimates can only be interpreted properly in light of their associated sampling errors. Since weighting often increases variances of estimates, use of standard variance calculation formulae with weighted data can result in misleading statistical inferences. With weighted data, two general approaches for variance estimation can be distinguished. One is Taylor Series linearization, in which a nonlinear estimator is approximated by a linear one, and then the variance of this linear proxy is estimated using standard variance estimation methods. The second method of variance estimation is replication, in which several estimates of the population parameters under the study are generated from different, yet comparable parts of the original sample. The variability of the resulting estimates is then used to estimate the variance of the parameters of interest using one of several replication techniques, such as Balanced Repeated Replication (BRR) and Jackknife. There are several statistical software packages that can be used to produce design-proper estimates of variances using linearization or replication methodologies, including: SAS, SPSS, SUDAAN, WesVar, and Stata.

An Approximation Method for Variance Estimation

Researchers who do not have access to appropriate software for design-proper estimation of standard errors can approximate the resulting variance inflation due to weighting and incorporate that in subsequent calculations of confidence intervals and tests of significance. With W_i representing the final weight of the i^{th} respondent, the inflation due to weighting, which is commonly referred to as *Design Effect*, can be approximated by:

$$\delta = 1 + \frac{\sum_{i=1}^{n} \frac{\left(W_i - \bar{W}\right)^2}{n-1}}{\bar{W}^2}$$

For calculation of a confidence interval for an estimated percentage, $\hat{p}$, one can obtain the conventional variance of the given percentage $S^2(\hat{p})$, multiply it by the approximated design effect, δ, and use the resulting quantity as adjusted variance. That is, the adjusted variance $\hat{S}^2(\hat{p})$ would be given by:

$$\hat{S}^2(\hat{p}) \approx S^2\left(\hat{p}\right)(\hat{p}) \times \delta = \frac{\hat{p} \times \left(1 - \hat{p}\right)}{n-1}\left(\frac{N-n}{N}\right) \times \delta$$

Subsequently, the (100-α) percent confidence interval for *P* would be given by:

$$\hat{p} - z_{\alpha/2}\sqrt{\frac{\hat{p} \times (1 - \hat{p})}{n-1}\left(\frac{N-n}{N}\right) \times \delta} \leq P \leq \hat{p} + z_{\alpha/2}\sqrt{\frac{\hat{p} \times (1 - \hat{p})}{n-1}\left(\frac{N-n}{N}\right) \times \delta}$$

Appendix F
Quality Assurance Project Plan

Nutrient Water Quality Benefit Study Quality Assurance Project Plan

TO: Nick Von Stackelberg/DWQ

FROM: Paul Jakus/USU, John Loomis/CSU, Nanette Nelson/WSAC, and Mary Jo Kealy/CH2M HILL

CC: Jeff Ostermiller/DWQ, Jeff Denbleyker/CH2M HILL

DATE: March 27, 2011, updated October 17, 2011

Introduction

The objective of this quality assurance project plan or QAPP is to define the quality control process. This Quality Assurance Project Plan (QAPP) presents the quality assurance (QA) and quality control (QC) requirements designed to ensure that recreation and household willingness to pay survey data collected for the study to evaluate the economic costs and benefits of nutrient criteria implementation will be of the appropriate quality to achieve the Data Quality Objectives (DQOs) defined in this QAPP. Specific protocols for sampling, administering the surveys, and data evaluation and assessment are discussed. Requirements for performance evaluations and corrective actions are specified. The elements included in the QAPP are consistent with those specified in the United States Environmental Protection Agency (EPA) *Requirements for Quality Assurance Project Plans, EPA QA/R-5* (EPA, 2001). The objectives of the Nutrient Water Quality Benefit Study (NWQBS) QAPP are as follows:

- Ensure that survey data collection and procedures are standardized among all participants.
- Monitor the administration of the various surveys to evaluate the current response rate and provide rapid feedback, so that corrective measures, if needed, can be taken before data quality is compromised.
- Verify that reported data are sufficiently precise, accurate, representative, complete, and comparable, so that they are suitable for their intended use.

Planned Survey Sampling and Data Quality Objectives

The desired outcomes for the survey data collection and analysis components of this project are to (1) ascertain water quality conditions that are deemed undesirable for recreation and, (2) assess the benefits to Utahns of nutrient load reduction and the associated improvements in water quality. It is likely that the bulk of benefits will accrue to those who directly use the waters of Utah for recreation, namely boating, fishing, swimming, hunting, etc. It is also possible that Utahns who do not engage in these water-based activities will also benefit from quality improvements. Recreation users and non-users alike may value protecting and improving the water quality of Utah's surface waters to ensure a quality of life for current and future generations of Utahns.

These varied, but related, goals will require us to use different surveys to contact the recreation surface water user and non-user populations. For the user population, at the most general level our choice is between off-site methods of contacting people (e.g., mail, phone, or door-to-door surveys) or on-site methods (e.g., fixed access point intercepts, roving access point intercepts). Each method has its advantages and disadvantages depending upon the type of information to be collected. Any method selected, of course, must also stay within the budget allocated for survey activities. For the non-user population, only off-site methods are feasible.

Intercept methods have the advantage of high response rates (people actually complete the survey) for the targeted population and are excellent for eliciting the details of the current activities. For recreation activities the primary disadvantage is that participants will not tolerate lengthy surveys or those that are cognitively burdensome—they want to get on with their activity. Intercept surveys also suffer from "avidity bias;" such surveys will systematically intercept those who engage in the recreation most frequently. Finally, intercept methods are expensive relative to non-intercept methods, especially for statewide surveys such as that needed for this study. A survey must have adequate coverage, assuring that all users at all sites have an equal probability of participating in the sample, which is a necessary condition for a representative sample. This means that intercepts must take place at sites that are popular and at sites that are not popular. Intercept surveys that are not truly representative can be corrected for any inherent bias, but sampling correction factors for intercept surveys can become quite complicated.

Off-site methods such as mail or telephone surveys have a higher degree of non-response (people ignore the survey) and are relatively inefficient in reaching a targeted population in comparison to on-site methods. Off-site surveys—especially mail surveys—can have many advantages over on-site surveys, though, and these advantages often outweigh the disadvantages just mentioned. First, a mail survey can be longer in length than a face-to-face interview. That is, a relatively complex description of a proposed policy, such as the nutrient reduction policy and its effects, can be better served in printed survey materials where some thought is required of the respondent. Because the survey is received at home respondents have plenty of time to consider their response. Mail surveys, when properly designed, can avoid the problems of avidity bias and incomplete coverage of the targeted population. While it is possible that an off-site sample would not be truly representative of the targeted population, the probability of a biased sample is relatively low and sample correction procedures based upon zip code or census block information are relatively straightforward. We address such methods below.

After considering all the advantages and disadvantages of the various surveys approaches, we recommend using a combination of several mail surveys to estimate the benefits of nutrient load reductions for our various groups. The key advantages tipping the balance toward mail surveys are: (1) the somewhat complicated scenarios used to estimate total economic value and, (2) the need to adequately "cover" all water bodies in the state. The sampling will make use of two sampling frames: the first frame will consist of addresses of all households in Utah and the second frame will consist of all households in Utah believed to engage in water-based recreation.

Our two planned surveys and their goals are:

- **Total Economic Value (TEV) Survey**
  - Estimate proportion of general population that engages in lake recreation, river recreation, and waterfowl hunting.
  - Estimate total economic value (i.e., use and non-use value) for reducing nutrient loads in Utah waterbodies.
  - Determine water quality condition that is deemed undesirable for recreation and aesthetics.
- **Recreation Value Survey of Lake and River Users (“Recreation Survey”)**
  - Estimate recreation demand model for lake and river recreation in Utah.
  - Estimate recreation value of lake and river users for reducing nutrient loads at site-specific locations.
  - Estimate total recreation value of nutrient load reductions for Utah lake and river users.

Per Contract Amendment 1 with DWQ, a survey of waterfowl hunters will be conducted in conjunction with a survey sponsored by Friends of the Great Salt Lake (FGSL) and Bioeconomics, Inc. The goals of the waterfowl hunter survey are parallel to those of the two surveys outlined above, namely (a) estimate recreation demand model for waterfowl hunting in Utah, (b) estimate non-market value of waterfowl hunters for reducing nutrient loads at site-specific locations , and (c) estimate total recreation value of nutrient load reductions for Utah waterfowl hunters. The DQOs for the waterfowl hunting survey are included in *2010 Utah Waterfowl Hunter Survey: Data, Collection Methods and Coding* prepared by Bioeconomics, Inc. The data quality assessment methods reported here, though, will be applied to the hunting information coming from the FGSL-Bioeconomics survey effort.

Survey Sampling

The goal in all survey sampling is to accurately depict the attitudes, preferences, and/or activities of a well-defined target population. No survey is perfect, but a high quality survey has four key characteristics:

- Every unit in the *target population* (*e.g.*, all households in the state of Utah) has an equal and known chance of participating in the survey
- All those sampled actually respond to the survey, or those choosing to respond are similar to those who do not respond, thus minimizing *nonresponse error*
- The sample size is large enough to achieve the desired level of precision, i.e., *sampling error* is reduced to its target level
- The questions on the survey are unambiguous to both researchers and respondents, thus minimizing *measurement error*

Our sampling and survey design efforts will be considered in light of all four sources of potential survey error—the target population, potential non-response, sampling error, and survey validity (i.e., measurement error).

A. Target Population

The target population differs with the intent of each survey. The target population for the Total Economic Value (TEV) survey is all households in the state of Utah, whereas the target population for the waterfowl hunter survey is exactly that: waterfowl hunters. The populations are dissimilar; in a household survey we would expect survey respondents to reflect the demographics of the state while the demographic characteristics of hunters is likely to be very different from those of the typical state resident, and one should not be surprised to find the waterfowl hunter population to be composed predominately of older males with above average incomes.

Our approach to sampling is governed by the need to maximize the coverage of our samples (assure that no eligible respondents are systematically excluded) and to minimize the variance of our economic benefit estimates (best accomplished with larger sample sizes), all while trying to stay within the survey budget. Our approach uses a mix of random sampling and targeted sampling. In the tables that follow we report what we believe will be the minimum response rate. In all surveys we will use elements of Dillman's Total Design Method to increase the response rate (Dillman, 2000). Such elements include a carefully crafted and signed cover letter explaining the purpose of the survey and the need for the respondent to complete the survey, as well as a series of timed follow-up contacts and "replacement" surveys sent to non-respondents.

We will monitor the response rate for both surveys on a weekly basis by assessing the effect of each mailing to inform future mailings. After the second mailing of replacement surveys we will evaluate the need for a third mailing of the questionnaire in order to improve on the number of completed surveys. For the TEV survey, which will have multiple versions, we will monitor the number of completed surveys for each version so that all versions of the survey will have approximately equal numbers of completions. If after the second mailing the number of completed surveys for a particular version of the TEV survey is lower than other versions, we will focus our third mailing on these non-respondents to secure a comparable number of completed surveys. The implications of response rate to the study are discussed in the next section.

Our TEV survey is fairly straightforward. With the goal of estimating total economic value (willingness to pay) of reductions in nutrient loads in the state, this will be a random sample of 2100 households. The random draw of households will be pulled from a sampling frame maintained by a private survey research that specializes in maintaining high quality, up-to-date sampling frames. Consistent with current mail survey response rates, we anticipate a response rate of approximately 30%, yielding 630 completed surveys.

The Recreation Survey is a bit more complicated in that we plan to use a combination of (1) a "targeted" sample of households believed to engage in water-based recreation and, (2) a supplemental random sample of the general population. The firm from which we will purchase an address list maintains a list of households which it predicts (with 70% accuracy) have used (visited) lakes or rivers in the past 12 months. There are two advantages to using such a list. First, we can be far more efficient with the survey budget when we can target the population we want; no surveys are wasted by sending them to people who do not recreate on Utah waters. Second, the survey is likely to be far more salient to users than non-users. Assuming an original sample of some 3,000 addresses, we will contact approximately 2,100 (70%) households with members who enjoy water-based recreation. Survey saliency means that users tend to have greater response rate; our working number is 40%.

The drawback of a targeted sample is that, depending on how the list is created, maintained, and updated, the probability of systematically excluding an "eligible" portion of the population is always present. Thus, for the Recreation Survey we propose supplementing our targeted sample with a second sample comprised of the general population. The goal of this sample is to assure that our targeted sample did, indeed, truly capture a representative sample of lake and river users. In the event we find systematic differences between the targeted and supplemental surveys we will devise a weighting scheme to restore a representative sample.

TABLE 1
Estimated Completed Surveys, by Sampling Frame, Recreation Survey

	Water Users (Targeted Sample)	**Supplemental General Population**
Sample size	2,100	1,200
Response rate	0.4	0.3
Completed surveys	840	360

We anticipate approximately 1,200 completed responses from Utahns who receive the Recreation Survey.

B. Sample Non-response

After establishing the target populations for each survey, the next facet of our survey and sampling design focuses on potential non-response from sampled units. If one achieves a large enough sample to achieve the desired level of precision (see below), a low survey response rate is not a problem if the attitudes, preferences and activities of those who have responded accurately reflect those of the target population. That is, if sample respondents are the "same" as those not responding, then it really doesn't matter if the survey response rate is 10% or 90%; one is getting an accurate depiction of the target population.

However, low response rates are often correlated with survey "saliency": the relative importance of the survey topics to the respondent. Respondents who actively recreate on Utah's lakes and rivers may be more likely to complete a mail survey about water-based recreation than those who are less active. Similarly, respondents who are more sensitive about environmental conditions in Utah's waters may be more likely to complete a survey than those who are less sensitive. In such cases the responses to the survey are not reflective of the target population, and conclusions based on a sample are subject to *non-response error*.

A high quality sampling effort will always assess the degree to which non-response error may be present in the sample; if non-response effects are found the analysis will correct for these effects. We discuss detection of non-response bias first, followed by discussion of the ways to correct for non-response bias.

Detecting Sample Non-response. The general approach to detecting sample non-response is to compare some sample statistics to those known to hold for the target population at large. For general population surveys, U.S. Bureau of Census reports can be used to evaluate the degree to which characteristics of the sample differ from those reported by the Census. In our study, we will use Census statistics to evaluate non-response for the Total Economic Value survey. Secondly, demographic information will also be provided by the sampling firm providing the team with the names and addresses of those to be sent the surveys. Such data are commonly available at the census tract of zip code level, and contain items such as average household income, household size, age structure, racial composition, etc. Again, one can compare survey responses—in the aggregate or at the tract/zip code level—to evaluate the representativeness of the sample. If non-response error is potentially present, we will adjust our analysis using standard correction techniques described below.

The Recreation Survey will rely on a dual sampling frame: one of which is aimed at a targeted sample of those believed to be active in water-based recreation and another aimed at the general population. We use the targeted sample because surveys are expensive and we wish to be cost-effective: we know, and fully expect, that those who recreate on Utah waters will be more likely to return the recreation survey than those who do not. Concern for non-response is why we have supplemented the targeted sample with a general population sample. Responses from the general population component of the Recreation Survey—which will include both users and non-users—can be used to (1) compare users and non-users in the general population sample only, (2) compare users across the general population and targeted samples, and (3) compare nonusers who received the Recreation Survey to those who received the TEV Survey.

Another method of detecting non-response error is to use a supplemental telephone survey aimed directly at non-respondents. One constructs a short telephone survey that asks key demographic questions and, perhaps, a couple of key questions of substance (e.g., *Have you visited a lake or river in Utah in the last 12 months?)*. The statistics gleaned from the phone survey can be used to determine if non-respondents are significantly different from those who chose to respond to the survey. We will consider a phone "follow up" if serious non-response bias is detected.

Correcting for Non-response Error. The professional sampling firm with which we are working to draw the sample will also provide data that allows for non-response bias testing, i.e., we have census tract or zip code information level demographics for every member of the sample. Though we may not know the exact household income or number of members in a household, we will know the average income and household size (among other variables) within a given tract or zip code. We will also know the response rates within each tract or zip code region: some regions will have relatively high response rates while others will have lower response rates. If nonresponse is determined to be a problem, we can use such information to estimate probabilistic models of response. The models will identify the factors which influence the probability of a household's response to the survey; the probability estimates can then be used to develop weights to adjust for systematic nonresponse error.

Similarly, we can model whether a sampling unit engages in water-based recreation using demographics from the TEV and Recreation (general population sample) survey responses. That is, if we determine that our targeted users sample has resulted in a biased sample, we can estimate a probabilistic model on the general population responses: the dependent variable measures whether or not they engaged in water-based recreation, using demographic variables of respondents that are the *same* demographic variables available for non-respondents. If one or more demographic variables are statistically significant predictors of whether they are water users or not, we can then predict for the nonrespondents the proportion of users and nonusers.

C. Sampling Error: The Precision of Statistics

Our sampling methodology has been designed to maximize the probability that unbiased estimators of population proportions and means will be achieved. What remains is to assess the precision of such estimates. For some estimators (e.g., sample proportions) we can state the precision of the estimator with great confidence, whereas we can state only the procedures we will use to assess the level of precision for other estimators (e.g., WTP estimates calculated using a non-linear combination of random variables). Our assessment methods are as follows:

1. **Sampling error of a population proportion** (e.g., what proportion of households participate in lake recreation?; is a given photo depicting trophic status desirable or undesirable for recreation?)

Let's start with some variable definitions:

N = Population
n = Completed Surveys
p = proportion of surveyed households engaging in recreation (lake, river, hunting, etc.)
a = number answering in the affirmative (e.g., yes, they are a lake user)
Proportion of users estimated as $p = a/n$
Proportion of non-users estimated as $q = 1 - p$

$$s^2 = \frac{pq}{n} \times \frac{N-n}{N-1}$$

where the second term is the finite population correction factor. When *N* is large relative to *n*, this term will approach 1 and can be effectively ignored. Therefore, we can estimate the standard deviation simply as the square root of s^2, or,

$$s = \text{Standard deviation} = \sqrt{\frac{pq}{n}}$$

The standard deviation is inversely proportional to the sample size (*n*); for any sample size, the standard deviation is at a maximum when $p = 0.5$. A 95% confidence interval around an estimate of a proportion is given by $p \pm 1.96 \times s$.

TABLE 2
Sample Size and 95% Confidence Interval, Estimate of Proportion

Sample Size	p=0.25	p=0.5	p=0.75
200	±6.0%	±6.9%	±6.0%
400	±4.5%	±4.9%	±4.5%
600	±3.7%	±4.0%	±3.7%

2. Sampling Error for a Mean (*e.g.*, what is the average number of trips made for lake recreation?)

Again starting with some variable definitions, and ignoring the finite population factor, which will approach one with our very large population relative to the number of completed surveys:

n = Completed Surveys

y_i = number of trips reported by responding household *i*

The mean is defined by summing the trips across all households and dividing by *n*,

$$\bar{y} = \sum_{i=1}^{n} y_i \Big/ n$$

with its associated variance given by,

$$s^2 = \frac{\sum_{i=1}^{n} (y_i - \bar{y})^2}{n-1}$$

The standard deviation is given by the square root of the variance, or *s*. A 95% confidence interval for a mean is then,

$$\bar{y} \pm 1.96 \times s$$

3. Willingness to Pay (WTP) Estimates from Economic Models

Annual WTP for reduction in nutrient loads will be estimated via multinomial logistic modeling for lake users, river users, and waterfowl hunters. The WTP calculation includes both the increased quality of "current" trips, but also the incremental value associated with any changes in recreation visits due to better quality (*i.e.*, some people may choose to visit more often). In addition, econometric models will be used to estimate a household's annual WTP for statewide changes in water quality (the TEV survey). The parameters arising from any of these econometric models are random variables, and any WTP estimate will be a combination of random variables. The 95% confidence interval for such a combination of random variables will be related to the variances and covariances of each variable. For a simple linear relationship,

$$WTP = \beta_1 X_1 + \beta_2 X_2$$

the variance is fairly straightforward to calculate. The beta estimates are the random variables, and the variance of the combination is given by:

$$V(WTP) = X_1^2 V(\beta_1) + X_2^2 V(\beta_2) + 2X_1 X_2 \operatorname{cov}(\beta_1, \beta_2)$$

$V(\beta_j)$ measures the variance of the parameter β_j, while cov(.,.) measures the covariance, estimates of which can be obtained from the variance-covariance matrix of the econometric model.

Unfortunately the annual WTP estimate from the more appropriate non-linear models we are planning to use is not a linear combination of random variables, but is instead a non-linear combination of the following type:

$$WTP = \frac{\beta_1 X_1 + \beta_2 X_2}{\beta_3}$$

It is difficult to find solutions for the variance for even simple non-linear combinations of random variables. Instead, researchers have relied upon the properties of unbiased random samples to approximate a variance (and, hence, a 95% confidence interval) using the *bootstrap* technique. While there are many forms of bootstrapping, we will consider three forms.

a. Bootstrapping the Sample

Assuming the original sample is truly unbiased (or can be corrected using weighting techniques), then that sample is as likely to have been drawn as any other of the myriad possibilities one could have obtained. Each observation in the sample presumably represents other elements in the population, and that all elements are represented in accordance with their true proportion in the population. If so, then the random sample in hand can effectively act as a population, and one can draw an equally random sample from this sample (i.e, "re-sampling from the sample"). The procedure is as follows:

1. Draw a random sample of size *n* (with replacement) from the random sample
2. Estimate the econometric model
3. Estimate the mean WTP for this resample and save the estimate
4. Repeat Steps 1-3 at least 1000 times, saving estimated WTP each time
5. Order the 1000 WTP estimates from smallest to largest. This is called the "empirical distribution of WTP". The 95% CI is given by the bound of the 51st and 949th estimate in the ordered distribution.

b. Simulation (Bootstrapping) from the Variance-Covariance Matrix

As an alternative to bootstrapping from the sample, one can "re-sample" from the variance-covariance (VC) matrix. This is known as simulation or bootstrapping from the VC matrix. For a three parameter model the symmetric variance-covariance matrix appears as:

$$\left. \begin{matrix} V(\beta_1) & \operatorname{cov}(\beta_1, \beta_2) & \operatorname{cov}(\beta_1, \beta_3) \\ \operatorname{cov}(\beta_1, \beta_2) & V(\beta_2) & \operatorname{cov}(\beta_2, \beta_3) \\ \operatorname{cov}(\beta_1, \beta_3) & \operatorname{cov}(\beta_2, \beta_3) & V(\beta_3) \end{matrix} \right)$$

Using a Cholesky decomposition of the variance-covariance matrix, one can obtain what is akin to a matrix of standard errors; the matrix shows the relationship between all variables in the model. We then take a random draw from this matrix (which defines the multivariate distribution of parameter estimates), allowing us to calculate a new value for the random variable β = β + ε, where ε is the random draw. The procedure is as follows:

1. Estimate the baseline economic model, retaining both the parameters β and the variance-covariance matrix.
2. Using the decomposed variance-covariance matrix, perform a random draw and calculate the "new" value for β.
3. Calculate mean WTP for the sample at the new β vector. Save it.
4. Do steps 2-3 at least 1000 times, generating an empirical distribution of 1,000 estimates of mean WTP.
5. Order the WTP estimates from smallest to largest; the 95% CI is given by the interval between the 51st and 949th estimates.

c. The Delta Method

A third approach is called the delta method, and also relies upon the variance covariance matrix to characterize the multivariate distribution of the random variables (parameters) used in calculating WTP. The calculation is relatively straightforward,

$$V(WTP) = \left[\frac{\partial WTP}{\partial \beta'}\right]\left[VC(\beta)\right]\left[\frac{\partial WTP}{\partial \beta}\right],$$

where the first and last terms involve the derivatives of the non-linear WTP function and the middle term is the variance-covariance matrix. The calculation yields a one-by-one matrix, V(WTP), the square root of which is an estimate of the standard deviation. The 95% confidence interval is calculated as the mean plus or minus 1.96 times the standard deviation.

Under any of the three approaches described in this section, we cannot assure a confidence interval of a given size because we do not have a simple solution for the standard error of the distribution of WTP. The greater the precision with which the parameter estimates are estimated the greater the precision of the WTP estimate. Based on team experience in past studies, the confidence intervals around a mean WTP can be as small as ±15% and as large as ±75%. The important point is that although we cannot predict the confidence limits in advance, we will provide confidence intervals around the estimates of mean WTP.

4. Scaling from the Sample to the Population

The TEV and Recreation surveys will be used to estimate annual household economic values (WTP for reduced nutrient load) using non-linear econometric models; 95% confidence intervals for the household WTP will be estimated using the techniques outlined in Section B.3.

Estimating the total WTP for the Utah population from the household level WTP estimates from the TEV Survey is fairly straightforward. We know there are *N* households in the state; we may simply multiply the mean household WTP_{TEV} by *N*. A more conservative estimate assumes that those households choosing not to respond to the survey have a WTP equal to zero. If the response rate is given as *r*, then the adjusted aggregate WTP estimate is given by,

$$Total\ WTP_{TEV} = N \times WTP_{TEV} \times r$$

An alternative to assigning non-respondents with a WTP equal to zero is to replace the sample means with population means for the demographic variables in the estimated WTP equation.

For the Recreation Survey, the procedure is a bit more complicated because we must estimate the total number of households engaging in lake recreation, river recreation or near water recreation. Each of these estimates is a random variable, so that our estimate of total value for all users in the state is, once again, a non-linear combination of random variables. Let p_L be the estimated proportion of households engaged in, say, lake recreation, and let WTP_L be the mean willingness to pay for reduced loads on some subset of lakes in the state.

We will obtain estimates of p_L from both the TEV Survey and the general population sample of the Recreation Survey. Both samples are relatively large and we expect no statistical difference in the estimated proportion across the samples. Recall that the standard deviation of a proportion is given by,

$$\text{Standard deviation} = \sqrt{\frac{pq}{n}}$$

The standard deviation allows us to identify the distribution of p_L from which we will perform random draws for the bootstrapping procedure. We will use bootstrap from both the distribution of p_L and the empirical distribution of the WTP estimate to arrive at an aggregate WTP measure for all lake users (WTP_L) in the state. Following the bootstrap procedure (and assuming that the distributions of p_L and WTP_L are independent) an aggregate value is then given by

$$Total\ \ WTP_L = p_L \times N \times WTP_L$$

where each p_L and WTP_L will be drawn via a bootstrap. We will repeat the bootstrap at least 1,000 times, generating an empirical distribution of the aggregate WTP_L estimate.

A more conservative approach adjusts for sample non-response by assuming that those choosing not to participate in the survey had a WTP value of zero. Letting the response rate be denoted by r, the adjustment in aggregate WTP is given as,

$$Total\ \ WTP_L = (p_L \times N \times WTP_L) \times r$$

A similar approach will be used for river users, near water users (i.e., those who picnic or walk along a river or lakeshore), and waterfowl hunters.

Theoretically, for any given household the following relationship should hold:

$$WTP_{TEV} \geq WTP_L + WTP_R + WTP_N + WTP_H$$

where all measures are annual WTP values and the subscripts *L*, *R*, *N* and *H* refer to lake users, river users, near water users and waterfowl hunters respectively. The inequality should also hold when aggregated to the state level (i.e., *Total WTP*). The difference between the left-hand side of the inequality and the right-hand side should consist of annual household values for non-use benefits of reduced nutrient loads and any reductions in future drinking water treatment costs. Unfortunately, this is another outcome that cannot be guaranteed *a priori*; we simply will need to test for the inequality after the data are collected. Each side of the inequality consists of random variables, and bootstrap techniques will be used to statistically test if the left-hand side is greater than the right-hand side.

D. Measurement Error

Measurement error occurs when a respondent answers a question inaccurately or without precision. Such a response need not be a willful decision on the part of the respondent: a poorly worded question that is misunderstood can lead to an inaccurate answer. The design of the survey instrument must include efforts to assure that measurement error is minimized. That is, does a survey question actually measure the construct of interest, and is the question posed in the survey interpreted by the respondent in the manner intended by the researcher? For example, in our Total Economic Value survey about eutrophication of Utah’s waters we must first explain to survey respondents the source of nutrients, what they do in water, and how eutrophication affects people, plants and wildlife. The cost of a program designed to address nutrient loading must be described, along with the subsequent effects on people, plants and wildlife. The biological processes involved in eutrophication are complex and “uneven”, that is, the effects of nutrient loading of a given magnitude will differ across multiple sites. Crafting a survey instrument that accurately describes such complex processes—doing justice to the science—whilst simultaneously using easy-to-understand text can be very difficult; doing a poor job can lead to measurement error.

An important technique used to minimize measurement error is the focus group. Researchers rely on focus groups to ensure that what *survey respondents think* the question is asking corresponds with what *researchers think* the question is asking. A focus group is a directed discussion amongst a small group of people. Focus groups provide valuable feedback in the design process in that members of the target population are enlisted as active participants in writing survey questions. Although the exact order of focus group activities may vary, in general participants are told the goals of the survey and the target population (which explains why they have been recruited), and then asked to answer draft versions of important survey questions. The subsequent facilitated discussion continues with a participant debriefing: what did participants think the question asked. If the focus group facilitator senses a discrepancy with the researchers' intent of the question, focus group participants are then asked to help rewrite the question.

There is no way to quantitatively assess measurement error introduced by a poorly designed survey question. Therefore, our survey design process will use multiple focus groups for the Total Economic Value and Recreation surveys to identify potential sources of measurement error and mitigate them in advance of conducting the analysis.

Summary

This QAPP specifies protocols for sampling, administering the surveys, and data evaluation and assessment requirements and resultant corrective measures designed to ensure that recreation and household willingness to pay survey data collected for the study are the appropriate quality to achieve the Data Quality Objectives (DQOs) for evaluating the economic benefits of nutrient criteria implementation. It is acknowledged that the confidence limits around the benefit estimates cannot be specified in advance. However, such bounds can and will be estimated as part of the study. The sampling and analysis methods are shown to meet the critical objective of producing results that represent the general population of the state of Utah as well as the population of water-based recreation participants in Utah.

Reference

Dillman, Donald A. 2000. Mail and Internet Surveys: The Tailored Design Method. New York: John Wiley & Sons.

Appendix G
TEV Survey Frequencies

APPENDIX G

Survey Results
Total Economic Value – Utah's Lakes & Rivers Recreation Survey 2011

Introduction

Thank you for taking the time to complete this survey. Your participation in this survey is voluntary. Refusal to participate will have no effect on any benefits to which you are otherwise entitled. This survey should be answered by the adult in your household (age 18 or older) who has most recently had their birthday.

Excess Nutrients in Our Water

Nutrients like nitrogen and phosphorus are necessary for all life to live and grow. Nitrogen and phosphorus are important components of the fertilizers we use to help our lawns and crops grow. When too much nitrogen and phosphorous reach our lakes and rivers, these excess nutrients cause water quality problems.

The following sources contribute to excess nutrients in our water systems throughout the State of Utah:

- Discharge of treated sewage from your home, your neighbors' homes, and businesses statewide
- Water runoff from fertilized lawns
- Leaking septic tanks
- Storm water runoff from urban areas
- Runoff from agricultural fields and waste from animal farms

Excess nutrients pollute our lakes and rivers.

Changes in Water Quality from Excess Nutrients

Excess nutrients result in Poor water quality, the consequences of which are:

I. Increased Algae Blooms - Algae reproduce rapidly, a situation called an algae bloom, which can lead to low levels of oxygen in the water (which adversely affects some fish species such as trout). Some of these blooms are harmless, but some blooms can contain toxins, other harmful chemicals, or pathogens.

II. Changes in Fish Species - Cool or cold water fish species (e.g., trout, walleye, Kokanee salmon) are replaced by other fish species (e.g., carp, green sunfish, channel catfish) that can tolerate low levels of oxygen.

III. Reduced Biodiversity - Fewer plant and animal species are found in the water, and some species that are normally present are missing.

IV. Degraded Aesthetics - The water turns green, limiting the depth to which one might see. The water may also have a strong and unpleasant odor.

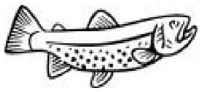
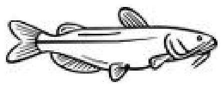
V. Lower Quality Recreation - The quality of swimming, fishing or boating experiences will diminish. On rare occasions, people may experience a skin rash after coming into contact with the water.

VI. Degraded Drinking Water Aesthetics - Increased chance of municipal drinking water having an earthy or musty taste and/or smell, despite being treated to the standards of the Safe Drinking Water Act.

Not all of our water systems have excess nutrients. Some have just the right amount to supply drinking water free of odor and taste issues, support aquatic life, and provide high quality recreation. These systems are classified as having Good water quality as opposed to the Poor water quality conditions described above.

We use the water quality categories - Good, Fair and Poor - to describe the changes in water quality measures that result from the level of nutrients in the water. See the table on Page 3.

Summary Table of Water Quality Measures

	Water Quality Measure		Water Quality Category: POOR	FAIR	GOOD
I	Algae Blooms		Frequent and cover a large area of water	Occasional, brief, and do not cover a large area of water	Rare
II	trout  Cool or cold water fish species		Rare	Less Common	Common
II	catfish  Fish species tolerant of low levels of oxygen		Abundant	Common	Less Common
III	Biodiversity		Low	Medium	High
IV	Aesthetics	Water clarity	Not clear at all	Not very clear	Clear
IV	Aesthetics	Color	Often dark green	Greenish tint	No green
IV	Aesthetics	Unpleasant odor	Strong	Faint	None
V	 Recreation		Limited recreation opportunities, swimming advisories may be posted	Most recreation allowed but with diminished quality	All recreation allowed with high quality
VI	 Drinking water aesthetics		Frequent musty or earthy taste and odor	Occasional musty or earthy taste and odor	No taste or odor issues

Q1. When you think about changes in water quality resulting from excess nutrients, what importance do you personally place on preventing each of the following?

Q1a. Increased frequency of algae blooms

	Frequency	Valid Percent
High Importance	293	50.4%
Moderate Importance	219	37.7%
Low Importance	53	9.1%
No Importance	16	2.8%
Total	581	100.0%
Not Sure	37	
No Answer	10	
Total Missing	47	
Total	628	

Q1b. Reduced abundance of cool/cold water fish (e.g., trout, walleye, Kokanee salmon)

	Frequency	Valid Percent
High Importance	357	60.0%
Moderate Importance	163	27.4%
Low Importance	45	7.6%
No Importance	30	5.0%
Total	595	100.0%
Not Sure	24	
No Answer	9	
Total Missing	33	
Total	628	

Q1c. Increased abundance of fish tolerant of low oxygen (e.g., carp, green sunfish, channel catfish)

	Frequency	Valid Percent
High Importance	244	41.8%
Moderate Importance	187	32.0%
Low Importance	115	19.7%
No Importance	38	6.5%
Total	584	100.0%
Not Sure	33	
No Answer	11	
Total Missing	44	
Total	628	

Q1d. Reduced biodiversity

	Frequency	Valid Percent
High Importance	271	49.2%
Moderate Importance	196	35.6%
Low Importance	71	12.9%
No Importance	13	2.4%
Total	551	100.0%
Not Sure	51	
No Answer	26	
Total Missing	77	
Total	628	

Q1e. Reduced water clarity, changes in color, and increased odor

	Frequency	Valid Percent
High Importance	432	71.5%
Moderate Importance	129	21.4%
Low Importance	32	5.3%
No Importance	11	1.8%
Total	604	100.0%
Not Sure	13	
No Answer	11	
Total Missing	24	
Total	628	

Q1f. Less suitable for recreational uses

	Frequency	Valid Percent
High Importance	298	49.8%
Moderate Importance	203	33.9%
Low Importance	71	11.9%
No Importance	26	4.3%
Total	598	100.0%
Not Sure	16	
No Answer	14	
Total Missing	30	
Total	628	

Q1g. Unfavorable taste and odor of drinking water even after treatment

	Frequency	Valid Percent
High Importance	527	86.3%
Moderate Importance	60	9.8%
Low Importance	17	2.8%
No Importance	7	1.1%
Total	611	100.0%
Not Sure	8	
No Answer	9	
Total Missing	17	
Total	628	

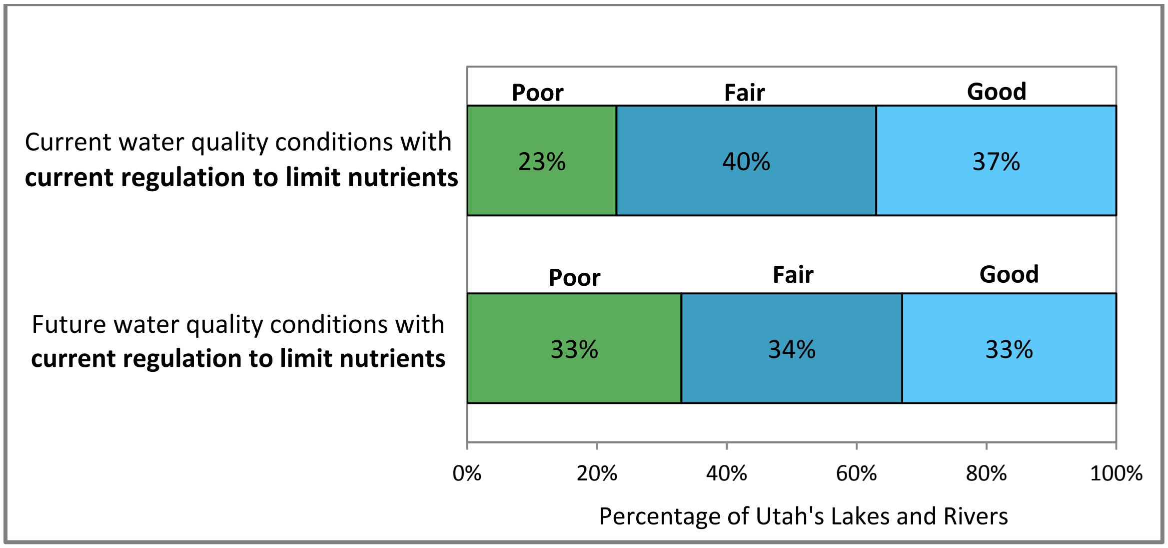
Current and Future Water Quality Conditions

The State of Utah's Division of Water Quality (DWQ) has assessed the current quality of all of Utah's lakes and rivers:

- 23% have excess nutrients resulting in Poor water quality
- 40% have levels of nutrients that result in Fair water quality
- 37% have the optimal amount of nutrients to support aquatic life and recreational uses resulting in Good water quality

DWQ already limits the amount of nutrients reaching our lakes and rivers. Nevertheless, as our population grows, nutrient concentrations will increase and the quality of Utah's lakes and rivers will decrease over time. The projected condition of water quality in Utah's lakes and rivers in 20 years is:

- 33% would have Poor water quality (an increase of 10 percentage points)
- 34% would have Fair water quality (a decrease of 6 percentage points)
- 33% would have Good water quality (a decrease of 4 percentage points)



Q2. When you think about water quality in Utah, what importance do you personally place on each of the following?

Q2a. Improving water quality for fish and wildlife

	Frequency	Valid Percent
High Importance	389	62.9%
Moderate Importance	188	30.4%
Low Importance	34	5.5%
No Importance	7	1.1%
Total	618	100.0%
Not Sure	4	
No Answer	6	
Total Missing	10	
Total	628	

Q2b. Keeping monthly water bills as low as possible

	Frequency	Valid Percent
High Importance	349	56.2%
Moderate Importance	191	30.8%
Low Importance	69	11.1%
No Importance	12	1.9%
Total	621	100.0%
Not Sure	3	
No Answer	4	
Total Missing	7	
Total	628	

Q2c. Maintaining water quality for future generations

	Frequency	Valid Percent
High Importance	521	84.0%
Moderate Importance	80	12.9%
Low Importance	14	2.3%
No Importance	5	0.8%
Total	620	100.0%
Not Sure	2	
No Answer	6	
Total Missing	8	
Total	628	

Q2d. Imposing water cleanup costs on industry

	Frequency	Valid Percent
High Importance	383	63.4%
Moderate Importance	168	27.8%
Low Importance	37	6.1%
No Importance	16	2.6%
Total	604	100.0%
Not Sure	18	
No Answer	6	
Total Missing	24	
Total	628	

Q2e. Improving water quality in lakes and rivers used primarily for recreation

	Frequency	Valid Percent
High Importance	292	47.2%
Moderate Importance	249	40.2%
Low Importance	64	10.3%
No Importance	14	2.3%
Total	619	100.0%
Not Sure	4	
No Answer	5	
Total Missing	9	
Total	628	

Q2f. Maintaining good water quality in lakes and rivers so I can visit in the future

	Frequency	Valid Percent
High Importance	372	60.1%
Moderate Importance	193	31.2%
Low Importance	45	7.3%
No Importance	9	1.5%
Total	619	100.0%
Not Sure	4	
No Answer	5	
Total Missing	9	
Total	628	

Q2g. Improving water quality in all lakes and rivers even those not frequently used by people

	Frequency	Valid Percent
High Importance	322	52.1%
Moderate Importance	202	32.7%
Low Importance	79	12.8%
No Importance	15	2.4%
Total	618	100.0%
Not Sure	6	
No Answer	4	
Total Missing	10	
Total	628	

Nutrient Reduction Program to Improve Water Quality

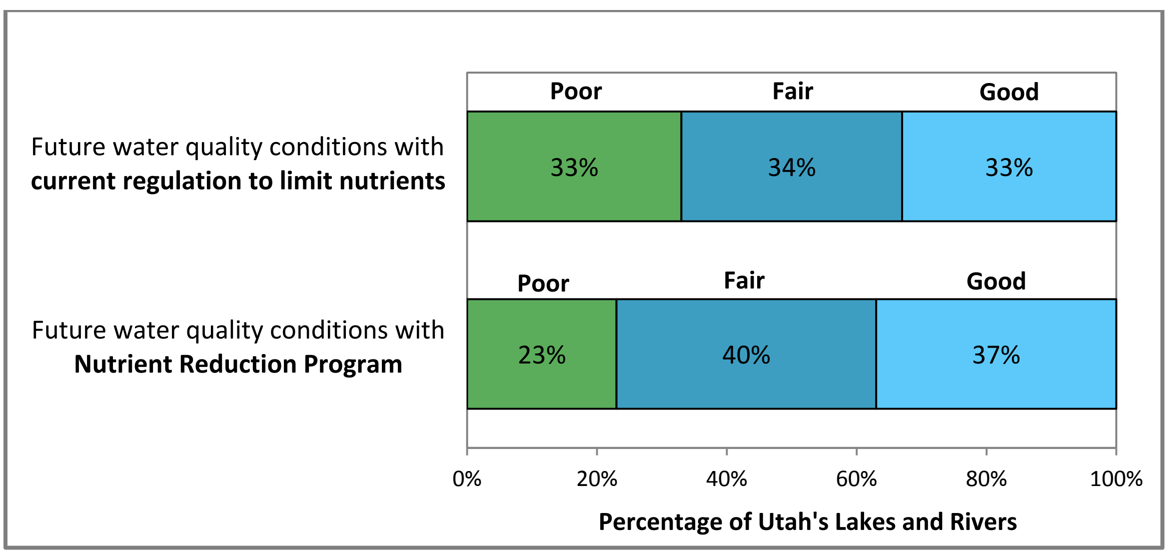
DWQ is considering a new program that will further limit the amount of nutrients that reach lakes and rivers, improving water quality over time.

If a majority of people favor the new program it will be paid for by increasing the amount each household and business will pay for their monthly water and sewer bill. If you do not currently receive a water and sewer bill (e.g., you rent your home or your house is on a septic system) you will receive a separate monthly bill for this program. The funds collected will be used to implement and enforce the Nutrient Reduction Program.

The Nutrient Reduction Program will require:

- Upgrades in wastewater treatment plants for treating sewage from your home, your neighbors' homes, and businesses statewide
- Programs to encourage proper application of lawn fertilizers and maintenance of septic systems
- Structures to control storm water runoff from streets, parking lots, and roof-tops
- Improvements to agricultural nutrient management practices

The Nutrient Reduction Program will reduce the percent of waters in the Poor category from 33% down to 23% and increase the percent of waters in Good condition from 33% to 37%. Implementation of the program would start next year and be phased in over 20 years. In some cases, complete clean up may take longer than 20 years.



The costs of the program will be shared between households, businesses, and industry in proportion to their share of total nutrient discharges. Based on these proportions, the share of the cost for each Utah household will be an additional per month.

Q3. Which one of the following two options regarding your household's monthly water and sewer bill would you choose? Please do NOT consider what other people could or could not afford.

	Frequency	Valid Percent
Under the current regulations to limit nutrients ($0 increase)	309	50.0%
Under the Nutrient Reduction Program ($x increase)	309	50.0%
Total	618	100.0%
No Answer	10	
Total Missing	10	
Total	628	

Dollar Value ($)	Under the current regulations to limit nutrients ($0 increase)	Under the Nutrient Reduction Program ($x increase)	Total
$2	17	52	69
	24.6%	75.4%	100.0%
$5	15	44	59
	25.4%	74.6%	100.0%
$7	28	32	60
	46.7%	53.3%	100.0%
$10	34	33	67
	50.7%	49.3%	100.0%
$12	27	31	58
	46.6%	53.4%	100.0%
$15	34	27	61
	55.7%	44.3%	100.0%
$20	28	29	57
	49.1%	50.9%	100.0%
$30	33	22	55
	60.0%	40.0%	100.0%
$40	53	23	76
	69.7%	30.3%	100.0%
$50	40	16	56
	71.4%	28.6%	100.0%
Total	309	309	618

Q4. How sure are you of this answer?

	Frequency	Valid Percent
1 (not sure at all)	15	2.4%
2	4	0.6%
3	17	2.8%
4	19	3.1%
5 (somewhat)	106	17.2%
6	44	7.1%
7	104	16.9%
8	71	11.5%
9 (certain)	236	38.3%
Total	616	100.0%
No Answer	12	
Total Missing	12	
Total	628	

Q5. In general, would you say the Nutrient Reduction program is ...?

	Frequency	Valid Percent
Not a good use of my money	158	27.4%
A good use of my money	419	72.6%
Total	577	100.0%
No Answer	51	
Total Missing	51	
Total	628	

Q6. To help us better understand your answer to Question 3 on the Page 5 please indicate the SINGLE most important reason for your response.

	Frequency	Valid Percent
I cannot afford to pay this amount each month	136	23.3%
The Nutrient Reduction Program is not realistic or is unclear	91	15.6%
I don’t contribute to this problem and I shouldn’t have to pay	32	5.5%
Everyone needs to share in the cost of the Nutrient Reduction, even me	161	27.6%
I believe Utah’s lakes and rivers should be protected no matter the cost	61	10.4%
No one should have the right to damage Utah’s lakes and rivers in the first place	103	17.6%
Total	584	100.0%
No Answer	44	
Total Missing	44	
Total	628	

Visits to Lakes and Rivers in Utah

Q7. In the last 12 months, how many total trips have you and members of your household taken to lakes in Utah?

➔ *If you answered ZERO to Question 7, do not answer Question 9a.*

Q8. In the last 12 months, how many total trips have you and members of your household taken to rivers in Utah?

➔ *If you answered ZERO to Question 8, do not answer Question 9b.*

Q9a. Which ONE activity do you and members of your household spend the most time doing while visiting LAKES?

	Frequency	Valid Percent
Fishing-cold water fishery	99	27.7%
Fishing-warm water fishery	6	1.7%
Boating (e.g. motor-boating, house boating, sailing, canoeing, kayaking, water-skiing, tubing or jet skiing)	77	21.5%
Swimming (e.g., playing in the water, wading or windsurfing)	45	12.6%
Near-shore activities (e.g., playing in the water, wading or windsurfing)	126	35.2%
Hunting	5	1.4%
Total	358	100.0%
No Answer	51	
System Missing	219	
Total Missing	270	
Total	628	

Q9b. Which ONE activity do you and members of your household spend the most time doing while visiting RIVERS?

	Frequency	Valid Percent
Fishing-cold water fishery	107	31.3%
Fishing-warm water fishery	5	1.5%
Boating (e.g. motor-boating, house boating, sailing, canoeing, kayaking, water-skiing, tubing or jet skiing)	15	4.4%
Swimming (e.g., playing in the water, wading or windsurfing)	24	7.0%
Near-shore activities (e.g., playing in the water, wading or windsurfing)	183	53.5%
Hunting	8	2.3%
Total	342	100.0%
No Answer	35	
System Missing	251	
Total Missing	286	
Total	628	

Opinions of Water Quality

Q10. Please review the photos of algae in rivers on both sides of the one-page insert included in this survey. For each photograph on the insert tell us if the level of algae would be desirable or undesirable for YOUR most common uses of rivers, if any. There are no correct answers; this is your opinion only. *Fill in one bubble for each number.*

Q10. Photograph 1

	Frequency	Valid Percent
Desirable	565	96.6%
Undesirable	20	3.4%
Total	585	100.0%
No Answer	43	
Total Missing	43	
Total	628	

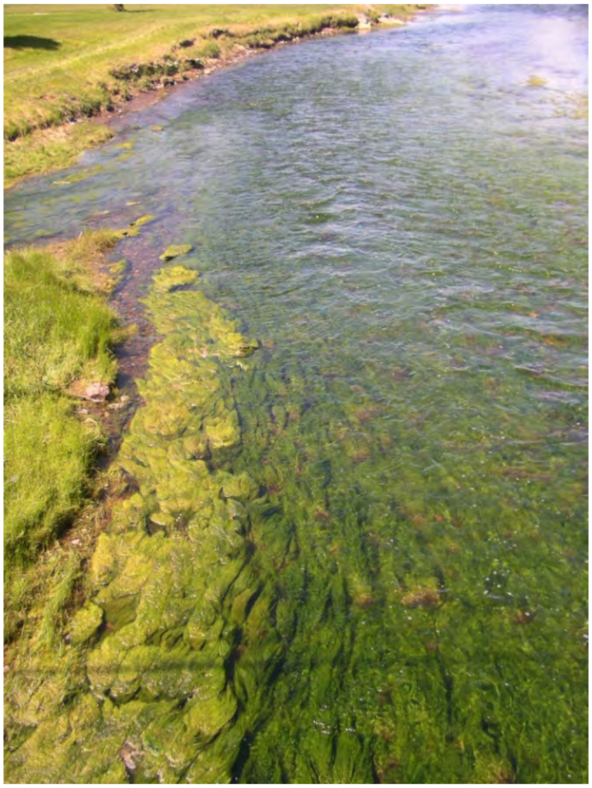
Q10. Photograph 2

	Frequency	Valid Percent
Desirable	177	30.6%
Undesirable	401	69.4%
Total	578	100.0%
No Answer	50	
Total Missing	50	
Total	628	

Q10. Photograph 3

	Frequency	Valid Percent
Desirable	84	14.7%
Undesirable	488	85.3%
Total	572	100.0%
No Answer	56	
Total Missing	56	
Total	628	

10. Photograph 4



	Frequency	Valid Percent
Desirable	48	8.3%
Undesirable	530	91.7%
Total	578	100.0%
No Answer	50	
Total Missing	50	
Total	628	

Q10. Photograph 5

	Frequency	Valid Percent
Desirable	97	16.8%
Undesirable	479	83.2%
Total	576	100.0%
No Answer	52	
Total Missing	52	
Total	628	

Q10. Photograph 6

	Frequency	Valid Percent
Desirable	343	59.4%
Undesirable	234	40.6%
Total	577	100.0%
No Answer	51	
Total Missing	51	
Total	628	

Q10. Photograph 7

	Frequency	Valid Percent
Desirable	539	92.8%
Undesirable	42	7.2%
Total	581	100.0%
No Answer	47	
Total Missing	47	
Total	628	

Q10. Photograph 8

	Frequency	Valid Percent
Desirable	82	14.1%
Undesirable	498	85.9%
Total	580	100.0%
No Answer	48	
Total Missing	48	
Total	628	

Demographics

Q11. Are you male or female?

	Frequency	Valid Percent
Male	358	58.0%
Female	259	42.0%
Total	617	100.0%
No Answer	11	
Total Missing	11	
Total	628	

Q12. In what year were you born?

	Frequency	Valid Percent
18 - 24 years	30	4.9%
25 - 34 years	96	15.7%
35 - 44 years	99	16.2%
45 - 54 years	105	17.2%
55 - 64 years	134	21.9%
65 or older	148	24.2%
Total	612	100.0%
No Answer	16	
Total Missing	16	
Total	628	

Q13. Do you pay a water and sewer bill?

	Frequency	Valid Percent
Yes	531	87.0%
No	79	13.0%
Total	610	100.0%
No Answer	18	
Total Missing	18	
Total	628	

➔ *If 'No', skip to question 14.*

Q13a. On average, how much do you pay a month for your water and sewer bill? Round to the *nearest dollar.*

Q14. What is the highest level of school you have completed?

	Frequency	Valid Percent
Some high school	18	2.9%
High school graduate or GED	77	12.5%
Some college or technical school	195	31.6%
Undergraduate degree	139	22.5%
Some graduate school	35	5.7%
Graduate degree	154	24.9%
Total	618	100.0%
No Answer	10	
Total Missing	10	
Total	628	

Q15. Do you belong to any local, state or national organization whose main purpose is to protect the environment?

	Frequency	Valid Percent
Yes	70	11.3%
No	549	88.7%
Total	619	100.0%
No Answer	9	
Total Missing	9	
Total	628	

Q16. Including yourself, how many adults, age 18 or older, currently live in your household?

	Frequency	Valid Percent
1	117	18.9%
2	360	58.1%
3	94	15.2%
4	41	6.6%
5	6	1.0%
6	2	0.3%
Total	620	100.0%
No Answer	8	
Total Missing	8	
Total	628	

Q17. How many children, age 17 or younger, currently live in your household?

	Frequency	Valid Percent
0	385	62.5%
1	87	14.1%
2	71	11.5%
3	42	6.8%
4	16	2.6%
5	10	1.6%
6	1	0.2%
7	3	0.5%
9	1	0.2%
Total	616	100.0%
No Answer	12	
Total Missing	12	
Total	628	

Q18. Are you of Hispanic, Latino, or Spanish origin?

	Frequency	Valid Percent
Yes	22	3.6%
No	581	96.4%
Total	603	100.0%
No Answer	25	
Total Missing	25	
Total	628	

Q19. Here is a list of racial categories. Please select one or more to describe your race. *(Mark all that apply.)*

	Frequency	Valid Percent*
White	582	94.8%
Black or African American	6	1.0%
American Indian or Alaska Native	14	2.3%
Native Hawaiian or other Pacific Islander	4	0.7%
Asian	12	2.0%
Some other race	18	2.9%
Total	614	100.0%
No Answer	14	
Total Missing	14	
Total	628	

*Percentages for 'Mark all that apply' may total greater than 100%.

Q20. Next we'd like to ask about your household income. Your answer will only be used for comparing groups of people. Which of the following income groups best describes your household's total income in 2010, before taxes?

	Frequency	Valid Percent
Less than $25,000	92	15.4%
$25,000 up to $50,000	152	25.4%
$50,000 up to $75,000	147	24.5%
$75,000 up to $100,000	102	17.0%
$100,000 up to $150,000	70	11.7%
$150,000 up to $200,000	20	3.3%
$200,000 or more	16	2.7%
Total	599	100.0%
No Answer	29	
Total Missing	29	
Total	628	

Thank you for participating in this survey. If you have comments on the survey or water quality in Utah, please use the space below.

- $20 a month seems to be a lot of money, perhaps you could start the most important parts of the program with a smaller amount of money (i.e. $20 a year) and work on cutting the costs of the program. I am sure you could find some volunteers (people like me) who would be more willing to share our time and skill more than our money. Which I think would pay bigger dividends in the long run because of the individual ownership of the populous.

- $40 per household is a lot of money. I would like more information on the proposed project, along with estimates of cost and percent of importance or improvement in the plan.
- $50 a month is too high for household water bill increase. The program is worthwhile, but perhaps the goals are too aggressive and if reduced would result in better support and affordability.
- $50 a month is way out there; $5 a month would be more affordable. I feel some of the ideas would be good and others I wouldn't like to support. I'm a single mom of five kids on $2000 a month; $50 isn't in my budget.
- 5, 10, 15 dollar a month increases continually added to one's monthly utilities bill, in additional to other cost increases, make it hard on a fixed income person. I don't make politician wages. I am not in favor for any increase in any amount. Taxes and costs are too high as it is. I'm ready to revolt against all the increased taxation! It just keeps coming regardless, doesn't it? Thanks for letting my vent my frustration and for your time and effort.
- A $12 per month increase is a pretty significant increase. My water and sewer bill has been increased just recently and will face additional scheduled increases over the next 3-5 years. $12 additional dollars per month is too much for most people, particularly where we don't have a lot of information regarding where the problems exist, who the major contributors are to the problem, how effective will the program be, etc.
- A bit difficult to determine if the pictures show algae or colored rocks; algae in cold streams is less offensive than algae in stagnant ponds or streams.
- Adding Adya Clarity to our waterways like they do in Japan would clear them up naturally and create pure, healthy water in Utah.
- Although I am against paying an additional $360 per year for something I already thought I was paying for, I fully suspect there are enough ways for you to slant my answers to be able to do what you plan on doing anyway. And that is to continue to take large amounts of money and mismanage both the money and the water. This should not be a "for profit" business, but rather a public service.
- An educational program, or take from Project Wild to offer to students would be most understandable. If our kids need to learn about burning the tropical forest, how much more productive for them to learn how to protect their own recreational water and water supply. I enjoyed filling this out; thank you.
- Appropriate funds should be pulled from existing monthly charges, <u>not</u> in addition to! It's easy to solve the problem with money overall when in fact it could be managed better. Educating the public about fertilizer and preservation will help. How often to fertilize, amounts, etc. can help people with this issue. I love Utah and its waterways. Thank you for helping to make this state beautiful.
- As far as chemical run-off from lawns, it would be great if more city ordinances allowed for xeriscaping instead of requiring grass.
- As is known, lower water is worse than the upper water. Why can't we put in upper water dams with hydroelectric power to offset the cost of water treatment?
- Audits of extra money spent on the Nutrient Reduction Program need to be accessible to the public so we'll know the extra money is actually going toward the program and not some government official's salary who sits and plays Farmville all day long during work hours. The public who supports this program needs to be incentivized for shelling out our hard-earned dough (i.e. free FISHING LICENSES!)
- Awareness is good and this problem clearly needs to be addressed. But not everyone can afford an extra $10 a month. Industry should have to pay a bigger percentage to clean up the mess, especially since they are a larger contributor to the problem.

- Because my landlord pays for water/sewer, I'm not concerned about the increase but I ultimately believe the party(s) responsible for destroying the water quality should be the party(s) responsible for cleaning it up; but then they would end up raising their prices ultimately affecting the consumer, so better $7 increase than possibly more.
- Cancel the whole darn thing to reduce our national debt.
- Cut the wasteful spending and get this done without increases by using the same kind of ingenuity found in private business. Fire poor performing employees more quickly and pay more to top performers. Make things more competitive and you'll find a way to get this done without increases.
- Did changing our dishwater detergents really help? It frustrates me so much that my glasses are no longer clean. We're going overboard in some ways. What does that measure compared to agricultural run-off?
- Don't understand much of this survey.
- Drinking water is a major concern of mine. I live in Magna and am told the water is perfectly safe to drink. It tastes funny and smells bad. I think there should be stricter laws concerning the quality of water of households and businesses.
- For what cause of this survey brings our city to perform? Will we get informed if this procedure overrides to an approach for the help of our own finances? Or is this survey, a majority rules kind of act, to help the city earn more finances for a different use of our money; that we're not aware of?
- Good job! Keep it up.
- Good luck on this one folks. Most Utahans seem to have an attitude of survival of the fittest and every man for himself. I am disabled and care for a mother who is on hospice. Money is tight. Water is a crucial element that everyone needs for survival, not just for ourselves but for the future generations to come. This is an important issue. Unfortunately the conservative fiscal response to everything is don't budget money for anything. Perhaps partners in power, like say the Mormon Church, might find it a wise thing to support maintaining this state in the condition in which they found it. It's only fair. Utah Lake used to abound with trout and clear water. Yikes, look at it now! Shame on us. What a legacy to pass on. Thanks for your efforts.
- How about educating people more about the problem and how they can help prevent it, rather than spending tons of money on cleanup that would be ongoing? $40 a month is ridiculously high. Use your brains and come up with better solutions. This is a down economy. People can't afford it.
- I agree we should pay for good quality water, but $30 per month is a steep increase just for this program. Maybe only table a couple of objectives at a time.
- I agree with protecting the water quality and improving it. And while $10 a month isn't much to pay for improved water quality, I don't think this survey does much to describe the program and provide assurances that the money will be wisely used. So I'm agreeing to contribute, but with reservations.
- I am 80 years old. I have never fished and have not visited your lakes. I'm from Southern California.
- I am a bit suspicious of the $30 per month flat rate fee. It seems more fair to use a graduated scale based on water usage and industrial usage. Also, there is no other option in either supporting the $30 fee or not. Seems like a $10 option would be more feasible. However, I elected to support the $30 fee because the alternative of <u>NOT</u> further protecting out water was unsatisfactory.
- I am concerned about the amount of the increase. $50 a month is a $600 yearly increase; that's a lot. Can it be implemented more slowly or businesses share more of the load?
- I am currently unemployed and have been more than a year. The expense would be difficult, but I see its value and importance.

- I am especially concerned with the water quality of Bear Lake remaining high since there is so much new construction and so many more people using it.
- I am grateful for the quality of water I receive in my household. I would like to see our lakes and rivers be rid of a big buildup of algae, etc. I am concerned about insurgents or undesirables destroying our waterways. Maybe more security in strategic places throughout the state of Utah.
- I am suspicious of government programs with good intentions but poor results. I want the results, but I fear added expense with no visible improvement in water quality. Utah's state government can't even spell conservation or wildlife management. Our resources are currently being managed (or pillaged) for income rather than for quality and preservation.
- I am unaware of fees/taxes charged to motor boating enthusiasts, but I don't enjoy petro-film left on lakes either. I would also like to see a mandatory cleaning of boats before moving from one lake to another; something to prevent the transfer of undesirable organisms.
- I appreciate the quality of water in the state, you do a great job. My bigger concern is with water waste; too many businesses and government entities do not control their sprinkler systems and have wrong landscapes for our area. Thanks.
- I believe US citizens do not pay enough for water OR gasoline (another story). Water should be protected and conserved but I am SKEPTICAL of the governments or Universities' bureaucratic attempts at doing this, particularly with unlimited TAX funds. Perhaps partnering with or subcontracting Sierra Club, Nature Conservancy, National Wildlife Defense, or a similar organization with a track record of results would be comforting/reassuring to tax payers.
- I believe water quality in Utah will continue to deteriorate no matter what we do. Millions more people plus increased industry (oil, gas, coal, other minerals, and factory farms) will doom us to a decreased quality of life in the future.
- I care but think whoever is responsible for the excess nutrients should fix it. If it is too general to pinpoint due to a variety of factors, admission to use these resources should be considered. Big companies should fix this.
- I care very much about the well-being of the water quality. I have tasted water in other parts of the USA and I have realized the valuable resource of quality water. I support efforts and research to prevent poor water and habitats. Thanks for all you are doing.
- I do appreciate good water quality for humans and animals, but being single with one income, I can't afford higher than I am paying now. I think single/multiple incomes per household/apartment, etc. need to be included in decisions.
- I do believe the waters of our lakes and rivers need protection. But I do not believe the state government can solve it all, and not at expense of economic regulation. Do not put people out of work for these regulations.
- I do feel that improving our water quality is very important, however, as a lower, middle class citizen (as much of our population is) $40 a month is more than I can afford, especially to not see results for 20 years.
- I do feel that these issues are important. I simply could not afford another $50 payment right now. Give me a year or two and several of my answers would be different.
- I do not know anything about the questions on this questionnaire; so I am sorry and thank you.
- I do want to conserve our natural resources and the quality of our waters and drinking water. I would like to see the increase in our GOOD waters more toward 60% or higher and those in the FAIR category more toward the 20% mark; lower for this category and the poor water quality if possible. I would also like to contribute and do my part toward this cause, more toward $30 monthly would be better for me. Because of current and the recent past (last few years) economic conditions, many people and businesses increase their prices. Even

food stores increase the costs to the consumer and lower the quantity of the food products. Costs increase everywhere, it seems, and my income does not.

- I don’t know why you want my opinion when it comes to city or state problems; they usually do what they want regardless of how we feel. But I gave mine anyway. Have a good day and God bless you in your efforts to help us and the life in our lakes and rivers.
- I don’t really have a complaint, but I do think that the manufacturing industry that contributes to most of the water quality issues should pay for the lion’s share.
- I don’t support the idea of increased costs without a clear plan. It appears most of the plan is to target industry, when general public may be as much, if not more, of a contributor.
- I don’t want to improve the water quality by eliminating or restricting access to Utah waterways!
- I feel like adding $20 to everyone’s bill is really going to add up. Do we really need to that much? I think there needs to be a set plan and breakdown of costs. That way we could see what the money would be going to exactly. Also, how long would we be paying the extra $20?
- I feel like our environment is important, but I just can’t afford $40 a month extra. I’ll be going to college soon and I just can’t afford it. If there is a way we can be educated on ways to reduce excess nutrient runoff I would be willing to make lifestyle changes, but $40 a month I just can’t do.
- I feel that this is an important program. Keep up the good work. We cannot improve unless everyone helps out; but that will take time, money, and a more environmentally conscious generation. We MUST start somewhere!
- I get sick when I see how dark, murky, and dirty our rivers and lakes are. However, my husband has been laid off and we are on a limited budget. It’s about time cities, counties, and state and federal governments limit their budgets.
- I have lived in Utah my entire life and a big part of that life is the boating, fishing, swimming, and camping I do here. Utah has some of the best water in the U.S. and I think it should be protected. I only hope to see more steps clean and protect these natural assets.
- I have physical and mental problems which make it impossible for me to fish or hunt anymore, but I think keeping our waters and lands clean is really important.
- I have very limited income, but I feel that those who are responsible should pay the majority of the cost to improve our water resources. Industry, businesses that contribute to problems, also paid fertilizer companies to apply, should be held to regulations to prevent pollution.
- I haven’t lived in this household long enough to answer 13a.
- I like water, but the program doubles my water bill, which means it is expensive to a silly degree.
- I live by the Jordan river in Rose Park, if this program could clean up THAT river, I would be mighty happy.
- I lived on Lake Washington near Seattle when the lake went in bloom from excessive nitrates and septic tank leakage. Visibility was less than one foot. When shoreline sewers and lift stations were installed, the lake water cleared in about three to four years.
- I pay $50 a month for sewer and don’t have water (private well water). I feel like the state of Utah is trying to sell me something.
- I really can’t answer these questions when I don’t have full understanding of what this is all about. I would have to do a lot more research on it. Yes, I want clean water but on the other hand what would it cost to do some of these things?

- I spent the majority of my life in Washington and Idaho; the use of reservoirs is new to me but your use and monitoring of water quality is impressive.
- I support a program that can be well run and maintained keeping costs low. I think $40 per month is steep and not something that would make it past legislation. $10 to $20 would be pushing it but I use and enjoy water enough to pay.
- I support an increase to protect lakes, streams and rivers, but $50 a month is too much at this time.
- I support anything to improve water quality. For fishing for all types of fish and recreation things. And most of all, good drinking water now and years to come.
- I think businesses and industries should pay according to not only volume, but type of waste being discarded. Maybe those businesses with greater interest (i.e. jet ski shops, boat shops, sports places) might help more than average.
- I think is important but the cost seems a bit high for the small improvements (less than 20% in examples provided) if this cost was less than $10, say more like $5, I would be more willing to pay even though I rarely use our lakes and rivers.
- I think it is a great program and will benefit all. But those with fixed income or loss of wages and employment will not be able to come up with an extra $12 per month; when things are already so tight.
- I think it is great that you want to improve water quality. However, you are crazy to think that people want to pay that much each month. It is an outrageous amount to charge $30 more a month. In the real world, people can't afford that kind of extra bill with everything else we have to pay for. Most people's wages haven't gone up and you want to add more to tight budgets. Not everyone uses water from lakes and rivers for drinking or recreation. Some areas have things called springs for drinking water and some people very rarely, if ever, go to lakes and rivers. You need to come up with a better way to fund your program. Why not charge a little more for boat registration or try asking for donations. Maybe give a fundraiser a try. Stop taking the easy way out by trying to force everyone to pay.
- I think it might be a good idea, but I already lose $1,000 in taxes every pay check. The government has plenty of money to pay for it, if we cut how big of a pay check they made.
- I think it would be effective to put the photo ranking before the other questions so raters have the images in mind before filling out the rest of the survey.
- I think that this is a good program for the environment and for us to protect our drinking water, but $15 per month is a little high. I wish that you could do it, but for a lower cost.
- I think the major polluters should be heavily fined, including dairy, pork, and crop farmers for chemical runoff and more stringent laws need to be enacted to help prevent chemical and genetic crop engineering corporations from screwing up organic producers. More federal funding for sewage treatment facilities. Pesticides and fumigants need to be banned and more funding to promote organic methods of production farming needs to be done.
- I think there should be more incentives to use less water. No penalty for using more but maybe a tax incentive for using less water. You could even base it on members of a household, divide water used by person, figure a rate that way.
- I think this is an excuse for more taxes. Government agencies need to use what they have; get rid of all unnecessary upper management. Less government. Use what you have; revisit your priorities. How much did this survey cost us? Can't you figure out the algae problem?? That is your job.
- I think this survey is a waste of my tax dollars.

- I think water quality needs to be understood by everyone, but I think the disbursement of state and federal funds could be better spent to help alleviate the public. Also, people and/or companies should be fined and have to participate in the cleanup process. This affects all of us in a lot of ways.
- I truly can't afford $40 a month more. Find a cheaper way and I'm okay.
- I used to live in a house and water was the expensive bill I had to pay, and expecting extra charged is not something I would like, but now if the quality of water can be improved and keep a good water if there are going to be a long project to keep my family safety. I believe we all can help, even if it is extra money to pay. Thank you for giving me the opportunity to learn and participate in your survey.
- I was surprised to learn that fertilizing lawns contributes to poor water quality.
- I would be supportive of a program to help keep Utah's water systems in a good water quality category, but feel that $15 per household PER MONTH is an extremely excessive amount to pay.
- I would be willing to pay $10 a month to the program but think that doubling what I pay is a bit excessive. I am single, I use very little in fertilizers in my yard, and I have replanted my yard with a low water landscape. I already have done all I can to reduce my impact on the environment and the water system and think that should be rewarded instead of penalized by another tax/fee.
- I would like an increased effort to take care of the phragmite problem.
- I would like more information on how the cleanup process takes place; like how do you clean it up? Where do you put the excess algae?
- I would like more information on how this program will achieve these results before agreeing to increased fees.
- I would like to know more about the Nutrient Reduction Program and how the percent water quality of 33% to 5% was determined.
- I would like to see more of a crack-down on people abusing water (i.e. watering too much, washing sidewalks and driveways, watering during 10 AM-6 PM, etc.) I would also like to see more public education on the fact that this is a desert.
- I would need to know exactly where the $5 a month is spent and what the cost of administration is before endorsing the increase.
- I would support a $3.00 per month increase ($12 per month is too much).
- I would support additional legislation to reduce lawn fertilizing and watering which is inappropriate in an arid environment. I assume agricultural chemicals are a big contributor to this problem. I support additional legislation in this area. Based on factors such as water scarcity, desert climate, temperature extremes, elevation, and short growing season, Utah is not that suitable for agriculture on a long-term, substantial basis.
- Ideally I think making more strict regulations would be beneficial, but the cost per month increase is too much to make it affordable.
- If some industries are polluting our water then they should pay for cleaning up the mess are making. (I made a few notes concerning several questions on your survey. Question number one could be misunderstood by some people.)
- If the states need money to pay for the cleanup of our water supply, why not charge Monsanto, DuPont, etc. (the makers of the polluting products) and maybe THEY could make them more environmentally friendly. Why must the citizen pay for everything?
- If this were to take effect, when would the bills start to increase?
- In a strong economy I'd be happy to pay increased costs. Times are tough. Not a good time to increase fees.

- In God we trust.
- In my opinion, motorized vehicles should be banned from ALL parks, rivers, and most trails. Thank you.
- In my opinion, my opinion doesn't matter! The so-called educated world will do what they want any way. They say the ground is losing nutrients; so our food has less, and now our water has too much!
- In my opinion, this survey is a waste of my tax dollar. Water quality shouldn't be an issue, water sustains live, we should take care of it at any cost and people using the waterways should be smart enough to clean up after themselves, if not, don't use them; and the government employees we pay should be more willing to clean things up instead of just riding around in our trucks that we as tax payers supply. Our government needs to clean up their own messes and quit wasting our tax dollars!
- Increasing money for water, I believe, will help people understand how important it is to be responsible with water. If we have to pay more for things we use, indifference to such things like water quality will quickly change.
- It appears that for an additional $7 per month for every household, business, and industry that only the status quo can be maintained. In my mind that is unacceptable and makes the excess nutrients program a poor program. Money is well spent only if the status quo can be approved upon. Question: Why are we returning this to Wyoming instead of a Utah location?
- It just seemed like a lot of money, millions of dollars, to only go up 4% into the good category and only 10% to fair.
- It would be helpful if there was a more detailed description of what EXACTLY the nutrient reduction program entails.
- It would help to be a little more clear on what this program involves.
- Let's ban NPK chemical fertilizers and lawns. Get people to switch to organic gardening. Let's crack down on pig, chicken, and other corporate animal farms that dump their waste into the environment without treating it or composting it.
- Let's be real, this could have been put together better. Too much information given before each question, etc.
- Life everywhere is dependent on water, and quality of life everywhere is dependent on water quality. There is no cost too high to maintain high water quality in the lakes and rivers of Utah, the second most arid state in the U.S.!
- Major blooms are caused by farming and ranching. Plus tons from industry. This is who should finance the project. Also, these companies that apply fertilizer to lawns and shrubs should also pay. They are the worst. Someone needs to regulate and severely fine these so-called lawn care experts. Me paying an extra two bucks a month to make sure my poop is nitrogen free is nothing compared to what the big picture is. It's not fair that the regular Joe pays for the big guys to pollute.
- Make the #1 polluters pay for the cleanup; even if this is means to make the farmers pay for higher costs.
- Make water pollution fines higher rather than penalize everyone else.
- Most government program waste money top heavy with management and spend the least amount possible to actually help the water system. It would be nice to have honest programs and people who truly cared about help and not just increasing taxes.
- Most people want to have good water, but to add another tax on to our already high tax is not the way to do it. Use more wisely what you get now.
- My comment on this survey is that it is very relevant to maintain the water quality of drinking, as well as lakes and rivers. But my question is can't they city themselves donate $5 to this project. If it needs to be, I would be willing to pay $5.

- My general perception is that Utah's lakes and rivers are clean with the exception of Utah Lake. $10 per month feels like a high cost to improve water quality only marginally in my opinion.
- My only concern with the twelve extra dollars is that although I know the importance of maintaining good quality water, I also know that my water bill is getting bigger just as well as the cost of living.
- My water bill is included in my Condo Home Owner Association dues.
- Need to change laws that don't allow any access to our rivers. Why should we try to clean them up when people claim that they own the property and won't allow us to use or fish on the property? In my mind they don't the water way. Let them pay to clean up the rivers or change the law!
- Nice push poll!
- No fluoride please.
- Not all water quality can be blamed on industry to clean up the water.
- Not sure I understood the photos that well. Nutrient reduction program consider effects on farms and production of food, i.e. expense and "controls" by government! Handle locally and state.
- One of things I like about visiting northern California is the clean rivers and lakes. It would be worth the time and energy to get our lakes and rivers up to that standard.
- Oppose natural gas "fracking". Oppose Vegas pumping Skull Valley aquifer.
- Page 4 question 2d; industry is not the only source of excess nutrients. The source generators of the excess nutrients should pay. Page 5 questions 3 and 4; the sewage system in my area discharges nowhere. There are no lakes, streams, or rivers in this area.
- Plant more fish! Strawberry has few fish. Our fishfinders show low, low numbers. You have a lot more people than you need. They collect fees, drive new trucks; a lot of my friends are mad as hell at you. You plant fish and the birds are right there eating them. Get out lakes full or fish and we will be happy. Your survey sucks. Put the topic word and ask how we rate it. Make it simpler. How can you take a one page survey and make it an eight page survey and one page for pictures is a great lesson on WASTE!
- Please preserve/protect stream and lake shorelines from thoughtless land owners. Please preserve common access to lakes and stream beds as a common resource for the common people. Increase Utah tourism by improved lake and stream access for fishing. Restore native fish species and natural fish population size profiles. More common rights and less private (land owner) rights for trespass, giving more people a vested interest in lake and stream quality.
- Prior to the past 12 months we have visited lakes and rivers more frequently!
- River access is a problem as well. If we pay to improve water quality we should be able to access public rivers. No owns the water. I am all for preserving our natural resources.
- Riverton water is slimy. Good thing I don't live in West Jordan.
- Sorry; hard to conceptualize what you want when I'm on pain medications.
- Stop push-polling! This was a silly survey and an absolute waste of tax payer money. Of course we want clean water and pictures of pretty water. Most residents already pay for water and sewer treatment. To the extent water quality is affected by agriculture and industry discharge and runoff; then these sources should be looked to for clean-up.
- Thank you for asking my opinion.
- Thank you for looking ahead to the future to try and maintain biodiversity in Utah's lakes and rivers. I would pay any amount to protect the environment for us and future generations. I appreciate this survey.

- Thank you for looking for a solution to improving our water.
- Thank you; it was very well done and it opened my eyes.
- The $15 for the Nutrient Reduction Program would not be a hardship for me but you gave no detail as to what efforts the $15 per household would fund. I feel like I am being asked to put money into a new government program without being given any specifics as to how the program would proceed. Give me some more information.
- The choice between $0 and an extra $600 a year doesn't make sense. Surely there is a more affordable alternative, especially for those reaching retirement age. This should include industry paying their fair share, and perhaps legal restrictions on home fertilizers and more xeriscaping required, with drip irrigation.
- The choices are pretty simplistic: opt out of paying more and the world goes to hell or pay for a program that will accomplish who knows what. There are other alternatives to improve the situation. A poor survey with limited thoughtfulness.
- The Forest Service and Fish and Game people in the Carbon County area need to be replaced with people that will get out of the office and do some work!
- The government should cover the cost of this project. Some of the things the money is spent on are totally wrong.
- The main contributors to the negative effects on water quality should pay to limit the impact; i.e. agriculture, industry, etc.
- The mineral content of our city-supplied drinking water (Smithfield) is exponentially way too high. In fact, if water is left in a cooking pot overnight, there is a great amount of mineral deposits visible and on the bottom of the pot in the morning!
- The money needed for this project seems very high per household.
- The NRP, as explained, is too general and could be easily manipulated to misuse public funds. You would need a broader range of scientific opinion to come up with a consistent, moderate approach, good for the long term.
- The program needs an improvement on the quality of outcome. The research shows that the water quality will remain the same in the future as it is today. There should be an improvement in water quality if the people are paying extra for it.
- The questions were biased and designed for a specific response.
- The suggested fee increase is too high; make the industrial polluters pay more! A $1 increase would be okay.
- The water is an issue to me because when I served in the Marines at Camp Lejeune, North Carolina, the water that we bathed in, cooked with, and drank were poisoned; refer to www.thefewtheproudtheforgetten.com or www.tftptf.com. The information there is only a small reference to my family's issues concerning the water.
- There is too much garbage (trash) in watersheds and lakes. People need to carry out what they carry in. Help keep our watersheds and rec areas clean. Clean water is a clean life; it is our duty as stewards of this planet.
- There's no mention of xeriscaping to reduce use of water and fertilizers containing phosphates. I don't want a program that "encourage[s] proper application of lawn fertilizers" for a dessert climate! Let's cut out green lawns, use less water, and reduce fertilizer use. Thank you! Kill two birds with one stone.
- This "survey" appears to be a piece of propaganda designed to get the answers a regulatory agency wants. Of course, everyone wants good quality water, but no examples of real problems are given with estimated costs of correcting them. I wouldn't vote to increase fees with this vague instrument. This "survey" offends me, and is an example of the "junk science" being used to justify regulation.

- This “survey” appears to be biased to me. You obviously have an agenda, like increasing tax revenue. Please read up on the Hudson River Project. That is a more realistic approach. No mention of cost to farmers or impact on agriculture. I don’t trust government.
- This is obviously a piece designed to promote a program. I don’t think it’s a legitimate use of tax dollars.
- This is the most ridiculous, leading survey I have ever seen. Get a grip; most households in Utah cannot afford $50 per month increase in water bill right now; try again.
- This is the worst attempt I have ever witnessed at trying to shape public opinion through social engineering. And then using the results to justify going for a tax increase of $50 a household per month to fund your liberal, anti-business agenda.
- This questionnaire needs work! It is very confusing and not written well. No indication on your scale of most preferred or which is the good side of the scale for questions one and eight. This is a poorly written survey to ASSESS the desires of citizens concerning our lakes and rivers. Question one needs attention and needs to be re-written. Can’t you have the photos attached to this booklet? Surely it costs more money to have them separate.
- This would be one more unfair taxation to the middle class tax payer. Impose taxes or fines on companies that would/could cause water resources to be damaged. Once again, the government wants to impose rules/regulations that are unfair and costly.
- Too complicated for the layperson. Need to simplify, especially picture comparison. My income is not relevant to this survey, NOYB.
- Too long! Is it a DWQ survey?
- Too personal.
- Turn algae into fuel!
- Two dollars is a small price to pay to maintain and improve our water environment. I don’t know anything about our state’s budget currently allocated for this purpose. Too often state departments’ budgets need the people to supplement them so they can do their jobs. I am embarrassed that they need to result to subtle polls, like this, to show evidence of the people’s support.
- Utahans are far too behind on environmental issues: water AND air. You cannot clean up water until you address “ALL” issues effecting environment.
- Utilize algae to make fuel.
- Water quality is a concern. I think the programs in place now are working. I see this program as a way to raise money for other uses. I can’t believe all the charges I pay to use the water. Is insufficient to run a good program.
- Water quality is important to all residents. I do not object to supporting a program if the money is spent wisely. Too often funding is spent for impact studies and recommendations instead of the actual problem.
- Water quality is important; now is not the time to raise taxes. Come up with other methods to reduce pollution at this time.
- Water quality is just fine. There needs to be some algae to feed the fish. Excess nutrients is not the problem.
- Water quality is of high importance to me and my family.
- Water resources are incredibly precious to the state of Utah, and pressures related to both protecting and improving these resources will only increase. Significant action taken now will bode well for all future generations, and the medium to long-term economic benefit will be material.

- Way too high of a monthly increase; this rate needs to be a flow rate based fee. A one or two person household should not pay as much as a six or seven person household, also lot size. The businesses that pollute the worst should pay more than home owners. Can fertilizers be [illegible]? Something should be done and all of us should help to slow the problem and share the cost but $40 a month would be a 100% increase in a lot of homeowner's bills. Don't know if you noticed, but the economy has not increased and a lot of people just could not afford this program. There has to be other ways to get this done.
- We cannot afford to pay more money to government. Reduce fees and taxes, not increase.
- We don't need new government agencies to make rules to control people and take money for administers to embezzle and not take care of any real problems. We need to get rid of these blood sucking parasites. Thank you!
- We have participated in hunting, fishing, swimming, and hiking activities in Utah as a family for more than 30 years, most of the activities and places we have been have been great. The last couple years we have been disappointed on how the lakes have appeared and the fishing; I would be interested in how these surveys turn out. Thanks.
- We love the lake, we also love to go fishing. Keeping the lake clean is very important. Please help have less abundance of fish.
- We must keep pushing for excellent water quality. In Utah, too much emphasis on mining and development with little thought of good environmental control.
- We need to mandate that <u>all</u> pipelines from any oil source have a pipe in a pipe! That way it leaks in the pipe or second pipe, not the water, stream, like half a mile at least. Any petroleum product should be pipe in a pipe for at least half a mile or more. I'll pay the extra to ensure the best water! And no, I can't afford it.
- We need to protect these waters but this is the wrong way to do it. Fishing and hunting licenses pay for these already. I already pay for this with camping and recreation fees. DO NOT PASS THE NUTRIENT PREVENTION PROGRAM as stated in this pamphlet.
- We strongly support this program <u>and</u> programs to protect our rivers and lakes from invasive species. Thank you!
- We would support any measures UDEQ takes to increase water quality as it affects the quality of life for Utah residents and sustains Utah's tourism industry!
- Weber River needs help! Morgan County, north end.
- What are water quality comparative to the clean water [illegible]? What rivers/lakes have the poorest quality [illegible]? Why not set rate based on the county, i.e. counties with the poorest qualities pay higher rates?
- While I would support an effort to clean up the waterways, $40 per month is too steep. Surely the state could do something with a lesser amount per household, say $10-$15 per month.
- Why are we paying a university in Wyoming to do a study for Utah when we have competent researchers at our universities?
- Why does the state of Utah use my tax dollars to contract with out of state people of agencies? Thanks for asking though.
- Why is the University of Wyoming doing a Utah water study?
- Why is the University of Wyoming doing this study? Shouldn't UTAH be doing it?
- Why not get a federal grant. $40 across income levels is not fair. Puts more burden on lower incomes. Why no increase regulations? Evidence shows with increased regulation, water and air quality increase. It is evident with the latest trend of de-regulation, water and air quality have decreased.

- Will we be able to see results of your survey when it's over?
- Would like to see Utah move to a more xeriscaping; desert native plants instead of keeping out grass green. We're high desert and should conserve our resources.
- You should regulate the cities AF my bill is $120. The same bill in Lehi is $75; it costs $25 more to [expletive removed] in AF, figure that out. You should limit watercrafts on lakes and reservoirs or start ticketing boaters for litter. The class of people that boat are slobs and they should pay a lot more. Do you have the guts to do this? I just got back from Jordanelle; boaters and jet ski people are rude and pigs! The thought of them in my water makes me want to gag.
- Your questions are redundant; not all non-native plants are fish are undesirable! By and large, we in Utah are not native. There are game fish besides trout! A one dollar a month increase would be more realistic. There are several existing processes to remove N and P from water in waste water treatment plants.

Appendix H
Recreation Survey Frequencies

APPENDIX H

Survey Results
Recreation Demand - Utah's Lakes & Rivers Recreation Survey 2011

Thank you for taking the time to complete this survey. Your participation in this survey is voluntary. Refusal to participate will have no effect on any benefits to which you are otherwise entitled. This survey should be answered by the **adult in your household** (age 18 or older) **who has most recently had their birthday**.

This survey concerns the management of Utah's lakes, reservoirs, and rivers. For the purposes of this survey, please think of lakes and reservoirs as the same thing. Similarly, consider rivers to include streams.

To start, we would like to know whether or not your household visits lakes or rivers and if so, which lakes and rivers you visit and what activities you do there. By "visit" we mean any trip you or members of your household take for the purpose of viewing or using a lake or river. Also, if you or members of your household bike, walk, or jog along a river or on the shores of a lake, include that as a visit as well. If you live on a lake or river, even for part of the year, each day equals 1 visit.

If neither you nor members of your household have visited any lakes or rivers in Utah in the last 12 months we still need your responses.

Q1a. Did you or members of your household visit any lakes in Utah in the last 12 months?

	Frequency	Valid Percent
Yes	1021	72.7%
No	384	27.3%
Total	1405	100.0%
No Answer	6	
Total Missing	6	
Total	1411	

➔ *If you answered no, skip to Question 2a.*

Q1b. Please identify all the lakes you or members of your household visited and how many times in the last 12 months. To assist you, we have included a map showing many of Utah's popular lakes. Each lake on the map has an ID number. Both the name of the lake and its ID are listed in a table next to the map. If you do not see a lake listed in the table, please write in the name of the lake and the nearest town in the space provided to the right of the table below. If you need additional space please go to the last page of this survey.

Lake ID	Frequency
Bear Lake	266
Lake Powell	216
Strawberry Res.	205
Utah Lake	186
Deer Creek Res.	179
Pineview Res.	169
Jordanelle Res.	160
Flaming Gorge Res.	149
GSL – Willard Bay	127
East Canyon Res.	110

Lake ID	Frequency
Rockport Res.	106
Echo Res.	82
GSL – Antelope Island	81
Mirror Lake	75
Scofield Res.	75
Fish Lake	65
Hyrum Res.	53
Quail Creek Res.	49
Causey Res.	48
Starvation Res.	47

Lake ID	Frequency
Mantua Res.	43
Tibble Fork Res.	41
Trial Lake	35
Tony Grove Lake	33
Silver Lake Flat Res.	32
Otter Creek Res.	32
Navajo Lake	31
Gunlock Res.	30
Lost Creek Res.	29
Smith and Morehouse	28

Lake ID	Frequency
Res.	
Panguitch Lake	28
Currant Creek Res.	26
GSL – Farmington Bay	24
Palisade Lake	23
Mill Hollow Res.	22
Porcupine Res.	21
Joes Valley Res.	21
Newton Res.	20
Grantsville Res.	19
Butterfly Lake	19
Moon Lake	19
Steinaker Res.	19
Washington Lake	17
Whitney Res.	16
Red Fleet Res.	16
Pelican Lake	16
Electric Lake	16
Wall Lake	15
Johnson Valley Res.	15
Upper Enterprise Res.	15
Kolob Res.	15
Baker Dam Res.	15
Cutler Res.	14
Salem Pond	14
Ferron Res.	14
Little Dell Res.	13
Browne Lake	13
Matt Warner Res.	13
Gunnison Res.	13
Piute Res.	13
Stansbury Lake	12
Lake Mary	12
Huntington Res.	12
Koosharem Res.	12
Cleveland Res.	12
Birch Creek Res. #2	10

Lake ID	Frequency
Spirit Lake	10
Duck Fork Res.	10
Forsyth Res.	10
Yankee Meadow Res.	10
Mona Res.	9
Fairview Lake (#2)	9
Miller Flat Res.	9
Sevier Bridge Res.	9
Tropic Res.	9
Settlement Canyon Res.	8
Lyman Lake	8
Mill Meadow Res.	8
Gunnison Bend Res.	8
Newcastle Res.	8
Kens Lake	8
Marsh Lake	7
Hoop Lake	7
Lower Gooseberry Res.	7
Rex Res.	7
Minersville Res.	7
Recapture Res.	7
Big East Lake	6
Stateline Res.	6
Long Park Res.	6
East Park Res.	6
Upper Stillwater Res.	6
Red Creek Res.	6
Huntington Lake North	6
Manning Meadow Res.	6
Kents Lake	6
Blanding City Res. #4	6
Puffer Lake	5
Little Creek Res.	4
Bridger Lake	4
China Lake	4
Big Sand Wash Res.	4

Lake ID	Frequency
Donkey Res.	4
Lower Bowns Res.	4
Pine Lake	4
LaBaron Lake	4
Anderson Meadow Res.	4
Sheep Creek Lake	3
Calder Res.	3
Brough Res.	3
D.M.A.D. Res.	3
Redmond Lake	3
Barney Lake	3
Lower Box Creek Res.	3
Dark Canyon Lake	3
Rush Lake	2
Long Park Res.	2
Ashley Twin Lakes	2
Scout Lake	2
Marshall Lake	2
Posy Lake	2
Ninemile Res.	2
Three Creeks Res.	2
Monticello Lake	2
Woodruff Res.	1
Meeks Cabin Res.	1
Beaver Meadow Res.	1
Oak Park Res.	1
Hoover Lake	1
Paradise Park Res.	1
Millsite Res.	1
Cook Lake	1
Red Creek Res. (Iron Co)	1
Lloyds Res.	1
Wide Hollow Res.	0

Q2a. Did you or members of your household visit any rivers in Utah in the last 12 months?

	Frequency	Valid Percent
Yes	604	43.5%
No	786	56.5%
Total	1390	100.0%
No Answer	21	
Total Missing	21	
Total	1411	

- ➔ *If you answered no, skip to Question 3.*
- ➔ *If you answered no to both Question 1a and 2a, skip to Question 28.*

Q2b. Please identify all the rivers you or members of your household visited and how often in the last 12 months. To assist you, we have included two maps showing many of Utah's popular rivers. Each river on the map has an ID number with the larger rivers having multiple ID numbers for various sections. Both the name of the river and its ID are listed in a table next to the map. If you do not see a river listed in the table, please write in the name of the river and the nearest town in the space provided to the right of the table below. If you need additional space please go to the last page of this survey.

River ID	Frequency
Ogden River	70
Provo River-01	67
Provo River-03	61
Logan River-01	55
Green River-01	45
Logan River-02	38
Big Cottonwood Creek-02	38
Weber River-03	36
Provo River-04	36
Colorado River-04	34
American Fork River-01	31
Blacksmiths Fork-01	30
Jordan River-06	30
Big Cottonwood Creek-01	28
Provo River-06	28
Weber River-04	26
Little Cottonwood Creek-02	23
Virgin River-01	22
Virgin River-02	22
Strawberry River-02	21
Green River-02	21
South Fork Ogden River	21
Jordan River-03	20
Little Cottonwood Creek-01	20

River ID	Frequency
Bear River-01	19
Weber River-07	19
Diamond Fork-01	19
Weber River-06	18
Tibble Fork	18
Weber River-01	17
Santa Clara-01	16
Virgin River-03	16
Colorado River-03	16
Currant Creek (Wasatch Co.)	16
Left Hand Fork/ Blacksmiths Fork	16
Jordan River-08	15
Hobble Creek-01	15
Colorado River-02	14
Huntington Creek	14
Blacksmiths Fork-02	14
Santa Clara-02	13
North Fork Virgin River	13
Strawberry River-03	13
Bear River-02	13
Weber River-08	13
Provo Deer Creek	13
Green River-04	12
Blacks Fork	12
Middle Fork Ogden River	12
Bear River-06	11

River ID	Frequency
Mill Creek-02	11
City Creek	11
Emigration Creek	11
Mill Creek-03	11
Hobble Creek-03	11
Spanish Fork River-01	11
Green River-03	10
Jones Hole Creek	10
Bear River-03	10
East Canyon Creek - 01	10
Jordan River-01	10
Beaver Dam Wash	9
Little Bear River-02	9
Mill Creek-01	9
South Fork Provo River	9
Heber Valley	9
Diamond Fork-02	9
Otter Creek (Sevier Co. & Piute Co.)	9
East Fork Virgin	8
San Juan River-01	8
Fremont River-02	8
Green River-05	8
Price River-01	8
Duchesne River-03	8
Duchesne River-04	8
Little Bear River-01	8

River ID	Frequency
Wheeler Creek	8
Weber River-10	8
Mill Creek-01	8
Sevier River-25	8
Lost Creek	8
Sevier River-08	8
Colorado River-05	7
Duchesne River-01	7
Malad River	7
North Fork Ogden River	7
North Fork Provo River	7
Hobble Creek-02	7
Nebo Creek	7
Monroe Creek	7
Sevier River-06	7
Lower Escalante	6
Dirty Devil	6
East Fork Little Bear	6
Beaver Creek-01	6
Farmington Creek	6
Bells Canyon	6
Spanish Fork River-02	6
Thistle Creek	6
Peteetneet Creek	6
Clear Creek (Sevier Co.)	6
Mammoth Creek	6
Coal Creek	6
San Juan River-02	5
Fremont River-03	5
Dolores River	5
Lower Cottonwood Creek	5
Upper Yellowstone	5
Cub River	5
Bear River-04	5
Causey Reservoir Tributaries	5
Weber River-09	5
Main Creek-01	5
Little South Fork Provo	5
Rock Canyon	5
Cottonwood Creek	5
Sevier River-22	5
East Fork Sevier River-03/04	5
Kanab Creek	4
Paria River-03	4
Duchesne River-02	4
Rock Creek	4
Lost Creek Lower	4
Smith Morehouse River	4
Weber River-11	4
South Fork Provo	4
Dry Creek-01	4
Sevier River-24	4
Salina Creek	4
East Fork Sevier River-02	4
Panguitch Creek	4
Fremont River-04	3
Lower Muddy Creek	3
Upper San Rafael	3
White River	3
Brush Creek	3
Sheep Creek (Daggett Co.)	3
West Fork Bear River	3
Beaver Creek	3
East Canyon Creek-02	3
Chalk Creek-01	3
Mountain Dell Creek	3
Lambs Canyon	3
Daniels Creek-01	3
Snake Creek-01	3
Beer Creek	3
Currant Creek	3
Corn Creek	3
East Fork Sevier River-01	3
Beaver River-02	3
Beaver River-03	3
Deep Creek (Washington Co.)	2
Paria River-02	2
San Juan River-03	2
Upper Escalante	2
Bullfrog Creek	2
Lower San Rafael	2
Price River-05	2
Price River-03	2
Price River-02	2
Ninemile	2
Deep Creek (Uintah Co.)	2
Uinta River-02	2
Upper Whiterocks River	2
Lower Ashley Creek	2
Upper Ashley Creek	2
Burnt Fork Creek	2
Otter Creek (Rich Co.)	2
Four Mile Creek	2
Lost Creek Upper	2
Echo Creek	2
Barton Creek	2
Butterfield Creek	2
Sixth Water Creek	2
Sheep Creek	2
Starvation Creek	2
San Pitch-01	2
San Pitch-05	2
Beaver River-01	2
Deep Creek (Tooele Co.)	2
North Creek	1
Johnson Wash	1
Paria River-01	1
Harris Wash	1
Lower Ivie Creek	1
Kane Spring Wash	1
Lower Ferron Creek	1
Upper Ferron Creek	1
Price River-04	1
Miller Creek	1
Willow Creek (Carbon Co.)	1
Willow Creek (Grand Co. & Uintah Co.)	1
Hill Creek	1
Upper Bitter Creek	1
Uinta River-01	1
Lower Whiterocks River	1
Dry Gulch Creek	1
Lake Fork-02	1
Diamond Gulch	1
Woodruff Creek	1
Francis Creek	1
Chalk Creek-02	1
South Fork Chalk Creek	1

River ID	Frequency
Chalk Creek-03	1
East Fork Chalk Creek	1
Bingham Creek	1
Rose Creek	1
Daniels Creek-02	1
Lake Creek-02	1
Soldier Creek-01	1
Dairy Fork	1
Soldier Creek-02	1
Benjamin Slough	1
Spring Creek	1
Sevier River-20	1
Sevier River-17	1
San Pitch-03	1
Sevier River-15	1
Sevier River-09	1
Sevier River-04	1
Sevier River-03	1
Grouse Creek	1
Chinle Creek	0
Montezuma Creek	0
McElmo Creek	0
Middle Muddy	0
Gordon Creek	0
Pariette Draw Creek	0
Uinta River-03	0
Lake Fork-01	0
Lake Fork-03	0
Antelope Creek	0
Avintaquin Creek	0
Middle Red Creek	0
Clarkston Creek	0
Big Creek	0

River ID	Frequency
Hardscrabble Creek	0
Kimball Creek	0
Huff Creek	0
Chalk Creek-04	0
Silver Creek	0
Stone Creek-01	0
Third Water Creek	0
Lake Fork	0
Mill Fork	0
Tie Fork	0
Indian Creek	0
Clear Creek	0
Summit Creek	0
Sevier River-02	0
Sevier River-01	0
Raft River	0
Deep Creek (Box Elder Co.)	0
Ogden River	70
Provo River-01	67
Provo River-03	61
Logan River-01	55
Green River-01	45
Logan River-02	38
Big Cottonwood Creek-02	38
Weber River-03	36
Provo River-04	36
Colorado River-04	34
American Fork River-01	31
Blacksmiths Fork-01	30
Jordan River-06	30
Big Cottonwood Creek-01	28

River ID	Frequency
Provo River-06	28
Weber River-04	26
Little Cottonwood Creek-02	23
Virgin River-01	22
Virgin River-02	22
Strawberry River-02	21
Green River-02	21
South Fork Ogden River	21
Jordan River-03	20
Little Cottonwood Creek-01	20
Bear River-01	19
Weber River-07	19
Diamond Fork-01	19
Weber River-06	18
Tibble Fork	18
Weber River-01	17
Santa Clara-01	16
Virgin River-03	16
Colorado River-03	16
Currant Creek (Wasatch Co.)	16
Left Hand Fork/ Blacksmiths Fork	16
Jordan River-08	15
Hobble Creek-01	15
Colorado River-02	14
Huntington Creek	14
Blacksmiths Fork-02	14
Santa Clara-02	13
North Fork Virgin River	13
Strawberry River-03	13

Q3. Now think about the <u>most recent visit to a lake</u> in Utah that you or members of your household took in the <u>last 12 months</u>. Please tell us which lake that was and how many members of your household including yourself were on that visit.*

Lake ID	Frequency
Bear Lake	112
Lake Powell	106
Strawberry Res.	71
Deer Creek Res.	63
Pineview Res.	44
GSL – Willard Bay	43
Flaming Gorge Res.	40
Tibble Fork Res.	36

Lake ID	Frequency
Rockport Res.	26
Washington Lake	25
East Canyon Res.	22
Hyrum Res.	16
GSL – Antelope Island	16
Scofield Res.	15
Mill Hollow Res.	13
Fish Lake	13

Lake ID	Frequency
Quail Creek Res.	13
Mirror Lake	12
Navajo Lake	11
Echo Res.	10
Tony Grove Lake	7
Mantua Res.	7
Causey Res.	7
Lost Creek Res.	7

Lake ID	Frequency
Smith and Morehouse Res.	7
Lake Mary	7
Starvation Res.	7
Otter Creek Res.	7
Panguitch Lake	7
Gunlock Res.	7
Trial Lake	5
Steinaker Res.	5
Palisade Lake	5
Matt Warner Res.	4
Red Fleet Res.	4
Joes Valley Res.	4
Gunnison Res.	4
Yankee Meadow Res.	4
Upper Enterprise Res.	4
Newton Res.	3
Cutler Res.	3
Porcupine Res.	3
Whitney Res.	3
Currant Creek Res.	3
Pelican Lake	3
Gunnison Bend Res.	3
Koosharem Res.	3
Kolob Res.	3

Lake ID	Frequency
Recapture Res.	3
Birch Creek Res. #2	2
Grantsville Res.	2
Wall Lake	2
Wall Lake	2
Salem Pond	2
Big East Lake	2
Bridger Lake	2
Lyman Lake	2
Browne Lake	2
Spirit Lake	2
East Park Res.	2
Butterfly Lake	2
Scout Lake	2
Moon Lake	2
Red Creek Res.	2
Miller Flat Res.	2
Ferron Res.	2
Johnson Valley Res.	2
Pine Lake	2
Tropic Res.	2
Kents Lake	2
Baker Dam Res.	2
Blanding City Res. #4	2
Woodruff Res.	1

Lake ID	Frequency
Stansbury Lake	1
Settlement Canyon Res.	1
Jordanelle Res.	1
Silver Lake Flat Res.	1
Utah Lake	1
Marsh Lake	1
Paradise Park Res.	1
Upper Stillwater Res.	1
Big Sand Wash Res.	1
Lower Gooseberry Res.	1
Electric Lake	1
Huntington Res.	1
Huntington Lake North	1
Rex Res.	1
Piute Res.	1
LaBaron Lake	1
Kens Lake	1
Monticello Lake	1
GSL – Farmington Bay	1
288	1
334	1
336	1
388	1
510	1

*Note: The number of family members on lake trip is not displayed.

Q4. Now think about the <u>most recent visit to a river</u> in Utah that you or members of your household took in the last <u>12 months</u>. Please tell us which river that was and how many members of your household including yourself were on that visit.*

River ID	Frequency
Ogden River	32
Provo River-03	27
Logan River-01	25
Provo River-01	24
Green River-01	21
Colorado River-04	19
Weber River-03	15
Provo River-04	15
Weber River-04	13
Jordan River-06	12
American Fork River-01	12
Provo River-06	11
Big Cottonwood Creek-02	10

River ID	Frequency
Green River-02	9
Logan River-02	8
Weber River-01	8
South Fork Ogden River	8
Virgin River-02	7
Virgin River-03	7
Blacksmiths Fork-01	7
Middle Fork Ogden River	7
Bear River-06	6
Virgin River-01	5
Huntington Creek	5
Green River-03	5
Blacks Fork	5

River ID	Frequency
Mill Creek-03	5
Little Cottonwood Creek-01	5
Tibble Fork	5
Santa Clara-02	4
Fremont River-02	4
Colorado River-02	4
Price River-01	4
Upper Yellowstone	4
Currant Creek (Wasatch Co.)	4
Little Bear River-01	4
Weber River-07	4
Weber River-08	4
Weber River-10	4

River ID	Frequency
City Creek	4
Little Cottonwood Creek-02	4
Jordan River-08	4
Hobble Creek-01	4
Spanish Fork River-01	4
Diamond Fork-01	4
Sevier River-08	4
North Fork Virgin River	3
Strawberry River-02	3
Strawberry River-03	3
Bear River-01	3
Malad River	3
Bear River-02	3
East Canyon Creek -01	3
Weber River-06	3
Beaver Creek-01	3
Farmington Creek	3
Mill Creek-01	3
Big Cottonwood Creek-01	3
South Fork Provo River	3
Provo Deer Creek	3
Rock Canyon	3
Mammoth Creek	3
Santa Clara-01	2
Fremont River-03	2
Lower Cottonwood Creek	2
Green River-04	2
Duchesne River-01	2
Upper Whiterocks River	2
Duchesne River-03	2
Duchesne River-04	2
Rock Creek	2
Sheep Creek (Daggett Co.)	2

River ID	Frequency
Left Hand Fork/ Blacksmiths Fork	2
North Fork Ogden River	2
Chalk Creek-01	2
Weber River-09	2
Barton Creek	2
Mill Creek-02	2
Jordan River-03	2
Mill Creek-01	2
Daniels Creek-01	2
Sevier River-25	2
Panguitch Creek	2
Otter Creek (Sevier Co. & Piute Co.)	2
Coal Creek	2
1	1
10	1
64	1
Beaver Dam Wash	1
East Fork Virgin	1
Paria River-01	1
San Juan River-01	1
San Juan River-03	1
Lower Escalante	1
Dirty Devil	1
Fremont River-04	1
Colorado River-03	1
Upper San Rafael	1
Lower Ferron Creek	1
Price River-05	1
Price River-03	1
Deep Creek (Uintah Co.)	1
Uinta River-02	1
Lower Ashley Creek	1
Jones Hole Creek	1
Bear River-03	1

River ID	Frequency
Blacksmiths Fork-02	1
Little Bear River-02	1
East Fork Little Bear	1
Bear River-04	1
Four Mile Creek	1
Wheeler Creek	1
Causey Reservoir Tributaries	1
East Canyon Creek-02	1
Lost Creek Lower	1
Lost Creek Upper	1
Smith Morehouse River	1
Jordan River-01	1
Emigration Creek	1
Main Creek-01	1
Lake Creek-02	1
Hobble Creek-02	1
Hobble Creek-03	1
Dry Creek-01	1
Soldier Creek-01	1
Beer Creek	1
Peteetneet Creek	1
Sevier River-24	1
Salina Creek	1
Lost Creek	1
Sevier River-09	1
Clear Creek (Sevier Co.)	1
Sevier River-06	1
East Fork Sevier River-02	1
Beaver River-03	1
Deep Creek (Tooele Co.)	1
Grouse Creek	1

*Note: The number of family members on river trip is not displayed.

Q5. We would like to know how much money you spent on these visits. Please write down your best estimate of what your household spent for each kind of item on the most recent visit to a lake and/or a river in Utah that you or members of your household took in the last 12 months. If you did not spend any money on an item, please enter a zero for that item. We realize that some households may have spent a lot of money on their most recent lake or river visit, whereas other households may have spent very little money. Answers to this question will allow us to calculate an average household expenditure per visit.

Q5a. Most Recent LAKE Trip

	Frequency	Mean
Lodging in hotels, motels, or bed/breakfasts	632	$58.75
Lodging in cabin or home rentals, or public or private campgrounds	670	$119.17
Gasoline, food and beverages purchased at gasoline stations and/or convenience stores	889	$178.44
Food and beverages purchased at grocery stores	837	$108.43
Food and beverages purchased at restaurants or fast food outlets	752	$38.69
Rental fees and supplies including rental cars, RVs, trailers, boats, and fishing and hunting supplies	652	$71.39
Other retail goods such as souvenirs (e.g., t-shirts, mugs, postcards)	638	$16.42

Q5. Most Recent RIVER Trip

	Frequency	Mean
Lodging in hotels, motels, or bed/breakfasts	393	$32.57
Lodging in cabin or home rentals, or public or private campgrounds	382	$19.35
Gasoline, food and beverages purchased at gasoline stations and/or convenience stores	477	$60.82
Food and beverages purchased at grocery stores	452	$40.43
Food and beverages purchased at restaurants or fast food outlets	425	$23.88
Rental fees and supplies including rental cars, RVs, trailers, boats, and fishing and hunting supplies	382	$20.82
Other retail goods such as souvenirs (e.g., t-shirts, mugs, postcards)	380	$6.37

Lakes Section

The questions in the next three sections of this survey - Questions 6 through 17 - have to do with lakes in Utah. If neither you nor members of your household visited any lakes in Utah in the last 12 months please fill in this circle and skip to page 8.

	Frequency	Valid Percent
Checked	156	100.0%
Total	156	100.0%
No Answer	234	
System Missing	1021	
Total Missing	1255	
Total	1411	

Lake Recreation

Q6. In the <u>last 12 months</u> which types of activities did you or members of your household typically participate in during your lake visits? *(Mark all that apply.)*

	Frequency	Valid Percent*
Boating (includes motor-boating, house boating, sailing, canoeing, kayaking, jet skiing)	664	66.5%
Fishing for warm water fish species (for example, bass, perch, catfish, crappie, sunfish)	331	33.1%
Fishing for cold water fish species (for example, trout, whitefish, salmon)	549	55.0%
Swimming (includes playing in the water, wading, windsurfing, water-skiing, tubing)	600	60.1%
Near-shore activities (includes walking, biking or running on trails, bird/wildlife/nature viewing, picnicking, camping)	629	63.0%
Hunting – waterfowl	56	5.6%
Hunting/Trapping – other	40	4.0%
Total	999	
No Answer	22	
System Missing	390	
Total Missing	412	
Total	1411	

*Percentages for 'Mark all that apply' may total greater than 100%.

Q7. In the <u>last 12 months</u> which ONE activity did YOU spend the most time doing during your lake visits? *(Choose only one.)*

	Frequency	Valid Percent
Boating (includes motor-boating, house boating, sailing, canoeing, kayaking, jet skiing)	287	31.7%
Fishing for warm water fish species (for example, bass, perch, catfish, crappie, sunfish)	63	7.0%
Fishing for cold water fish species (for example, trout, whitefish, salmon)	255	28.1%
Swimming (includes playing in the water, wading, windsurfing, water-skiing, tubing)	103	11.4%
Near-shore activities (includes walking, biking or running on trails, bird/wildlife/nature viewing, picnicking, camping)	192	21.2%
Hunting – waterfowl	3	0.3%
Hunting/Trapping – other	3	0.3%
Total	906	100.0%
No Answer	115	
System Missing	390	
Total Missing	505	
Total	1411	

Perceptions of Lake Water Quality in the Summer

We are interested in your <u>personal</u> perceptions of lake water quality in Utah. Please answer all of the questions in this section - Questions 8 through 16 - for the lake that <u>you</u> visited <u>most often this summer</u>. By summer we mean May through September.

Q8. Which lake in Utah did you visit most often this summer? Please record the lake ID number (or if the lake does not have an ID number then write in the name of the lake and the nearest town) and how long you have been going to this lake.

Q9. For each of the months listed below, how many visits did you make to this lake? For the month of September (post-Labor Day) please estimate the total number of visits you will make.

Q10. Which of the following best describes the water clarity you usually experienced at this lake this summer?

	Frequency	Valid Percent
You can see 12 or more feet deep into the water	101	10.9%
You can see 6 to 12 feet deep into the water	236	25.4%
You can see 1 to 6 feet deep into the water	426	45.9%
You can see at most 1 foot deep into the water	165	17.8%
Total	928	100.0%
Don't know	77	
No Answer	16	
System Missing	390	
Total Missing	483	
Total	1411	

Q11. Which of the following shades of green did the water usually have at this lake this summer?

	Frequency	Valid Percent
No green tint	185	21.3%
Slight greenish tint	487	56.0%
Dark greenish tint	197	22.7%
Total	869	100.0%
Don't know	122	
No Answer	30	
System Missing	390	
Total Missing	542	
Total	1411	

Q12. Which of the following unpleasant odor conditions coming from the water - particularly if the mud on the bottom were disturbed - did you usually experience at this lake this summer?

	Frequency	Valid Percent
No unpleasant odor	612	66.4%
Faint unpleasant odor	229	24.8%
Noticeable unpleasant odor	67	7.3%
Strong unpleasant odor	14	1.5%
Total	922	100.0%
Don't know	83	
No Answer	16	
System Missing	390	
Total Missing	489	
Total	1411	

Q13. Which of the following abundance levels for each fish type did you expect to be present at this lake this summer?

Q13a. Cold water species (trout, whitefish, salmon).

	Frequency	Valid Percent
Abundant	142	26.4%
Common	276	51.3%
Less common	60	11.2%
Rare	60	11.2%
Total	538	100.0%
Don’t know	210	
Not applicable	176	
No Answer	97	
System Missing	390	
Total Missing	873	
Total	1411	

Q13b. Warm water species (bass, sunfish, or catfish).

	Frequency	Valid Percent
Abundant	89	25.4%
Common	159	45.3%
Less common	63	17.9%
Rare	40	11.4%
Total	351	100.0%
Don’t know	229	
Not applicable	259	
No Answer	182	
System Missing	390	
Total Missing	1060	
Total	1411	

Q14. Which of the following algae bloom conditions did you usually find at this lake this summer?

	Frequency	Valid Percent
Algae bloom would not be present	416	52.4%
Algae bloom covers less than 10% of the lake	252	31.7%
Algae bloom covers 10 – 25% of the lake	88	11.1%
Algae bloom covers 25 – 50% of the lake	27	3.4%
Algae bloom covers over 50% of the lake	11	1.4%
Total	794	100.0%
Don’t know	187	
No Answer	40	
System Missing	390	
Total Missing	617	
Total	1411	

Potential Changes to Lake and Water Quality in the Summer

Water quality in lakes can change with the seasons. Changes in water quality may or may not affect the number of visits you make to a lake.

Q15. When you think about the lake you visited most often this summer, what importance do you personally place on each of the following attributes in choosing to visit this lake?

Q15a. Water clarity.

	Frequency	Valid Percent
No Importance	54	5.5%
Low Importance	166	17.0%
Moderate Importance	402	41.1%
High Importance	357	36.5%
Total	979	100.0%
No Answer	42	
System Missing	390	
Total Missing	432	
Total	1411	

Q15b. No unpleasant odor.

	Frequency	Valid Percent
No Importance	51	5.3%
Low Importance	106	11.0%
Moderate Importance	297	30.8%
High Importance	509	52.9%
Total	963	100.0%
No Answer	58	
System Missing	390	
Total Missing	448	
Total	1411	

Q15c. Cold water fish species are present.

	Frequency	Valid Percent
No Importance	250	26.4%
Low Importance	178	18.8%
Moderate Importance	177	18.7%
High Importance	341	36.0%
Total	946	100.0%
No Answer	75	
System Missing	390	
Total Missing	465	
Total	1411	

Q15d. Warm water fish species are present.

	Frequency	Valid Percent
No Importance	364	40.8%
Low Importance	259	29.0%
Moderate Importance	143	16.0%
High Importance	127	14.2%
Total	893	100.0%
No Answer	128	
System Missing	390	
Total Missing	518	
Total	1411	

Q15e. No algae bloom.

	Frequency	Valid Percent
No Importance	72	7.5%
Low Importance	190	19.9%
Moderate Importance	348	36.5%
High Importance	344	36.1%
Total	954	100.0%
No Answer	67	
System Missing	390	
Total Missing	457	
Total	1411	

Q15f. Proximity to your home.

	Frequency	Valid Percent
No Importance	70	7.2%
Low Importance	146	15.0%
Moderate Importance	382	39.2%
High Importance	376	38.6%
Total	974	100.0%
No Answer	47	
System Missing	390	
Total Missing	437	
Total	1411	

Q15g. Other, describe.

	Frequency	Valid Percent
No Importance	26	13.5%
Low Importance	2	1.0%
Moderate Importance	28	14.6%
High Importance	136	70.8%
Total	192	100.0%
No Answer	829	
System Missing	390	
Total Missing	1219	
Total	1411	

For questions 16a - 16d, please tell us the level of water quality at which you would STOP visiting the lake you visited most often this summer.

Q16a. Which of the following water clarity depths would result in you no longer visiting this lake?

	Frequency	Valid Percent
You can see at most 12 feet deep into the water	28	2.8%
You can see at most 6 feet deep into the water	153	15.5%
You can see at most 1 foot deep into the water	421	42.7%
Water clarity plays no role in my decision to visit this lake	384	38.9%
Total	986	100.0%
No Answer	35	
System Missing	390	
Total Missing	425	
Total	1411	

Q16b. Which of the following unpleasant odor conditions coming from the water would result in you no longer visiting this lake?

	Frequency	Valid Percent
Faint unpleasant odor	91	9.2%
Noticeable unpleasant odor	430	43.6%
Strong unpleasant odor	362	36.7%
Unpleasant odor plays no role in my decision to visit this lake	103	10.4%
Total	986	100.0%
No Answer	35	
System Missing	390	
Total Missing	425	
Total	1411	

Q16c. Which of the following abundance levels for each fish type would result in you no longer visiting this lake?

Q16c. Cold water species (trout, whitefish, or salmon).

	Frequency	Valid Percent
Common	73	11.6%
Less common	121	19.2%
Rare	163	25.9%
No longer present	91	14.5%
Fishing for cold water species plays no role in my decision to visit this lake	181	28.8%
Total	629	100.0%
Not applicable	322	
No Answer	70	
System Missing	390	
Total Missing	782	
Total	1411	

Q16c. Warm water species (bass, sunfish, or catfish).

	Frequency	Valid Percent
Common	53	12.0%
Less common	74	16.7%
Rare	88	19.9%
No longer present	54	12.2%
Fishing for cold water species plays no role in my decision to visit this lake	173	39.1%
Total	442	100.0%
Not applicable	422	
No Answer	157	
System Missing	390	
Total Missing	969	
Total	1411	

Q16d. Which of the following algae bloom conditions would result in you no longer visiting this lake?

	Frequency	Valid Percent
Algae bloom covers less than 10% of the lake	120	12.1%
Algae bloom covers 10 – 25% of the lake	280	28.3%
Algae bloom covers 25 – 50% of the lake	248	25.1%
Algae bloom covers over 50% of the lake	171	17.3%
Algae blooms play no role in my decision to visit this lake	169	17.1%
Total	988	100.0%
No Answer	33	
System Missing	390	
Total Missing	423	
Total	1411	

Q17a. Currently is there a lake that you don't visit in the summer because the water quality is too poor?

	Frequency	Valid Percent
Yes	165	16.7%
No	825	83.3%
Total	990	100.0%
No Answer	31	
System Missing	390	
Total Missing	421	
Total	1411	

➔ *If you answered no, skip to Question 18.*

Q17b. If yes, which lake?

Rivers Section

The questions in the next three sections of this survey - Questions 18 through 27 - have to do with rivers in Utah. If neither you nor members of your household visited any rivers in Utah in the last 12 months please fill in this circle and skip to Question 28 on page 11.

Rivers Recreation

Q18. In the last 12 months which types of activities did you or members of your household typically participate in during your river visits? *(Mark all that apply.)*

	Frequency	Valid Percent*
Boating (includes motor-boating, house boating, sailing, canoeing, kayaking, jet skiing)	99	17.0%
Fishing for warm water fish species (for example, bass, perch, catfish, crappie, sunfish)	71	12.2%
Fishing for cold water fish species (for example, trout, whitefish, salmon)	276	47.5%
Swimming (includes playing in the water, wading, windsurfing, water-skiing, tubing)	158	27.2%
Near-shore activities (includes walking, biking or running on trails, bird/wildlife/nature viewing, picnicking, camping)	419	72.1%
Hunting – waterfowl	30	5.2%
Hunting/Trapping – other	30	5.2%
Total	581	
No Answer	23	
System Missing	807	
Total Missing	830	
Total	1411	

*Percentages for 'Mark all that apply' may total greater than 100%.

Q19. In the last 12 months which ONE activity did YOU spend the most time doing during your river visits? *(Choose only one.)*

	Frequency	Valid Percent
Boating (includes motor-boating, house boating, sailing, canoeing, kayaking, jet skiing)	43	7.7%
Fishing for warm water fish species (for example, bass, perch, catfish, crappie, sunfish)	16	2.9%
Fishing for cold water fish species (for example, trout, whitefish, salmon)	169	30.3%
Swimming (includes playing in the water, wading, windsurfing, water-skiing, tubing)	27	4.8%
Near-shore activities (includes walking, biking or running on trails, bird/wildlife/nature viewing, picnicking, camping)	293	52.6%
Hunting – waterfowl	2	0.4%
Hunting/Trapping – other	7	1.3%
Total	557	100.0%
No Answer	47	
System Missing	807	
Total Missing	854	
Total	1411	

Perceptions of River Water Quality in the Summer

We are interested in your personal perceptions of river water quality in Utah. Please answer all of the questions in this section - Questions 20 through 26 - for the river that you visited most often this summer. By summer we mean May through September.

Q20. Which river in Utah did you visit most often this summer? Please record the river ID number (or if the river does not have an ID number then write in the name of the river and the nearest town) and how long you have been going to this river.

Q21. For each of the months listed below, how many visits did you make to this river? For the month of September (post-Labor Day) please estimate the total number of visits you will make.

Q22. Which of the following unpleasant odor conditions coming from the water did you usually experience at this river this summer?

	Frequency	Valid Percent
No unpleasant odor	486	84.1%
Faint unpleasant odor	54	9.3%
Noticeable unpleasant odor	18	3.1%
Strong unpleasant odor	1	0.2%
Total	19	3.3%
Don’t know	578	100.0%
No Answer	26	
System Missing	807	
Total Missing	833	
Total	1411	

Q23. Which of the following abundance levels for each fish type did you expect to be present at this river this summer?

Q23a. Cold water species (trout, whitefish, salmon).

	Frequency	Valid Percent
Abundant	94	30.0%
Common	170	54.3%
Less common	31	9.9%
Rare	18	5.8%
Total	313	100.0%
Don't know	109	
Not applicable	140	
No Answer	42	
System Missing	807	
Total Missing	1098	
Total	1411	

Q23b. Warm water species (bass, sunfish, or catfish).

	Frequency	Valid Percent
Abundant	18	14.2%
Common	27	21.3%
Less common	32	25.2%
Rare	50	39.4%
Total	127	100.0%
Don't know	125	
Not applicable	211	
No Answer	141	
System Missing	807	
Total Missing	1284	
Total	1411	

Algae conditions in rivers typically change from May through September (see photos for what we mean by algae conditions). For Question 24a and 24b think about the algae condition as it would appear in late summer (e.g., August and September).

Q24a. Which of the following algae conditions did you usually see in late summer at this river?

	Frequency	Valid Percent
Present algae are brownish green and short	125	30.6%
Present algae are dark green and long	106	26.0%
Algae are not present	122	29.9%
Cannot see river bottom	55	13.5%
Total	408	100.0%
Don't know	157	
No Answer	39	
System Missing	807	
Total Missing	1003	
Total	1411	

Q24b. How much of the river bottom appeared covered by algae in late summer at this river?

	Frequency	Valid Percent
Less than 10%	180	52.9%
From 10 - 40%	120	35.3%
From 40 -75%	30	8.8%
More than 75%	10	2.9%
Total	340	100.0%
Don’t know	235	
No Answer	29	
System Missing	807	
Total Missing	1071	
Total	1411	

Potential Changes to River Quality in the Summer

Water quality in rivers can change with the seasons. Changes in water quality may or may not affect the number of visits you make to a river.

Q25. When you think about the river you visited most often this summer, what importance do you personally place on each of the following attributes in choosing to visit this river?

Q25a. No unpleasant odor.

	Frequency	Valid Percent
No Importance	50	8.8%
Low Importance	90	15.9%
Moderate Importance	210	37.0%
High Importance	217	38.3%
Total	567	100.0%
No Answer	37	
System Missing	807	
Total Missing	844	
Total	1411	

Q25b. Cold water fish species are present.

	Frequency	Valid Percent
No Importance	158	28.2%
Low Importance	87	15.5%
Moderate Importance	118	21.1%
High Importance	197	35.2%
Total	560	100.0%
No Answer	44	
System Missing	807	
Total Missing	851	
Total	1411	

Q25c. Warm water fish species are present.

	Frequency	Valid Percent
No Importance	289	54.7%
Low Importance	148	28.0%
Moderate Importance	64	12.1%
High Importance	27	5.1%
Total	528	100.0%
No Answer	76	
System Missing	807	
Total Missing	883	
Total	1411	

Q25d. Long threads of dark green algae are not present.

	Frequency	Valid Percent
No Importance	72	13.0%
Low Importance	196	35.5%
Moderate Importance	179	32.4%
High Importance	105	19.0%
Total	552	100.0%
No Answer	52	
System Missing	807	
Total Missing	859	
Total	1411	

Q25e. Proximity to your home.

	Frequency	Valid Percent
No Importance	38	6.7%
Low Importance	75	13.2%
Moderate Importance	193	33.9%
High Importance	263	46.2%
Total	569	100.0%
No Answer	35	
System Missing	807	
Total Missing	842	
Total	1411	

Q25f. Other (describe).

	Frequency	Valid Percent
No Importance	16	26.7%
Low Importance	1	1.7%
Moderate Importance	8	13.3%
High Importance	35	58.3%
Total	60	100.0%
No Answer	544	
System Missing	807	
Total Missing	1351	
Total	1411	

For questions 26a-26c, please tell us the level of water quality at which you would STOP visiting the river you visited most often this summer.

Q26a. Which of the following unpleasant odor conditions coming from the water would result in you no longer visiting this river?

	Frequency	Valid Percent
Faint unpleasant odor	46	8.0%
Noticeable unpleasant odor	253	44.0%
Strong unpleasant odor	211	36.7%
Unpleasant odor plays no role in my decision to visit this river	65	11.3%
Total	575	100.0%
No Answer	29	
System Missing	807	
Total Missing	836	
Total	1411	

Q26b. Which of the following abundance levels for each fish type would result in you no longer visiting this river?

Q26b. Cold water species (trout, whitefish, or salmon).

	Frequency	Valid Percent
Common	40	10.2%
Less common	82	20.9%
Rare	99	25.2%
No longer present	55	14.0%
Fishing for cold water species plays no role in my decision to visit this river	117	29.8%
Total	393	100.0%
Not Applicable	176	
No Answer	35	
System Missing	807	
Total Missing	1018	
Total	1411	

Q26b. Warm water species (bass, sunfish, or catfish).

	Frequency	Valid Percent
Common	21	9.1%
Less common	30	13.0%
Rare	36	15.6%
No longer present	26	11.3%
Fishing for cold water species plays no role in my decision to visit this river	118	51.1%
Total	231	100.0%
Not Applicable	283	
No Answer	90	
System Missing	807	
Total Missing	1180	
Total	1411	

Q26c. Which of the following amounts of algae (dark green and long in length) covering the river bottom in late summer would result in you no longer visiting this river?

	Frequency	Valid Percent
Covers 10 - 40% of river bottom	138	24.3%
Covers 40 -75% of river bottom	153	26.9%
Covers more than 75% of river bottom	91	16.0%
Algae covering the river bottom play no role in my decision	186	32.7%
Total	568	100.0%
No Answer	36	
System Missing	807	
Total Missing	843	
Total	1411	

Q27a. Currently is there a river that you don't visit in the summer because the water quality is too poor?

	Frequency	Valid Percent
Yes	34	6.0%
No	535	94.0%
Total	569	100.0%
No Answer	39	
System Missing	803	
Total Missing	842	
Total	1411	

➔ *If you answered no, skip to question 28.*

Q27b. If yes, which river?

Trips to Out-of-State

Q28. In the last 12 months, how many trips did you or members of your household take to lakes and rivers out of state?

Q28a. Lakes

	Frequency	Valid Percent
0	728	68.4%
1	157	14.8%
2	77	7.2%
3	29	2.7%
4	27	2.5%
5	16	1.5%
6	4	0.4%
7	3	0.3%
8	4	0.4%
9	2	0.2%
10	6	0.6%
11	1	0.1%
12	4	0.4%
15	2	0.2%
23	1	0.1%
25	1	0.1%
30	1	0.1%
32	1	0.1%
Total	1064	100.0%
No Answer	347	
Total Missing	347	
Total	1411	

Q28b. Rivers

	Frequency	Valid Percent
0	732	71.6%
1	137	13.4%
2	69	6.8%
3	21	2.1%
4	20	2.0%
5	15	1.5%
6	7	0.7%
7	4	0.4%
8	3	0.3%
9	2	0.2%
10	8	0.8%
15	4	0.4%
Total	1022	100.0%
No Answer	389	
Total Missing	389	
Total	1411	

Demographics

Finally, we have a few questions about you and your household needed for statistical purposes. Your responses are completely confidential.

Q29. Are you male or female?

	Frequency	Valid Percent
Male	814	58.7%
Female	573	41.3%
Total	1387	100.0%
No Answer	24	
Total Missing	24	
Total	1411	

Q30. In what year were you born?

	Frequency	Valid Percent
18 - 24 years	19	1.4%
25 - 34 years	96	7.0%
35 - 44 years	157	11.4%
45 - 54 years	261	18.9%
55 - 64 years	356	25.8%
65 or older	489	35.5%
Total	1378	100.0%
No Answer	33	
Total Missing	33	
Total	1411	

Q31. What is the highest level of school you have completed?

	Frequency	Valid Percent
Some high school	19	1.4%
High school graduate or GED	200	14.6%
Some college or technical school	515	37.5%
Undergraduate degree	247	18.0%
Some graduate school	85	6.2%
Graduate degree	306	22.3%
Total	1372	100.0%
No Answer	39	
Total Missing	39	
Total	1411	

Q32. Including yourself, how many adults, age 18 or older, currently live in your household?

	Frequency	Valid Percent
0	11	0.8%
1	174	12.6%
2	892	64.4%
3	195	14.1%
4	82	5.9%
5	23	1.7%
6	5	0.4%
7	2	0.1%
8	1	0.1%
Total	1385	100.0%
No Answer	26	
Total Missing	26	
Total	1411	

Q33. How many children, age 17 or younger, currently live in your household?

	Frequency	Valid Percent
0	932	69.3%
1	140	10.4%
2	123	9.2%
3	83	6.2%
4	44	3.3%
5	16	1.2%
6	4	0.3%
7	2	0.1%
Total	1344	100.0%
No Answer	67	
Total Missing	67	
Total	1411	

Q34. Are you of Hispanic, Latino, or Spanish origin?

	Frequency	Valid Percent
Yes	37	2.7%
No	1343	97.3%
Total	1380	100.0%
No Answer	31	
Total Missing	31	
Total	1411	

Q35. Here is a list of racial categories. Please select one or more to describe your race. ***(Mark all that apply.)***

	Frequency	Valid Percent*
White	1340	97.6%
Black or African American	8	0.6%
American Indian or Alaska Native	19	1.4%
Native Hawaiian or other Pacific Islander	8	0.6%
Asian	13	0.9%
Some other race	21	1.5%
Total	1373	
No Answer	38	
Total Missing	38	
Total	1411	

*Percentages for 'Mark all that apply' may total greater than 100%.

Q36. Next we'd like to ask about your household income. Your answer will only be used for comparing groups of people. Which of the following income groups best describes your household's total income in 2010, before taxes?

	Frequency	Valid Percent
Less than $25,000	121	9.3%
$25,000 up to $50,000	337	25.8%
$50,000 up to $75,000	316	24.2%
$75,000 up to $100,000	233	17.8%
$100,000 up to $150,000	184	14.1%
$150,000 up to $200,000	67	5.1%
$200,000 or more	50	3.8%
Total	1308	100.0%
No Answer	103	
Total Missing	103	
Total	1411	

Q37. Do you belong to any local, state or national organization whose main purpose is to protect the environment?

	Frequency	Valid Percent
Yes	153	11.1%
No	1226	88.9%
Total	1379	100.0%
No Answer	32	
Total Missing	32	
Total	1411	

Q38. How many years have you lived at your current residence or within 50 miles of your current residence?

Q39. Which of the following applies to your household? *(Mark all that apply.)*

	Frequency	Valid Percent*
Primary residence is on a lake	5	0.4%
Primary residence is on a river	17	1.3%
Own a second home on a lake	65	4.8%
Own a second home on a river	25	1.8%
Pay a moorage or slip fee for your boat	70	5.2%
Pay dues/fees for a water-based club	22	1.6%
None of the above	1173	86.5%
Total	1356	
No Answer	55	
Total Missing	55	
Total	1411	

*Percentages for 'Mark all that apply' may total greater than 100%.

Thank you for participating in this survey. If you have comments on the survey or water quality in Utah, please use the space below.

- #3-our entire family over the 4th of July, 35 people. It is not right that the BOR is trying to take over all lakes and rivers in Utah. Our state government should handle all of our waters and land.
- 16c- Fish abundance would only change our fishing trips not our boating and skiing trips.
- A clean environment, air, water, land, is very important to us. We support several environmental organizations but it's not enough We want the State of Utah to help more.
- Always informed of large amounts of fish being planted, but fishing is always poor for me and my friends. Limits used to be higher and easier to achieve!
- As age 88 I don't fish or water ski now. Gave boat to son out of state.
- B.O.R. The reclamation placement of vault toilets in areas of where sewer systems have been established and in place. Lack of resources and interest to maintain new and old developed areas. Scofield, UT.
- Bad bugs (gnats) on Willard.
- Bear Lake is a beautiful place and I find it well taken care of. I am a southerner and I know what I am saying.
- Brigham City has good tasting as well as clean water for drinking purposes but it disturbed me when I realized fluoride had been added. It may be good for your teeth in toothpaste but it is poison to our bodies. Warnings on toothpaste "Do not swallow".
- Burraston Ponds by Mona, Santaquin area used to be a beautiful place to go, but the last two times my family was there, the bathrooms were in poor shape. The place was trashy. I won't go back.
- Clean up Utah Lake so I wouldn't have to go so far to water ski.
- Could be simpler and easier to fill out. Would have gone more if not for gas prices.
- Deer Creek Reservoir is filling up with Carp. Soon it will be just like Utah Lake. Also, the Trout fishing is declining noticeably. It's too bad, this is a great lake. It is being managed poorly and is over fished.
- Didn't visit.
- Don't give Nevada any of our water.
- Due to illness, did not do any boating or fishing this year.

- Due to seven deaths in my family from January to September, I haven't visited any lakes this year.
- Due to surgery, we have not made trips this year but we have visited many lakes and rivers in other years. We love Utah's beauty outdoors.
- Dumb survey. Not all lakes are included. All lakes on Lasal Mountain are excluded. Was any of the tax payer's money spent on this project? I received it twice. Lots of paper used for this nonsense. Waste of trees.
- Even though our family has not visited a lake or river in the past year, we strongly support measures, fees, and taxes necessary to protect the quality of the environment for current and future generations, all lakes and all rivers in Utah.
- Even though water clarity isn't important for fishing catfish in Utah Lake, it would still be nice to have better water clarity. Less algae/floating weeds would be best for boating and water sports.
- Four wheeler ATV's off existing roads have been seen as a water quality problem.
- From what I have seen, the water quality in Utah is well looked after. It has gotten better over the years.
- Garbage on lakes and in shores.
- Habitat restoration for trout in the Spanish Fork River drainage needs attention.
- Hope my answers help with survey!
- I am 83 years old and my wife is 79. Our health prohibits us from doing any camping and much visiting.
- I am a 77 year old widow and have not visited lakes or rivers in the last few years.
- I am concerned about accessibility. If one can't access the water, the quality of the water quickly becomes a non-issue.
- I am concerned about mercury in fish and drinking water as well as other pollutants. I am comfortable drinking tap water in SLC, not sure of other areas. I still think the water here, in the USA, is better than most of the world. We should strive for best possible quality.
- I am sorry I do not use these facilities.
- I am too old. Visits to lakes and rivers are in the past.
- I am very concerned with the low water levels that the state allows the Weber River (below Echo and the Ogden River, below Pineview Dam). Loss of variable Trout is in high jeopardy. I also wonder why Bass are not planted like Trout in warm water resevoirs. It is time to do what the fishermen want.
- I avoid waterways that charge fees for use. I used Great Salt Lake marshes a lot for duck hunting, maybe 15 times.
- I believe in multiple uses, but I think it is utmost important to keep our waters clean and open to public recreation.
- I bought a mobile home from what turned out to be illegal aliens from Mexico; I got a parasite from that home and cannot go anywhere, not even church, because it's a danger to other people so I cannot even go fishing.
- I command those who participate in this effort.
- I do not swim, go fishing or boating. My activities are in gardening, cooking, and sewing. Sorry I'm not an outdoor person; I'm not even into hiking. That's why I didn't answer the first letter.
- I do not visit Kolob. I believe we need to restrict the use of four wheelers (ATV's). My last two visits were very unpleasant, young kids driving the dirt roads too fast and too loud for me, lots of dust.

- I do not want to promote the building of a water pipeline from Lake Powell to St. George and Cedar City. Let them zero scape their yards and use gray water for their golf courses.
- I don't know why I was called upon to answer questions, maybe a list from boat owners or fishermen, etc. would be better.
- I enjoy the lakes and rivers very much in Utah.
- I enjoy Utah's beautiful rivers and lakes. I love the outdoors and Utah provides many beautiful places to visit. The rivers and lakes are only a short drive away.
- I feel our water quality is very good in northern Utah. I am concerned about Mussel problem. Thank you for this opportunity.
- I feel that everyone who pays taxes for over 50 years of their life after they reach 65 years old should get a free pass on all of our State and Federal parks and campsites. Our government has taxed and spent us our country to a bad debt. Why don't they balance their budget like most people do. You only buy what you can pay off. Let's let the million of billionaires that make all the big money tax or help pay the debt off. They are the ones that are living so good. I think we need change in our government that will get us out of debt or get our [illegible] to where everyone can live.
- I firmly support environment policies that promote and protect our rivers and lakes. I oppose any activities that degrade our state's rivers and lakes. I follow environmental legislation on a state and national level and I vote in every election, supporting candidates who support and promote the preservation of Utah's wild environment, lakes and rivers. I will also spend a significant amount of money supporting local economies, in southern Utah, for example, that put environmental protection first.
- I fish local lakes a lot, 15 to 18 times a month during the summer and fall. Not much of a river fisher.
- I have a boat, but health conditions presently keep me from using it.
- I have been very sick this year due to cancer and heart problems. Have not been able to go fishing, etc. to enjoy our waterways. Hope to next year!
- I have found that water quality in both Ottercreek and Piute have been satisfactory.
- I have maintained a sailboat on the Great Salt Lake since 1978. Obviously that body of water has been my primary focus. It does not fit the emphasis of the survey.
- I have no money or a way to do all these things. I [illegible] to do all these things; poor health and no time.
- I have not fished in the last 15 years. Before that, all over Utah.
- I have not visited any lakes or streams in Utah for 75 years.
- I have noticed that noxious weeds have invaded the stream and lake banks I have visited. Riparian areas along the Price River are full of Russian Olive, Salt Cedar, Thistle, etc!
- I hope this helped out in some way. Utah has great fishing, let's keep it that way.
- I love all the lakes! I wish I had more money to go more!
- I love clean water where nature takes it's course. The more natural, the better. I want my family able to play/swim without worry of what's in the water chemical wise. Thanks.
- I love the mountains but have been ill this past year.
- I love Utah waters. I spend as much time as I can on lakes. I wish we could spend more time cleaning our shores. People are slobs and leave trash everywhere; that's my biggest problem. We need to start kicking butts.
- I never want fluoride added to our drinking water.

- I only when boating once with our children this year. My husband is handicap so we can't do this type of activity any more. We used to go every year to Moon Lake when our family was young and growing up. We love Moon Lake and some of our married children still go there every year with their family.
- I sold my jet skis because of the expense imposed by Utah and the harassment by DWR officers at Willard Bay. I stopped fishing because it is more for pro fishermen.
- I spend a lot of time near the rivers, far too many to cover. Mostly for off shore activities like running, hiking, and cycling.
- I sure wish that I could visit a beautiful Utah river or lake.
- I think all boaters should have to take a boating safety class before licensing their boat the first time.
- I think the drinking water is a problem. Ours has floaties and makes us ill.
- I think the survey is flawed. It doesn't ask if I would visit a lake more if the water quality were better. I would visit Utah Lake much, much more if it wasn't stinky and even if it had three feet of visibility instead of three inches.
- I think the water is fine. I fished Sevier a lot when I was younger, I'm 84 now. I miss it. Fished Koosherem and Otto Creek, but health won't let me now.
- I think Utah Lake should be dredged. I would be willing to donate. It is a disgrace to Utah. They've dredged some of the Great Lakes. We could do it to Utah Lake.
- I used to visit many Utah waters, High Uintah Mountains, Scofield Reservoir, Strawberry Reservoir, and adjacent streams and lakes with a fishing pole in my hand. Now I am recovering from knee, hip, and shoulder replacements and must be content to watch water recreation on TV.
- I was born in Jackson Wyoming. Until this year I have utilized the watersheds of Northern Utah and western Wyoming heavily. I'm an outdoors guy. I suffered shoulder damage in early spring 2011 that really wrecked my lifestyle this year. In general, there has been an increase in the quality of Utah water over the last ten years. Wyoming's are suffering due to heavy traffic. Darn undereducated tourists. Sorry I couldn't have been help.
- I wish I could have given you a better survey. In the last couple of years I have been disabled to the extent that I cannot drive a car and have to use a cane or walker to get around.
- I wish they would stock trout in Millcreek Canyon (386 stream or creek). There seems to be no fish up at the top of the canyon where I used to fish in past years.
- I worry about the future water quality at Bear Lake. The water is still very clear, but during low lake level years (which are quite often) people are allowed to park their vehicles on the then dry lake bed near the water. All vehicles drop some kind of fluid, oil, gas, antifreeze, etc. Overtime, this along with the trash people leave will eventually hurt this pristine, clear, beautiful lake. It is sad to know that a lot of people are really PIGS!
- I would go to Utah Lake more often because it is closer to our home, but it seems too polluted.
- I'm concerned about it, that's why I buy bottled. I don't like the taste of chlorine.
- I'm very ill now, but 10 years ago when I had my wave runner I went to East Canyon Reservoir a lot. It was beautiful water except Echo was dirty. I caught some kind of rash and still have flare-ups. Strawberry was okay but too crowded. East Canyon was our favorite.
- Idaho manages their fisheries much better than Utah without the harassment.
- If this survey included a period of the five years I could have participated.
- If we keep letting the federal government take more and more land as "wilderness area" our Utah towns are going to suffer from lack of tourism, (Torrey and Moab, etc.). Accessibility is very important!

- In our younger days we visited most lakes, rivers, and reservoirs in Utah, Idaho, Wyoming, and Montana. Our water then was clean and accessible.
- In previous years, I have used the lakes and rivers a lot more. I enjoy the rivers and lakes in Utah. My name was not correct when this was mailed to me. It was my address.
- In the past, we have gone boating at Utah Lake and water clarity and bugs were really bad. This year we went once, mid-August, and the conditions were much better!
- In years past, I have visited lakes and rivers in Utah, but because of age, in the last few years I have not done any river or lake recreation.
- Intentionally omitted 34,35,36.
- Is it possible to cleanup the water in Strawberry Reservoir in late summer-autumn months?
- It is very difficult to find places to fish from when you are dependent on wheelchairs or walkers.
- It may not seem like I care about water quality or fish and wildlife from my answers to this survey, but I do. I just really enjoy water recreation. Also my household attendance to water areas varies from year to year. This year was a lower one.
- It was finally a pleasure to visit Palisade, where our children could finally get in the water.
- It would be nice if visitors to lakes were monitored better in terms of their impact. I.e. repercussions for polluting especially! Fishing line left all over shore. Particularly bad at East Canyon Reservoir.
- It would be nice to have an accessible beach for families for kiteboarding with bathroom facilities.
- Just great.
- Just want to say that we have visited other lakes in Utah and rivers in years past that we like to visit. We hope that all the lakes in Utah will remain and remain clean with lots of fish to catch.
- Keep sheep and cattle out of high country streams and rivers. The [expletive removed]-faced brutes destroy the riparian zone, limit the number of fish that can inhabit the rivers, and pollute the water!
- Kind of a good waste of government money for this.
- Lake Bear, Lake Logan have too much agricultural waste. My biggest concern with all lakes and rivers is trash. Many upstream residents on Barton Creek dispose trash into the creek.
- Lake Powell is both in Utah and Arizona. Our boat is moored in Wahweap Marina, Page, AZ.
- Lake Powell was very clean this year.
- Lakes and rivers in Utah managed well.
- Lakes in Utah are beautiful. Had some health problems or would have visited more. Usually fish or camp but didn't do any this year. Love going to the lakes and streams.
- Lakes need more shade areas and facilities.
- Let some water out of Bear Lake to have some beaches back. Bear Lake is losing money due to lack of beach and parking for tourists.
- Long!
- Love and enjoy the lakes and rivers; they are clean, clear, and beautiful.
- Love the higher water levels but the debris is bad.
- Love the Uintah lakes!

- Magna water is not good. But most of the rest of the state has great water as far as I've had.
- Map/tables were hard to use. The map showed numbers at locations. The tables should be listed in numerical order to both numerically and a separate alphabetically. Looking up the ID number took too much time.
- Misapplication of trophic models in Utah is causing (in my opinion) mismanagement of Cutler Reservoir (ID 4). Cutler is a fun warm-water fishery that reminds me of southeastern bass ponds. Manage it that way.
- More concerned with fishing quality!
- Most of my visits to lakes and rivers are in Idaho to go fishing. Much better fishing in Idaho!
- Most of the trips are search and rescue or diving/training.
- Moved here from Midwest and miss the different variety of fish types in the lakes. If we could stock lakes with more warm water species it would be great.
- My dad has a pond in Cache Valley by Wellsville which is spring fed, we have rainbow trout in it. Water quality is important; the canal above for irrigation from Hyrum Reservoir needs to stay clean.
- My family primarily visits the Ogden River to rider our bicycles on the parkway. Pineview Reservoir is an enjoyable day visit for the kids to splash around in. I do not fish nor do I own a boat for skiing/recreation.
- My husband is ill, he is housebound; we can't do much. When he was well we did a lot of camping, always by water. Sorry.
- My husband rides the Jordan River Trail. Provo River was the only river we visited this year. That was to see Bridal Veil Falls.
- My wife and I are not boaters and do not fish. Our only contact with lakes and streams are when we ride our bikes along trails that are near lakes and streams.
- Need more wipers and walleye to Willard!
- Never take our lakes and river trips from the people! Keep open!
- No dams on the Bear River.
- No questions can be asked about income, ever! Even if it "appears" to be anonymous.
- No to the pipeline from Lake Powell! Keep the water where it is.
- None this year. Wife's health would not let us, usually we do!
- Of most lakes and rivers I have visited through out my 66 years, I think Utah has good water quality in most of them.
- Ogden River is improving every day. The new trails are very nice.
- One second home at Flaming Gorge, spend half the summer there.
- One year snap shot not as good as average visits would be.
- Our family has lived in Utah for 19 years now and we have owned a boat for 15½ years and camped with a tent, tent trailer, or motorhome for 16 years. We love the outdoors here in Utah and will continue to frequent as make Lakes and Reservoirs as possible. Our favorites are Lake Powell, Flaming Gorge, Bear Lake, Utah Lake, Jordanelle, Willard Bay, Soldier Creek, and Hyrun Reservoir. We hope that this survey helps all waterways stay open, clean, and accessible!
- Our time at lakes is spent more in the winter. We did not spend as much time at the water ways this year as usual due to weather conditions and water levels.
- Our visit to Bear Lake: Need to have toilets accessible so the lake is not used for the bathroom.

- Over population is ruining lakes, streams, and camping.
- Overall, Utah lakes and rivers are in good shape and among the best in the western United States.
- People smoking near our rivers and lakes and throwing their butts in our waters really bugs me!
- Place a low dam across (just south of) both northern arms of GSL very wide; turn both arms into fresh water, that would make fresh water available to the northwest arm of the lake for many uses and even provide a wide area as a road bed to reach the northwest side and make it useful, even for recreation.
- Plant more fish in Strawberry Reservoir. Fishing has been slow in the past three years. It's one of the most beautiful lakes in the state. Thanks.
- Please note that my reasons for visiting most lakes are work related as I am part of water quality monitoring surveys. For work I visit sites regardless of water quality. For recreation my answers would be different but the lake I visit most often is the result of work.
- Please raise the limit back to 8 fish. I wish the limit was more than 2 or 4, it should be 8. This would make me fish longer and stay longer. Less makes camping not worth it anymore.
- Please take care of our rivers or lakes. Would like to see people fined for trashing our lakes and rivers.
- Pretexting Utah rivers and lakes is important for maintaining the quality of life that draws both visitors and people moving to Utah.
- Quality of water in Utah is good.
- Question 39, have a second home in a town near a lake.
- Really, I just trust the government to keep track of the water quality. I just travel to enjoy the scenery. Usual routes from my home in Ogden are to Farmington, Bountiful, and Salt Lake. I also travel to Logan or Hyrum Highway 89 and up to Bear Lake. Also, I go north from Logan to the Idaho border to Soda Springs. So I visit the lakes and rivers on my travels. Too bad towns were not on the north Utah area. Numbers were too hard to pinpoint rivers and lakes.
- Right now all I do is eat, work, sleep.
- Scofield, Strawberry & Current Creek Res. All have algae issues that slightly detract from the overall fishing experience which is generally very good.
- Section 232 of Colorado River is in the National Park. The best presence the Park Service can have is NONE at all. Take away the patrol boats and 9mm's and give them row boats and garbage bags. It would be much more productive and cost effective. I know it is not the state's issue but it should be, look where it is.
- Significant snow/water year totals impacted run-off. This dramatically effected water quality/clarity. Need to explore methods to impede and slow run-off to more manageable levels. How is another question.
- Sorry I couldn't be of more help. For what it's worth, I believe the Lake Powell water pipeline to SW Utah is a money wasting boondoggle.
- Sorry we are not outdoor people.
- Sorry, I couldn't be of more help.
- Sorry, we have not gone or been to a lake or river this year.
- Thank you for all you do to make things as nice as possible!
- Thank you for the Reference Maps. Our family loves Utah and the recreation areas. The kids are all grown and gone. This has been a boring year.
- Thanks for caring!

- The boat ramps at Strawberry Reservoir are the worst in the state! Strawberry Reservoir does not honor Senior Citizen passes!
- The Colorado river below Moab is a concern for many due to the possible leaching of tailings from the Tailing Pile. It is in now in the process of being relocated.
- The idiots in Washington, mainly the party of “no” do not realize our natural resources need to be managed like EPA; they just want to sell public lands to the rich guys and put up “no trespassing” signs.
- The lake shores have way too much litter, mostly fishermen.
- The main reason we have not gone to the lakes and rivers is because my husband has terminal cancer and he can not travel at all. We used to go at least twice a month in the past. We love camping out and fishing, it’s the reason we moved here from California when we retired.
- The only place we go is Potter’s Pond and it is fantastic in every way.
- The State of Utah charges for night time use (double fee). They claim to pay rangers but no rangers are ever there. The state government has ran off a lot of people who would use the lakes but can’t afford double fees; [expletive removed] republicans.
- The Virgin River project to develop and protect nature’s trash fish is a big waste of money and effort.
- The water I am concerned about is drinking water and I hate having fluoride put in our drinking water.
- The water level in Willard Bay has been really high, therefore the quality of clean, clear water is all over the lake.
- The water quality in most lakes and reservoirs was great this year because of all the rain we’ve had and the extra snow in the mountains!
- The water quality in Utah is very good, there is nothing wrong with it.
- The water quality of irrigation reservoirs in the Uintah Basin is very good.
- This has been an exceptional year for us; as normally we do visit at least three to four Utah lakes and some rivers as well. We have never noticed bad odor or excessive algae blooms at the lakes we visit and feel like these resources have been well maintained.
- This is a very subjective survey. I don’t see how it can do much good. Questions are too subjected to guessing. The people’s garbage is the problem and not one question was asked about the subject.
- This is the first year in over 60 years I have not purchased a hunting or fishing license. Utah has so many changes and restrictions on every river and lake I would have to take a lawyer with me fishing to make sure I wasn’t breaking any laws. If Wyoming can offer a free license to seniors, why can’t Utah, with all their resources, do the same?
- This is the first year we haven’t gone down to King’s Pasture on the Boulder Mountain in 20 years.
- This past year was atypical. A down economy and health and family needs reduced lake/river recreation activities. Usually more time, activities, expenditures occur with or around Utah waterways. The quality of waterways is a high priority or me and future generations.
- This river constantly floods in the spring and early summer, areas need to be dredged so the water can move faster. I have 20 acres and it is not usable in the spring and summer.
- This survey should have been printed, conducted, and studied IN UTAH!
- Too much emphasis on recreation. Emphasis should be placed on water demands for the future.
- Too much litter around lakes.

- Typically my family and I enjoy the lakes and rivers in Utah. This past year was an exception for many reasons.
- Um creek is a beautiful little stream about ten miles above Fish Lake (past Johnson's Reservoir) it's beautiful!
- Use Idaho lakes and rivers more than Utah's. Fishing is better, the limits are higher.
- Utah is a poorly managed state.
- Utah Lake is usually a good place to picnic and do a little fishing. There are places to go where you don't have to pay. Provo Boat Harbor is close and you can get a permit yearly. Lincoln Beach is also good. The lake usually doesn't have a bad smell. Strawberry Reservoir is good for trout fishing and real fun with flies. They have a boat ramp and good parking.
- Utah Lake, for many, many years, is too shallow for safe boating. Hidden inlands, rocks, etc., pose hazards to boats, props, etc. This lake has a real problem with algae, water purity, etc. I used it only once or twice in all the years I've lived in Riverton, UT. I hope to get back to using Strawberry Resevoir fairly soon. That is where I went on a regular basis, in 2004, '05, '06. In 2007, I used Utah Lake (very little). 2008, '09, '10 and '11, I didn't get to lakes at all.
- Utah needs better management of resources. Too much road kill and no fish. We spend too much for a license and get not fish or game.
- Waste of time for government employees (you).
- Water quality is pretty good but I feel like Idaho's lakes and streams seem to be cleaner, not so much trash.
- Water quality is very important. Over my lifetime the quality is worsening.
- Water releases from bottom of Pineview Resevoir , makes Ogden River turbid and unfishable.
- We are all for public access to water ways but not through private land. We need to keep our private land private.
- We are doing just great with our rivers and lakes if we can just keep those environmental (Explitive Removed) out of the way.
- We are handicapped; some of these questions do not apply to us.
- We are opposed to the fluoride in our drinking water.
- We are retired. We have boated in Utah since 1952. We have visited most Utah lakes and several rivers. We have also trailered out 26 foot sailboat to many places outside Utah from Puget sound to Key West, Florida.
- We are too old to get out and enjoy the lakes and rivers like we did in our earlier years.
- We didn't visit any lakes or rivers in the last four years. Thanks.
- We do not go to the lakes anymore because of the inconsiderate wake boarders, lack of respect for fishermen, boating laws are not followed, etc.
- We don't visit the rivers/lakes because the kids are too little; when they get older, we plain on taking them a lot.
- We enjoy Utah Lake and enjoy its' poor reputation because it keeps the crowds away.
- We enjoy visiting the Gunnison Bend Reservoir and did a lot of fishing this year in the Sevier River with grandkids. The water is not great but it's close by and we have not time for travel to other lakes and rivers. Thanks.
- We enjoyed all lakes and rivers this year that our family visited. Nice Job!
- We go camping, not water sports.

- We have not had a chance to visit any lakes or rivers this year but last years past we have had opportunities. Utah's lakes are some of the most spectacular places to go and enjoy.
- We have not visit any lakes and/or rivers in Utah in the last 10 years.
- We have used lakes and rivers in Montana, but my husband died last year and I can't do that anymore.
- We have used the rivers and lakes in the past, just not this year.
- We have visited many lakes in prior years but health issues this year kept us home.
- We just moved to Utah, thus "no" years.
- We live a block from Rock Canyon and have a cabin in Smith Morehouse Canyon. Please do something about Utah Lake (dredge)?
- We live in a housing development near the Virgin River off of River Road and Riverside Drive in St. George. We enjoy the Virgin River view but seldom go to the river's edge due to mobility problems.
- We live in Taylorsville and I believe we have the best water in Utah. Thank for the maps. My grandson has been in Afghanistan and just came home so we will try to visit lakes and rivers next spring.
- We live on Stansbury Lake (#20), this lake needs to be cleaned up.
- We love Strawberry.
- We love to fish the Uinta Lakes but did not get out this year.
- We love Utah lakes and rivers and hope that the state of Utah is doing everything in its power to keep them healthy. The environment is very important to us; hopefully it is important to you too! Please make it more of a priority.
- We loved Fish Lake, had fun. Love Lake Powell! Utah Lake is close to us.
- We normally visit lakes and waterways in Utah, but due to financial and health problems, we did not make it this year. Favorites are camping along Mirror Lake Highway and Joe's Valley Reservoir.
- We only use lakes for fishing and this year we didn't go out much. We go to Deer Creek mostly and Rockport or East Canyon on occasion.
- We own property on the Duchesne River. Much damage was done to river banks during the high water.
- We really were upset when you started charging an extra $12.oo for night fishing, our most common way to fish. We and many of our friends, as well as others, quit going; we had already paid for a usage pass. We have been going back since it was lifted.
- We stayed away from the lakes and rivers this year. We have three kids under the age of five. The water reported from the news looked too dangerous.
- We used a lot of bodies of water for many years. Lyman Lake was one of our favorites when our children were young. My deceased husband was in the auxiliary Coast Guard and patrolled on Jordanelle and others.
- We usually go a lot more- lots of illness this year- we also go to Lake Powell & Flaming Gorge in regular years.
- We value the quality of our environment. We are very concerned about the small shell fish and thinking there should be more done to check the growth in our estuaries.
- We would like to have sewer dump docks at Flaming Gorge, maybe at Hide out. The one at Lucern Marina does not work most of the time, and there is only two for the whole lake. We need them bad!
- When visiting lake 134 the bugs were terrible and the foul odor was bad. I feel more people would visit that lake if something was done with the bugs and the foul smell.

- While Panguitch Lake is not a high priority with me, I think the high algae problem in the fall months can be reduced by re-repairing cattle fences upstream and moving the cattle from near the lake itself. Thank you for conducting this survey.
- Why am I sending a survey about Utah water to Wyoming? Also, why did you leave off the largest lake in the state? My sailboat is at Great Salt Lake, State Marina, not Antelope Island, which isn't a lake.
- Why is the state wasting our tax money on this survey and other like it?
- Willard Bay has the worst quality water around here and has the worst bug population so we never go there ever!
- Wish you could get the algae bloom under control in Sand Hollow/Quail Creek.
- Would like to see more fish stocked in lakes.
- You're wasting my time and tax money. I don't hunt because I refuse to buy a license to enter a lottery. I don't fish because the rules are so complicated I'd be sure to violate them.
- Your questions on this survey have little or nothing to do with real water quality. Most of the questions you are asking pertain more to natural seasonal changes in our lakes and rivers.
- Your reference maps are hard to follow. If putting them in alphabetical order, then number them that way also. Also, if this is a survey of Utah lakes and rivers, why are we paying the University of Wyoming for the survey? Let's keep the money in our state to support or economy!

Appendix I
Methods and Results for Evaluation of Nutrient Conditions in Utah Water Bodies for Recreation Demand Survey

APPENDIX I

Methods and Results for Evaluation of Nutrient Conditions in Utah Water Bodies for Recreation Demand Survey

The following section documents the methods and results for the projection of future water quality conditions under current policy and under the proposed Nutrient Reduction Program. The results of this analysis were used in the recreation demand modeling to estimate the economic benefit of implementing the Nutrient Reduction Program.

Water Quality Parameters

Several water quality parameters were selected as indicators of impacts associated with excess nutrients in Utah water bodies that would potentially affect recreationists' behavioral choices. In addition to being good indicators of eutrophication, the parameters needed to have a dataset from a large number of water bodies in order to be useful for the recreation demand modeling.

For lakes and reservoirs, the two parameters selected were the trophic state index (TSI) for Secchi depth [TSI(SD)] and the difference between the trophic state index for Chlorophyll a [TSI(CHL)] and TSI(SD). The TSI was originally developed by Carlson (1977) as an indicator of algal biomass in lakes using three parameters: Secchi depth, Clorophyll a, and total phosphorus. The index ranges from approximately zero to 100, although the index theoretically has no lower or upper bounds. The index involves a logarithmic transformation of the parameters that results in interpretation of the trophic state in 10-unit increments. Following are the equations used to calculate the indices:

$$TSI(SD) = 60 - 14.41 \ln(SD)$$
$$TSI(CHL) = 9.81 \ln(CHL) + 30.6$$

The TSI(SD) is an indicator of water clarity, which is directly tied to algal concentration; however, in some lakes and reservoirs the water clarity is primarily due to inorganics such as suspended solids or naturally occurring tannins. In order to distinguish between turbidity associated with sediments and turbidity associated with algae, the parameter TSI(CHL) – TSI(SD) was calculated. In general, a positive value of this parameter indicates an algal dominated lake and a negative value indicates a suspended sediment dominated lake.

For rivers and streams, the three parameters selected were total phosphorus, total inorganic nitrogen and dissolved oxygen saturation. Total phosphorus and total inorganic nitrogen, which is ammonia plus nitrate/nitrite, are direct measures of excess nutrients. Dissolved oxygen saturation (DOSAT), expressed as a percentage, is a response variable that when either too low or too high is an indicator of eutrophication. For maintenance of aquatic health, dissolved oxygen concentrations should approach saturation (i.e. DOSAT = 100%), which is the concentration that is in equilibrium with the partial pressure of atmospheric oxygen (Wang et al. 2003). In general, the optimal range of DOSAT is between 90% and 110%, though systems not impacted by excess nutrients will naturally fall outside of that range as well.

Current Conditions

Assessment of current conditions of Utah water bodies was based on monitoring data collected by UDWQ from January 1, 2006 to December 31, 2010, the 5 most recent years of data available at the time of this study. Data from individual monitoring stations were aggregated to the map identification (MAPID) level shown on the recreation demand survey. For calculated statistics (average, minimum, maximum), data from all monitoring stations within the MAPID were included.

Future Conditions

Future conditions were projected for three scenarios: continuation of current policy (DEGRADE), implementation of nutrient reduction program that will maintain water quality (MAINTAIN), and implementation of nutrient reduction program that will improve water quality (IMPROVE).

The projections for the future conditions were based on several watershed characteristics: land use, current nutrient impairment status, and impairment status under the proposed nutrient criteria.

The land use for each MAPID watershed was characterized by percent agriculture, percent public open space, percent developed and percent impervious change. The agricultural land use was used as an indicator of non-point source pollution. The public open space land use was used as an indicator of protected and less intensively used land (grazing, mining, recreation). The developed acreage was used as an indicator of urbanization, which is a source of stormwater and wastewater. The change in impervious area was used as an indicator of anticipated growth and urbanization in the watershed.

The watershed boundary for each MAPID was determined using automatic delineation tools within GIS. The automatic delineation approach does not account for flow diversions, and the watershed boundaries were not manually corrected. The 2006 National Land Cover Database (NLCD2006) was used for characterizing land use/land cover in the watersheds (Fry et al., 2011; Xian et al., 2011). NLCD2006 classifications were combined into four categories:

1. Urban: *Developed Open Space, Developed Low Intensity, Developed Medium Intensity, Developed High Intensity*
2. Agriculture: *Grasslands, Pasture/Hay, Cultivated Crops*
3. Open Space: *Barren Land, Deciduous Forest, Evergreen Forest, Mixed Forest, Shrub/Scrub, Woody Wetlands*
4. Water: *Open Water, Perennial Ice/Snow, Emergent Herbaceous Wetlands*

The maximum degradation was 50 percent and the maximum improvement was 80 percent. Actual degradation or improvement in an individual watershed was indexed to watershed characteristics as described below.

Future Conditions under Current Policy

Trophic conditions were expected to degrade in the future under the current policy primarily due to population growth and urbanization; therefore, the amount of degradation was indexed to the current developed area and the change in impervious area. Those watersheds with less than 5 percent combined agriculture and developed area were assigned no change in water quality in the future. Those watersheds with an approved TMDL related to excess nutrients were expected to improve in the future due to the requirements of the TMDL. Since nonpoint source pollution is typically managed on a voluntary, incentivized basis, there is less certainty that load reductions specified in the TMDL will be implemented. Stormwater and wastewater are regulated under the Utah Pollution Discharge Elimination System (UPDES) and load reductions are more certain to be implemented. Therefore, the amount of water quality improvement was expected to be greater for urbanized and urbanizing basins as compared to predominantly rural agricultural basins.

Future Conditions under Nutrient Reduction Program with Water Quality Maintenance

For this scenario, current conditions applied since the effect of the Nutrient Reduction Program would be to maintain water quality. Those watersheds anticipated to improve under the existing approved TMDLs were assigned the same level of improvement under this scenario.

Future Conditions under Nutrient Reduction Program with Water Quality Improvement

Trophic conditions were expected to improve in the future under this scenario. Those watersheds with less than 5 percent combined agriculture and developed area were assigned no change in water quality in the future. Those watersheds anticipated to improve under the existing approved TMDLs were assigned the same level of improvement under this scenario.

An assessment was made using the current water quality data (1999 – 2010) as compared to proposed thresholds for Chlorophyll a and total phosphorus for lakes/reservoirs and total inorganic nitrogen and total phosphorus for rivers/streams (Table I-1). A minimum of 5 samples were required for the assessment, and a watershed was considered impaired if more than 10 percent of the samples exceeded the proposed criteria.

TABLE I-1
Proposed Nutrient Criteria for Assessment

	Lakes/Reservoirs		Rivers/Streams	
Fishery	**Chl a (μg/L)**	**TP (mg/L)**	**TIN (mg/L)**	**TP (mg/L)**
Cold Water	8	0.025	1.0	0.05
Warm Water	20	0.083	2.0	0.05

Due to regulatory requirements, those watersheds projected to be impaired with the proposed nutrient criteria were expected to have a larger improvement in water quality than those without a TMDL. In addition, the amount of water quality improvement was expected to be greater for urbanized and urbanizing basins as compared to predominantly rural agricultural basins.

For lakes and reservoirs, because of the relationship between Secchi depth and Chlorophyll a, the percent change in water quality was applied to the TSI(CHL) and the difference in TSI(CHL) was applied to the TSI(SD). For rivers and streams, the percent change in water quality was applied directly to the current TIN and TP concentrations. For DOSAT, the water quality degradation/improvement was applied in relation to the optimal range of 90 percent to 110 percent (if current conditions were above the range and projected to improve in the future, the DOSAT was lowered). The improvement was only made up to the threshold of 90 percent from below and 110 percent from above.

The projected water quality improvements are summarized for lakes/reservoirs in Table I-2 and for rivers/streams in Table I-3.

Table I-2: Current and projected future water quality parameters for lakes and reservoirs

MAP ID	NAME	Current Condition (Summer)					Future Conditions-Current Policy						Future Conditions-Nutrient Reduction Program w/ Maintenance						Future Conditions-Nutrient Reduction Program w/ Improvement					
		Chlorophyll a Max		Secchi Depth		TSI(CHL) - TSI(SD)	Water Quality Change (%)	Chlorophyll a Max		Secchi Depth		TSI(CHL) - TSI(SD)	Water Quality Change (%)	Chlorophyll a Max		Secchi Depth		TSI(CHL) - TSI(SD)	Water Quality Change (%)	Chlorophyll a Max		Secchi Depth		TSI(CHL) - TSI(SD)
				Min	Max					Min	Max					Min	Max					Min	Max	
		mg/L	TSI	m	TSI			mg/L	TSI	m	TSI			mg/L	TSI	m	TSI			mg/L	TSI	m	TSI	
1	Bear Lake	1.2	32.4	5.6	35.2	-2.8	24.9	1.5	34.6	4.9	37.2	-2.6	0.0	1.2	32.4	5.6	35.2	-2.8	-44.9	0.7	26.5	8.1	29.8	-3.3
2	Newton Reservoir	92.2	75.0	0.2	83.2	-8.2	-39.6	55.7	70.0	0.3	78.7	-8.7	-39.6	55.7	70.0	0.3	78.7	-8.7	-39.6	55.7	70.0	0.3	78.7	-8.7
3	Tony Grove Lake	2.3	38.8	6.8	32.5	6.3	0.0	2.3	38.8	6.8	32.5	6.3	0.0	2.3	38.8	6.8	32.5	6.3	0.0	2.3	38.8	6.8	32.5	6.3
4	Cutler Reservoir	39.9	66.8	0.2	83.2	-16.4	-20.0	31.9	64.6	0.2	81.4	-16.9	-20.0	31.9	64.6	0.2	81.4	-16.9	-20.0	31.9	64.6	0.2	81.4	-16.9
5	Little Creek Reservoir	4	44.2	0.7	66.2	-22.0	0.0	4.0	44.2	0.7	66.2	-22.0	0.0	4.0	44.2	0.7	66.2	-22.0	0.0	4.0	44.2	0.7	66.2	-22.0
6	Hyrum Reservoir	5.7	47.7	1.7	52.4	-4.7	-28.7	4.1	44.4	2.1	49.3	-5.0	-28.7	4.1	44.4	2.1	49.3	-5.0	-28.7	4.1	44.4	2.1	49.3	-5.0
7	Porcupine Reservoir	2.7	40.3	3.8	40.8	-0.4	0.0	2.7	40.3	3.8	40.8	-0.4	0.0	2.7	40.3	3.8	40.8	-0.4	0.0	2.7	40.3	3.8	40.8	-0.4
8	Mantua Reservoir	26.9	62.9	1.7	52.4	10.5	-40.4	16.0	57.8	2.4	47.3	10.5	-40.4	16.0	57.8	2.4	47.3	10.5	-40.4	16.0	57.8	2.4	47.3	10.5
9	Birch Creek Reservoir	128.8	78.3	0.7	65.1	13.1	0.0	128.8	78.3	0.7	65.1	13.1	0.0	128.8	78.3	0.7	65.1	13.1	0.0	128.8	78.3	0.7	65.1	13.1
10	Woodruff Creek Reservoir	15.8	57.7	2.6	46.2	11.4	0.0	15.8	57.7	2.6	46.2	11.4	0.0	15.8	57.7	2.6	46.2	11.4	0.0	15.8	57.7	2.6	46.2	11.4
11	Whitney Reservoir	4.7	45.8	3.2	43.5	2.3	0.0	4.7	45.8	3.2	43.5	2.3	0.0	4.7	45.8	3.2	43.5	2.3	0.0	4.7	45.8	3.2	43.5	2.3
13	Causey Reservoir	3.3	42.3	2.6	46.2	-3.9	0.0	3.3	42.3	2.6	46.2	-3.9	0.0	3.3	42.3	2.6	46.2	-3.9	0.0	3.3	42.3	2.6	46.2	-3.9
14	Pineview Reservoir	26.2	62.6	1.8	51.5	11.1	-29.4	18.5	59.2	2.3	48.1	11.1	-29.4	18.5	59.2	2.3	48.1	11.1	-29.4	18.5	59.2	2.3	48.1	11.1
15	Lost Creek Reservoir	23	61.4	2.5	46.8	14.6	0.0	23.0	61.4	2.5	46.8	14.6	0.0	23.0	61.4	2.5	46.8	14.6	0.0	23.0	61.4	2.5	46.8	14.6
16	Echo Reservoir	27.6	63.1	1.9	50.8	12.4	28.5	35.5	65.6	1.6	53.2	12.4	0.0	27.6	63.1	1.9	50.8	12.4	-47.1	14.6	56.9	2.9	44.5	12.4
17	East Canyon Reservoir	194.3	82.3	2.4	47.4	34.9	-60.0	77.7	73.3	4.5	38.4	34.9	-60.0	77.7	73.3	4.5	38.4	34.9	-60.0	77.7	73.3	4.5	38.4	34.9
18	Rockport Reservoir	16.1	57.9	2.7	45.7	12.2	23.9	20.0	60.0	2.3	47.8	12.2	0.0	16.1	57.9	2.7	45.7	12.2	-24.4	12.2	55.1	3.3	42.9	12.2
19	Smith and Morehouse Reservior	2.7	40.3	2.7	45.7	-5.3	0.0	2.7	40.3	2.7	45.7	-5.3	0.0	2.7	40.3	2.7	45.7	-5.3	0.0	2.7	40.3	2.7	45.7	-5.3
20	Stansbury Lake	19.9	59.9	0.8	63.2	-3.3	16.7	23.2	61.5	0.7	64.6	-3.2	0.0	19.9	59.9	0.8	63.2	-3.3	-40.0	11.9	54.9	1.1	58.5	-3.5
21	Grantsville Reservoir	3.8	43.7	2.0	50.0	-6.3	0.0	3.8	43.7	2.0	50.0	-6.3	0.0	3.8	43.7	2.0	50.0	-6.3	0.0	3.8	43.7	2.0	50.0	-6.3
22	Settlement Canyon Reservoir	9.3	52.5	1.3	56.2	-3.7	16.7	10.9	54.0	1.2	57.6	-3.6	0.0	9.3	52.5	1.3	56.2	-3.7	-40.0	5.6	47.5	1.8	51.5	-4.1
23	Rush Lake	0.7	27.1	0.3	77.3	-50.2	16.7	0.8	28.6	0.3	77.9	-49.3	0.0	0.7	27.1	0.3	77.3	-50.2	0.0	0.7	27.1	0.3	77.3	-50.2
24	Little Dell Reservoir	0.9	29.6	6.8	32.4	-2.8	0.0	0.9	29.6	6.8	32.4	-2.8	0.0	0.9	29.6	6.8	32.4	-2.8	0.0	0.9	29.6	6.8	32.4	-2.8
25	Wall Lake	1.4	33.9	1.0	60.0	-26.1	16.7	1.6	35.4	0.9	60.9	-25.4	0.0	1.4	33.9	1.0	60.0	-26.1	-20.0	1.1	31.7	1.1	58.8	-27.1
26	Trial Lake	2	37.4	2.7	45.7	-8.3	18.0	2.4	39.0	2.5	47.0	-8.0	0.0	2.0	37.4	2.7	45.7	-8.3	-20.8	1.6	35.1	3.1	43.8	-8.7
27	Washington Lake	2.4	39.2	3.3	42.8	-3.6	16.8	2.8	40.7	3.0	44.2	-3.5	0.0	2.4	39.2	3.3	42.8	-3.6	-20.1	1.9	37.0	3.8	40.8	-3.8
28	Jordanelle Reservoir	6	48.2	2.3	47.9	0.3	0.0	6.0	48.2	2.3	47.9	0.3	0.0	6.0	48.2	2.3	47.9	0.3	0.0	6.0	48.2	2.3	47.9	0.3
29	Lake Mary	2.2	38.3	2.0	50.0	-11.7	16.7	2.6	39.8	1.8	51.2	-11.3	0.0	2.2	38.3	2.0	50.0	-11.7	-20.0	1.8	36.1	2.2	48.3	-12.2
30	Silver Lake Flat Reservoir	2.2	38.3	3.1	43.7	-5.4	0.0	2.2	38.3	3.1	43.7	-5.4	0.0	2.2	38.3	3.1	43.7	-5.4	0.0	2.2	38.3	3.1	43.7	-5.4
31	Mill Hollow Reservoir	21	60.5	2.0	50.0	10.5	0.0	21.0	60.5	2.0	50.0	10.5	0.0	21.0	60.5	2.0	50.0	10.5	0.0	21.0	60.5	2.0	50.0	10.5
32	Tibble Fork Reservoir	1.7	35.8	3.1	43.7	-7.9	0.0	1.7	35.8	3.1	43.7	-7.9	0.0	1.7	35.8	3.1	43.7	-7.9	0.0	1.7	35.8	3.1	43.7	-7.9
33	Deer Creek Reservoir	15.8	57.7	2.9	44.8	12.8	-49.9	7.9	50.9	4.6	38.1	12.8	-49.9	7.9	50.9	4.6	38.1	12.8	-49.9	7.9	50.9	4.6	38.1	12.8
34	Utah Lake	206.1	82.9	0.2	81.3	1.5	50.0	309.2	86.8	0.2	85.3	1.5	0.0	206.1	82.9	0.2	81.3	1.5	-60.0	82.4	73.9	0.4	72.4	1.5
35	Salem Pond	82.8	73.9	0.9	61.3	12.7	50.0	124.2	77.9	0.7	65.2	12.7	0.0	82.8	73.9	0.9	61.3	12.7	-60.0	33.1	64.9	1.7	52.3	12.7
37	Mona Reservoir	31.5	64.4	0.2	83.2	-18.7	35.6	42.7	67.4	0.2	85.5	-18.1	0.0	31.5	64.4	0.2	83.2	-18.7	-31.4	21.6	60.7	0.2	80.3	-19.6
38	Meeks Cabin Reservoir	2.9	41.0	2.4	47.4	-6.3	18.0	3.4	42.7	2.2	48.8	-6.1	0.0	2.9	41.0	2.4	47.4	-6.3	-20.8	2.3	38.8	2.8	45.4	-6.6
39	Flaming Gorge Reservoir	6.3	48.7	4.9	37.0	11.7	21.3	7.6	50.6	4.3	38.9	11.7	0.0	6.3	48.7	4.9	37.0	11.7	-42.8	3.6	43.2	7.2	31.5	11.7
40	Stateline Reservoir	4.5	45.4	2.5	46.8	-1.4	18.0	5.3	47.0	2.2	48.4	-1.4	0.0	4.5	45.4	2.5	46.8	-1.4	-20.8	3.6	43.1	2.9	44.6	-1.5
41	Bridger Lake	15.9	57.7	2.5	46.8	10.9	0.0	15.9	57.7	2.5	46.8	10.9	0.0	15.9	57.7	2.5	46.8	10.9	0.0	15.9	57.7	2.5	46.8	10.9
42	Marsh Lake	9	52.2	4.5	38.3	13.8	0.0	9.0	52.2	4.5	38.3	13.8	0.0	9.0	52.2	4.5	38.3	13.8	0.0	9.0	52.2	4.5	38.3	13.8
43	China Lake	20.6	60.3	2.1	49.3	11.0	0.0	20.6	60.3	2.1	49.3	11.0	0.0	20.6	60.3	2.1	49.3	11.0	0.0	20.6	60.3	2.1	49.3	11.0
44	Lyman Lake	2.6	40.0	6.0	34.2	5.8	18.5	3.1	41.6	5.3	35.8	5.8	0.0	2.6	40.0	6.0	34.2	5.8	-21.1	2.1	37.6	7.1	31.9	5.8
45	Hoop Lake	1.8	36.4	1.2	57.4	-21.0	0.0	1.8	36.4	1.2	57.4	-21.0	0.0	1.8	36.4	1.2	57.4	-21.0	0.0	1.8	36.4	1.2	57.4	-21.0
46	Long Park Reservoir	4.5	45.4	1.7	52.8	-7.4	0.0	4.5	45.4	1.7	52.8	-7.4	0.0	4.5	45.4	1.7	52.8	-7.4	0.0	4.5	45.4	1.7	52.8	-7.4
47	Beaver Meadow Reservoir	2.9	41.0	1.6	53.2	-12.2	0.0	2.9	41.0	1.6	53.2	-12.2	0.0	2.9	41.0	1.6	53.2	-12.2	0.0	2.9	41.0	1.6	53.2	-12.2
48	Sheep Creek Lake	5.6	47.5	4.3	39.0	8.5	0.0	5.6	47.5	4.3	39.0	8.5	0.0	5.6	47.5	4.3	39.0	8.5	0.0	5.6	47.5	4.3	39.0	8.5
49	Browne Reservoir	15.2	57.3	1.8	51.5	5.8	-23.0	11.7	54.7	2.2	49.0	5.8	-23.0	11.7	54.7	2.2	49.0	5.8	-23.0	11.7	54.7	2.2	49.0	5.8
50	Spirit Lake	8.6	51.7	1.6	53.2	-1.5	17.3	10.1	53.3	1.4	54.8	-1.5	0.0	8.6	51.7	1.6	53.2	-1.5	-40.4	5.1	46.6	2.3	48.3	-1.7
51	East Park Reservoir	4.9	46.2	1.3	56.8	-10.6	19.4	5.9	47.9	1.1	58.2	-10.3	0.0	4.9	46.2	1.3	56.8	-10.6	-21.7	3.8	43.8	1.4	54.8	-11.0
52	Matt Warner Reservoir	99.9	75.8	1.2	57.8	17.9	-10.0	89.9	74.7	1.2	56.8	17.9	-10.0	89.9	74.7	1.2	56.8	17.9	-10.0	89.9	74.7	1.2	56.8	17.9
54	Oaks Park Reservoir	2.8	40.7	1.4	55.2	-14.5	19.4	3.3	42.4	1.3	56.4	-14.0	0.0	2.8	40.7	1.4	55.2	-14.5	-21.6	2.2	38.3	1.6	53.4	-15.1
55	Calder Reservoir	172	81.1	0.7	65.1	16.0	-45.0	94.6	75.2	1.1	59.3	16.0	-45.0	94.6	75.2	1.1	59.3	16.0	-45.0	94.6	75.2	1.1	59.3	16.0
56	Ashley Twin Lakes	1.4	33.9	2.4	47.4	-13.5	16.7	1.6	35.4	2.2	48.5	-13.1	0.0	1.4	33.9	2.4	47.4	-13.5	-20.0	1.1	31.7	2.7	45.8	-14.1
57	Butterfly Lake	7.9	50.9	1.9	50.8	0.1	0.0	7.9	50.9	1.9	50.8	0.1	0.0	7.9	50.9	1.9	50.8	0.1	0.0	7.9	50.9	1.9	50.8	0.1
58	Scout Lake	1.8	36.4	3.4	42.4	-6.0	0.0	1.8	36.4	3.4	42.4	-6.0	0.0	1.8	36.4	3.4	42.4	-6.0	0.0	1.8	36.4	3.4	42.4	-6.0
59	Mirror Lake	9.6	52.8	3.1	43.7	9.1	49.8	14.4	56.7	2.4	47.7	9.1	0.0	9.6	52.8	3.1	43.7	9.1	-59.9	3.9	43.8	5.8	34.7	9.1
60	Hoover Lake	2.9	41.0	3.8	40.8	0.3	0.0	2.9	41.0	3.8	40.8	0.3	0.0	2.9	41.0	3.8	40.8	0.3	0.0	2.9	41.0	3.8	40.8	0.3
61	Paradise Park Reservoir	1.8	36.4	2.5	47.1	-10.7	0.0	1.8	36.4	2.5	47.1	-10.7	0.0	1.8	36.4	2.5	47.1	-10.7	0.0	1.8	36.4	2.5	47.1	-10.7
62	Marshall Lake	5.7	47.7	5.5	35.4	12.2	0.0	5.7	47.7	5.5	35.4	12.2	0.0	5.7	47.7	5.5	35.4	12.2	0.0	5.7	47.7	5.5	35.4	12.2
63	Red Fleet Reservoir	3.4	42.6	1.9	50.8	-8.1	0.0	3.4	42.6	1.9	50.8	-8.1	0.0	3.4	42.6	1.9	50.8	-8.1	0.0	3.4	42.6	1.9	50.8	-8.1
64	Moon Lake	3.4	42.6	3.1	43.7	-1.1	16.9	4.0	44.1	2.8	45.2	-1.1	0.0	3.4	42.6	3.1	43.7	-1.1	-20.1	2.7	40.4	3.6	41.5	-1.1
65	Upper Stillwater Reservoir	1.3	33.2	4.4	38.7	-5.5	16.7	1.5	34.7	4.0	39.9	-5.3	0.0	1.3	33.2	4.4	38.7	-5.5	-20.0	1.0	31.0	5.0	36.8	-5.8
66	Steinaker Reservoir	2.3	38.8	3.5	41.9	-3.2	0.0	2.3	38.8	3.5	41.9	-3.2	0.0	2.3	38.8	3.5	41.9	-3.2	0.0	2.3	38.8	3.5	41.9	-3.2
67	Currant Creek Reservoir	2.5	39.6	1.5	54.2	-14.6	0.0	2.5	39.6	1.5	54.2	-14.6	0.0	2.5	39.6	1.5	54.2	-14.6	0.0	2.5	39.6	1.5	54.2	-14.6
68	Red Creek Reservoir	31.9	64.6	1.2	57.4	7.2	0.0	31.9	64.6	1.2	57.4	7.2	0.0	31.9	64.6	1.2	57.4	7.2	0.0	31.9	64.6	1.2	57.4	7.2
69	Big Sandwash Reservoir	2.5	39.6	2.5	46.8	-7.2	44.2	3.6	43.2	2.0	49.8	-6.7	0.0	2.5	39.6	2.5	46.8	-7.2	-36.5	1.6	35.1	3.2	43.0	-7.9
70	Brough Reservoir	1.8	36.4	1.6	53.2	-16.9	-39.0	1.1	31.5	2.0	49.9	-18.4	-39.0	1.1	31.5	2.0	49.9	-18.4	-39.0	1.1	31.5	2.0	49.9	-18.4
71	Pelican Lake	10.1	53.3	1.9	50.7	2.5	44.0	14.5	56.9	1.5	54.3	2.5	0.0	10.1	53.3	1.9	50.7	2.5	-36.4	6.4	48.8	2.6	46.3	2.5

Table I-2: Current and projected future water quality parameters for lakes and reservoirs

MAP ID	NAME	Current Condition (Summer)					Future Conditions-Current Policy						Future Conditions-Nutrient Reduction Program w/ Maintenance						Future Conditions-Nutrient Reduction Program w/ Improvement					
		Chlorophyll a		Secchi Depth		TSI(CHL) - TSI(SD)	Water Quality Change (%)	Chlorophyll a		Secchi Depth		TSI(CHL) - TSI(SD)	Water Quality Change (%)	Chlorophyll a		Secchi Depth		TSI(CHL) - TSI(SD)	Water Quality Change (%)	Chlorophyll a		Secchi Depth		TSI(CHL) - TSI(SD)
		Max		Min	Max			Max		Min	Max			Max		Min	Max			Max		Min	Max	
		mg/L	TSI	m	TSI			mg/L	TSI	m	TSI			mg/L	TSI	m	TSI			mg/L	TSI	m	TSI	
72	Strawberry Reservoir	4.8	46.0	6.0	34.2	11.8	-5.0	4.6	45.5	6.2	33.7	11.8	-5.0	4.6	45.5	6.2	33.7	11.8	-5.0	4.6	45.5	6.2	33.7	11.8
73	Starvation Reservoir	42.9	67.5	5.0	36.8	30.7	0.0	42.9	67.5	5.0	36.8	30.7	0.0	42.9	67.5	5.0	36.8	30.7	0.0	42.9	67.5	5.0	36.8	30.7
74	Scofield Reservoir	108.7	76.6	1.3	56.2	20.4	-28.0	78.3	73.4	1.6	53.0	20.4	-28.0	78.3	73.4	1.6	53.0	20.4	-28.0	78.3	73.4	1.6	53.0	20.4
75	Lower Gooseberry Reservoir	14	56.5	1.1	58.6	-2.1	0.0	14.0	56.5	1.1	58.6	-2.1	0.0	14.0	56.5	1.1	58.6	-2.1	0.0	14.0	56.5	1.1	58.6	-2.1
76	Fairview Lakes	18.3	59.1	2.3	47.8	11.3	0.0	18.3	59.1	2.3	47.8	11.3	0.0	18.3	59.1	2.3	47.8	11.3	0.0	18.3	59.1	2.3	47.8	11.3
77	Electric Lake	3.2	42.0	2.2	48.6	-6.6	0.0	3.2	42.0	2.2	48.6	-6.6	0.0	3.2	42.0	2.2	48.6	-6.6	0.0	3.2	42.0	2.2	48.6	-6.6
78	Huntington Reservoir	2.2	38.3	3.1	43.7	-5.4	0.0	2.2	38.3	3.1	43.7	-5.4	0.0	2.2	38.3	3.1	43.7	-5.4	0.0	2.2	38.3	3.1	43.7	-5.4
79	Miller Flat Reservoir	3	41.4	3.7	41.0	0.4	0.0	3.0	41.4	3.7	41.0	0.4	0.0	3.0	41.4	3.7	41.0	0.4	0.0	3.0	41.4	3.7	41.0	0.4
80	Huntington North Reservoir	1.1	31.5	3.0	44.2	-12.6	0.0	1.1	31.5	3.0	44.2	-12.6	0.0	1.1	31.5	3.0	44.2	-12.6	0.0	1.1	31.5	3.0	44.2	-12.6
81	Joe's Valley Reservoir	1.8	36.4	3.3	42.8	-6.4	23.0	2.2	38.4	2.9	44.5	-6.1	0.0	1.8	36.4	3.3	42.8	-6.4	-43.8	1.0	30.7	4.6	38.0	-7.3
82	Duck Fork Reservoir	0.5	23.8	4.8	37.4	-13.6	23.2	0.6	25.8	4.4	38.7	-12.9	0.0	0.5	23.8	4.8	37.4	-13.6	-23.9	0.4	21.1	5.4	35.7	-14.6
83	Ferron Reservoir	2.6	40.0	5.1	36.5	3.5	43.5	3.7	43.5	4.0	40.1	3.5	0.0	2.6	40.0	5.1	36.5	3.5	-56.1	1.1	31.9	8.9	28.4	3.5
84	Millsite Reservoir	3.1	41.7	2.0	50.0	-8.3	21.7	3.8	43.6	1.8	51.6	-8.0	0.0	3.1	41.7	2.0	50.0	-8.3	-23.0	2.4	39.1	2.3	47.9	-8.7
85	Johnson Valley Resevoir	46.8	68.3	0.5	70.0	-1.7	-30.1	32.7	64.8	0.6	66.6	-1.7	-30.1	32.7	64.8	0.6	66.6	-1.7	-30.1	32.7	64.8	0.6	66.6	-1.7
86	Fish Lake	3.3	42.3	6.6	32.8	9.5	26.6	4.2	44.6	5.6	35.1	9.5	0.0	3.3	42.3	6.6	32.8	9.5	-26.0	2.4	39.4	8.1	29.9	9.5
87	Forsyth Reservoir	34.1	65.2	3.0	44.2	21.1	-54.0	15.7	57.6	5.1	36.6	21.1	-54.0	15.7	57.6	5.1	36.6	21.1	-54.0	15.7	57.6	5.1	36.6	21.1
88	Mill Meadow Reservoir	116.2	77.2	0.7	66.2	11.0	-39.0	70.9	72.4	0.9	61.4	11.0	-39.0	70.9	72.4	0.9	61.4	11.0	-39.0	70.9	72.4	0.9	61.4	11.0
89	Donkey Reservoir	1.8	36.4	4.6	38.0	-1.6	0.0	1.8	36.4	4.6	38.0	-1.6	0.0	1.8	36.4	4.6	38.0	-1.6	0.0	1.8	36.4	4.6	38.0	-1.6
90	Cook Lake	8.7	51.8	2.5	46.8	5.0	0.0	8.7	51.8	2.5	46.8	5.0	0.0	8.7	51.8	2.5	46.8	5.0	0.0	8.7	51.8	2.5	46.8	5.0
91	Lower Bowns Reservoir	33.4	65.0	1.5	54.2	10.9	0.0	33.4	65.0	1.5	54.2	10.9	0.0	33.4	65.0	1.5	54.2	10.9	0.0	33.4	65.0	1.5	54.2	10.9
92	Posey Lake	4.2	44.7	4.5	38.3	6.4	0.0	4.2	44.7	4.5	38.3	6.4	0.0	4.2	44.7	4.5	38.3	6.4	0.0	4.2	44.7	4.5	38.3	6.4
93	Wide Hollow Reservoir	15.5	57.5	0.3	77.3	-19.9	0.0	15.5	57.5	0.3	77.3	-19.9	0.0	15.5	57.5	0.3	77.3	-19.9	0.0	15.5	57.5	0.3	77.3	-19.9
95	DMAD Reservoir	9.5	52.7	0.3	80.0	-27.3	0.0	9.5	52.7	0.3	80.0	-27.3	0.0	9.5	52.7	0.3	80.0	-27.3	0.0	9.5	52.7	0.3	80.0	-27.3
96	Sevier Bridge Reservoir	15.6	57.6	0.5	70.0	-12.4	28.9	20.1	60.0	0.4	72.0	-12.0	0.0	15.6	57.6	0.5	70.0	-12.4	-27.4	11.3	54.4	0.6	67.4	-13.0
97	Gunnison Bend Reservoir	5.9	48.0	0.3	80.0	-32.0	28.0	7.6	50.4	0.2	81.4	-31.0	0.0	5.9	48.0	0.3	80.0	-32.0	-26.8	4.3	45.0	0.3	78.1	-33.2
98	Gunnison Reservoir	6	48.2	1.0	60.0	-11.8	35.0	8.1	51.1	0.8	62.4	-11.2	0.0	6.0	48.2	1.0	60.0	-11.8	-51.0	2.9	41.2	1.5	54.4	-13.2
99	Palisade Reservoir	7.4	50.2	0.8	63.2	-13.0	16.9	8.7	51.8	0.7	64.4	-12.7	0.0	7.4	50.2	0.8	63.2	-13.0	0.0	7.4	50.2	0.8	63.2	-13.0
100	Ninemile Reservoir	17.6	58.7	2.2	48.6	10.1	46.8	25.8	62.5	1.7	52.4	10.1	0.0	17.6	58.7	2.2	48.6	10.1	-58.1	7.4	50.2	4.0	40.1	10.1
101	Redmond Lake	73.3	72.7	0.1	93.2	-20.5	0.0	73.3	72.7	0.1	93.2	-20.5	0.0	73.3	72.7	0.1	93.2	-20.5	0.0	73.3	72.7	0.1	93.2	-20.5
102	Rexs Reservoir	6.8	49.4	1.2	57.4	-8.0	0.0	6.8	49.4	1.2	57.4	-8.0	0.0	6.8	49.4	1.2	57.4	-8.0	0.0	6.8	49.4	1.2	57.4	-8.0
103	Koosharem Reservoir	12.4	55.3	0.2	83.2	-27.9	-48.0	6.4	48.9	0.3	78.9	-30.0	-48.0	6.4	48.9	0.3	78.9	-30.0	-48.0	6.4	48.9	0.3	78.9	-30.0
104	Manning Meadow Reservoir	8.9	52.0	1.7	52.4	-0.3	20.8	10.8	53.9	1.5	54.2	-0.3	0.0	8.9	52.0	1.7	52.4	-0.3	-42.5	5.1	46.6	2.5	47.0	-0.3
105	Barney Lake	138.9	79.0	1.8	51.5	27.5	16.7	162.1	80.5	1.6	53.0	27.5	0.0	138.9	79.0	1.8	51.5	27.5	-40.0	83.3	74.0	2.5	46.5	27.5
106	Lower Boxcreek Reservoir	125.6	78.0	1.3	56.2	21.8	-80.0	25.1	62.2	3.9	40.4	21.8	-80.0	25.1	62.2	3.9	40.4	21.8	-80.0	25.1	62.2	3.9	40.4	21.8
107	Piute Reservoir	21.5	60.7	1.6	53.2	7.5	0.0	21.5	60.7	1.6	53.2	7.5	0.0	21.5	60.7	1.6	53.2	7.5	0.0	21.5	60.7	1.6	53.2	7.5
108	Otter Creek Reservoir	485	91.3	0.3	77.3	13.9	0.0	485.0	91.3	0.3	77.3	13.9	0.0	485.0	91.3	0.3	77.3	13.9	0.0	485.0	91.3	0.3	77.3	13.9
109	Pine Lake	1.7	35.8	6.7	32.6	3.2	0.0	1.7	35.8	6.7	32.6	3.2	0.0	1.7	35.8	6.7	32.6	3.2	0.0	1.7	35.8	6.7	32.6	3.2
110	Panguitch Lake	365	88.5	1.8	51.7	36.7	-63.0	135.1	78.7	3.5	42.0	36.7	-63.0	135.1	78.7	3.5	42.0	36.7	-63.0	135.1	78.7	3.5	42.0	36.7
111	Tropic Reservoir	0.9	29.6	3.4	42.4	-12.8	0.0	0.9	29.6	3.4	42.4	-12.8	0.0	0.9	29.6	3.4	42.4	-12.8	0.0	0.9	29.6	3.4	42.4	-12.8
112	Navajo Lake	1.8	36.4	4.0	40.0	-3.7	18.1	2.1	38.0	3.6	41.5	-3.5	0.0	1.8	36.4	4.0	40.0	-3.7	0.0	1.8	36.4	4.0	40.0	-3.7
113	Puffer Lake	119.1	77.5	1.0	60.0	17.5	-20.3	95.0	75.3	1.2	57.8	17.5	-20.3	95.0	75.3	1.2	57.8	17.5	-20.3	95.0	75.3	1.2	57.8	17.5
114	Three Creeks Reservoir	52.4	69.4	0.4	73.2	-3.8	29.0	67.6	71.9	0.3	75.6	-3.6	0.0	52.4	69.4	0.4	73.2	-3.8	-47.4	27.6	63.1	0.6	67.2	-4.1
115	Minersville Reservoir	35.9	65.7	1.2	57.6	8.1	-69.0	11.1	54.2	2.6	46.1	8.1	-69.0	11.1	54.2	2.6	46.1	8.1	-69.0	11.1	54.2	2.6	46.1	8.1
116	Middle Kents Lake	118.6	77.5	0.7	65.1	12.3	0.0	118.6	77.5	0.7	65.1	12.3	0.0	118.6	77.5	0.7	65.1	12.3	0.0	118.6	77.5	0.7	65.1	12.3
117	LaBaron Reservoir	45.8	68.1	1.7	52.4	15.8	0.0	45.8	68.1	1.7	52.4	15.8	0.0	45.8	68.1	1.7	52.4	15.8	0.0	45.8	68.1	1.7	52.4	15.8
118	Anderson Meadow Reservoir	5.3	47.0	2.8	45.2	1.8	0.0	5.3	47.0	2.8	45.2	1.8	0.0	5.3	47.0	2.8	45.2	1.8	0.0	5.3	47.0	2.8	45.2	1.8
119	Red Creek Reservoir	38.8	66.5	1.1	58.6	7.9	0.0	38.8	66.5	1.1	58.6	7.9	0.0	38.8	66.5	1.1	58.6	7.9	0.0	38.8	66.5	1.1	58.6	7.9
120	Yankee Meadows Reservoir	83.8	74.0	1.8	51.5	22.5	0.0	83.8	74.0	1.8	51.5	22.5	0.0	83.8	74.0	1.8	51.5	22.5	0.0	83.8	74.0	1.8	51.5	22.5
121	Newcastle Reservoir	224	83.7	0.5	69.0	14.6	0.0	224.0	83.7	0.5	69.0	14.6	0.0	224.0	83.7	0.5	69.0	14.6	0.0	224.0	83.7	0.5	69.0	14.6
122	Upper Enterprise Reservoir	46.9	68.3	0.8	62.8	5.6	0.0	46.9	68.3	0.8	62.8	5.6	0.0	46.9	68.3	0.8	62.8	5.6	0.0	46.9	68.3	0.8	62.8	5.6
123	Kolob Reservoir	3.6	43.2	3.3	42.8	0.4	0.0	3.6	43.2	3.3	42.8	0.4	0.0	3.6	43.2	3.3	42.8	0.4	0.0	3.6	43.2	3.3	42.8	0.4
124	Baker Dam Reservoir	134.1	78.7	0.9	61.5	17.1	-71.0	38.9	66.5	2.1	49.4	17.1	-71.0	38.9	66.5	2.1	49.4	17.1	-71.0	38.9	66.5	2.1	49.4	17.1
125	Gunlock Reservoir	12.1	55.1	1.2	57.4	-2.3	-32.0	8.2	51.3	1.5	53.7	-2.5	-32.0	8.2	51.3	1.5	53.7	-2.5	-32.0	8.2	51.3	1.5	53.7	-2.5
126	Quail Creek Reservoir	0.8	28.4	3.5	41.9	-13.5	0.0	0.8	28.4	3.5	41.9	-13.5	0.0	0.8	28.4	3.5	41.9	-13.5	0.0	0.8	28.4	3.5	41.9	-13.5
127	Cleveland Reservoir	4.1	44.4	2.9	44.7	-0.2	39.1	5.7	47.7	2.3	47.9	-0.2	0.0	4.1	44.4	2.9	44.7	-0.2	-33.5	2.7	40.4	3.8	40.7	-0.2
128	Kens Lake	3.1	41.7	2.8	45.2	-3.5	0.0	3.1	41.7	2.8	45.2	-3.5	0.0	3.1	41.7	2.8	45.2	-3.5	0.0	3.1	41.7	2.8	45.2	-3.5
129	Dark Canyon Lake	0.2	14.8	3.4	42.4	-27.6	16.7	0.2	16.3	3.3	42.9	-26.6	0.0	0.2	14.8	3.4	42.4	-27.6	-20.0	0.2	12.6	3.6	41.6	-29.0
130	Monticello Lake	1.6	35.2	4.0	40.0	-4.8	17.1	1.9	36.8	3.6	41.4	-4.6	0.0	1.6	35.2	4.0	40.0	-4.8	0.0	1.6	35.2	4.0	40.0	-4.8
131	Lloyds Reservoir	2.4	39.2	1.1	58.6	-19.4	0.0	2.4	39.2	1.1	58.6	-19.4	0.0	2.4	39.2	1.1	58.6	-19.4	0.0	2.4	39.2	1.1	58.6	-19.4
132	Recapture Reservoir	2	37.4	1.5	54.3	-16.9	27.1	2.5	39.8	1.3	55.9	-16.2	0.0	2.0	37.4	1.5	54.3	-16.9	-26.3	1.5	34.4	1.7	52.3	-17.9
133	Blanding Reservoir	1.6	35.2	4.0	40.2	-5.0	0.0	1.6	35.2	4.0	40.2	-5.0	0.0	1.6	35.2	4.0	40.2	-5.0	0.0	1.6	35.2	4.0	40.2	-5.0
136	Willard Bay	11.8	54.8	0.3	80.0	-25.2	18.0	13.9	56.4	0.2	81.1	-24.7	0.0	11.8	54.8	0.3	80.0	-25.2	0.0	11.8	54.8	0.3	80.0	-25.2
140	Sand Hollow Reservoir	0.9	29.6	7.4	31.2	-1.6	17.9	1.1	31.2	6.7	32.7	-1.5	0.0	0.9	29.6	7.4	31.2	-1.6	-20.7	0.7	27.3	8.6	29.0	-1.7

Table I-3: Current and projected future water quality parameters for rivers and streams

MAP ID	NAME	Current Conditions (Summer)			Future Conditions-Current Policy				Future Conditions-Nutrient Reduction Program w/ Maintenance				Future Conditions-Nutrient Reduction Program w/ Improvement			
		Ave TP (mg/L)	Ave TIN (mg/L)	Ave DOSAT (%)	Water Quality Change (%)	Ave TP (mg/L)	Ave TIN (mg/L)	Ave DOSAT (%)	Water Quality Change (%)	Ave TP (mg/L)	Ave TIN (mg/L)	Ave DOSAT (%)	Water Quality Change (%)	Ave TP (mg/L)	Ave TIN (mg/L)	Ave DOSAT (%)
200	Beaver Dam Wash	0.022	0.08	81.3	16.7	0.026	0.09	67.8	0.0	0.022	0.08	81.3	-20.0	0.018	0.06	90.0
201	Virgin River-1	1.067	1.86	130.5	17.5	1.254	2.18	153.2	0.0	1.067	1.86	130.5	-40.5	0.635	1.11	110.0
202	Santa Clara-1	0.149	1.32	112.5	9.1	0.163	1.43	122.8	0.0	0.149	1.32	112.5	-20.5	0.119	1.05	110.0
203	Santa Clara-2	0.041	0.11	99.7	0.0	0.041	0.11	99.7	0.0	0.041	0.11	99.7	0.0	0.041	0.11	99.7
204	Virgin River-2	0.105	0.41	107.1	8.9	0.114	0.45	116.6	0.0	0.105	0.41	107.1	-20.3	0.083	0.33	107.1
205	Virgin River-3	0.495	0.53	103.7	0.0	0.495	0.53	103.7	0.0	0.495	0.53	103.7	0.0	0.495	0.53	103.7
206	North Creek	0.030	0.62	106.9	0.0	0.030	0.62	106.9	0.0	0.030	0.62	106.9	0.0	0.030	0.62	106.9
207	North Fork Virgin River-1	0.095	0.16	96.0	0.0	0.095	0.16	96.0	0.0	0.095	0.16	96.0	0.0	0.095	0.16	96.0
209	East Fork Virgin-1	0.157	0.86	86.1	0.0	0.157	0.86	86.1	0.0	0.157	0.86	86.1	0.0	0.157	0.86	86.1
210	Kanab Creek-1	0.039	0.24	72.0	17.3	0.045	0.28	59.5	0.0	0.039	0.24	72.0	-40.4	0.023	0.14	90.0
211	Johnson Wash-1	0.080	0.34	60.2	0.0	0.080	0.34	60.2	0.0	0.080	0.34	60.2	0.0	0.080	0.34	60.2
212	Paria River-3	1.282	0.44	74.4	16.9	1.499	0.52	61.8	0.0	1.282	0.44	74.4	-40.2	0.767	0.26	90.0
213	Paria River-2	0.426	0.12	85.4	0.0	0.426	0.12	85.4	0.0	0.426	0.12	85.4	0.0	0.426	0.12	85.4
214	Paria River-1	0.018	0.10	99.6	0.0	0.018	0.10	99.6	0.0	0.018	0.10	99.6	0.0	0.018	0.10	99.6
215	San Juan River-1	0.243	0.29	83.1	17.0	0.284	0.34	68.9	0.0	0.243	0.29	83.1	-40.2	0.145	0.17	90.0
218	Montezuma Creek-3	0.036	0.72	78.2	17.4	0.042	0.84	64.6	0.0	0.036	0.72	78.2	-20.4	0.029	0.57	90.0
226	Fremont River-4	0.367	0.36	99.6	17.0	0.429	0.42	116.5	0.0	0.367	0.36	99.6	-40.2	0.219	0.22	99.6
227	Fremont River-3	0.039	0.16	106.8	17.2	0.046	0.19	125.1	0.0	0.039	0.16	106.8	-40.3	0.023	0.10	106.8
228	Fremont River-2	0.034	0.40	132.0	-10.4	0.030	0.36	118.3	-10.4	0.030	0.36	118.3	-10.4	0.030	0.36	118.3
229	Lower Muddy Creek	0.125	0.51	97.2	16.8	0.146	0.59	113.6	0.0	0.125	0.51	97.2	-40.1	0.075	0.30	97.2
230	Lower Ivie Creek	0.146	0.91	104.2	17.1	0.170	1.07	122.0	0.0	0.146	0.91	104.2	-20.2	0.116	0.73	104.2
235	Colorado River-4	0.910	0.87	99.3	17.1	1.066	1.01	116.3	0.0	0.910	0.87	99.3	-40.3	0.544	0.52	99.3
241	Lower San Rafael	0.283	0.18	99.4	17.0	0.331	0.20	116.3	0.0	0.283	0.18	99.4	-40.2	0.169	0.10	99.4
242	Upper San Rafael	0.834	0.14	91.9	17.1	0.977	0.16	107.6	0.0	0.834	0.14	91.9	-40.3	0.498	0.08	91.9
243	Lower Ferron Creek	0.037	0.91	114.0	17.2	0.044	1.06	133.7	0.0	0.037	0.91	114.0	-20.3	0.030	0.72	110.0
244	Upper Ferron Creek	0.181	0.61	111.8	17.0	0.212	0.72	130.9	0.0	0.181	0.61	111.8	-40.2	0.108	0.37	110.0
245	Lower Cottonwood Creek	0.246	0.23	116.8	17.3	0.288	0.26	136.9	0.0	0.246	0.23	116.8	-40.4	0.147	0.13	110.0
246	Huntington Creek-1	0.176	0.96	134.5	17.2	0.206	1.12	157.6	0.0	0.176	0.96	134.5	-40.3	0.105	0.57	110.0
248	Green River-4	0.263	0.20	101.8	16.9	0.308	0.23	119.1	0.0	0.263	0.20	101.8	-40.2	0.157	0.12	101.8
250	Price River-4	0.654	0.89	103.8	17.1	0.766	1.04	121.6	0.0	0.654	0.89	103.8	-40.3	0.391	0.53	103.8
252	Price River-3	1.701	1.01	99.9	0.0	1.701	1.01	99.9	0.0	1.701	1.01	99.9	0.0	1.701	1.01	99.9
253	Gordon Creek	0.030	0.25	115.7	0.0	0.030	0.25	115.7	0.0	0.030	0.25	115.7	0.0	0.030	0.25	115.7
254	Price River-2	0.032	0.12	100.9	0.0	0.032	0.12	100.9	0.0	0.032	0.12	100.9	0.0	0.032	0.12	100.9
256	Price River-1	0.020	0.15	110.4	0.0	0.020	0.15	110.4	0.0	0.020	0.15	110.4	0.0	0.020	0.15	110.4
258	Ninemile	0.036	0.80	97.8	0.0	0.036	0.80	97.8	0.0	0.036	0.80	97.8	0.0	0.036	0.80	97.8
259	Pariette Draw Creek	0.163	0.32	100.2	17.1	0.191	0.37	117.4	0.0	0.163	0.32	100.2	-40.3	0.097	0.19	100.2
268	Uinta River-2	0.020	0.34	112.2	17.1	0.023	0.39	131.3	0.0	0.020	0.34	112.2	-20.2	0.016	0.27	110.0
269	Lower Whiterocks River	0.010	0.08	104.6	17.7	0.012	0.09	123.1	0.0	0.010	0.08	104.6	-40.6	0.006	0.04	104.6
272	Dry Gulch Creek	0.010	0.08	96.1	17.8	0.012	0.09	113.2	0.0	0.010	0.08	96.1	-40.7	0.006	0.04	96.1
275	Duchesne River-2	0.034	0.08	107.4	17.0	0.039	0.09	125.7	0.0	0.034	0.08	107.4	-40.2	0.020	0.04	107.4
278	Upper Yellowstone	0.043	0.15	100.8	16.7	0.050	0.18	117.7	0.0	0.043	0.15	100.8	-20.0	0.034	0.12	100.8
281	Antelope Creek	0.051	0.48	105.7	0.0	0.051	0.48	105.7	0.0	0.051	0.48	105.7	0.0	0.051	0.48	105.7
282	Duchesne River-4	0.014	0.14	103.9	16.9	0.016	0.16	121.5	0.0	0.014	0.14	103.9	-40.1	0.008	0.08	103.9
284	Rock Creek	0.010	0.13	89.8	0.0	0.010	0.13	89.8	0.0	0.010	0.13	89.8	0.0	0.010	0.13	89.8
287	Middle Red Creek	0.030	0.33	96.3	0.0	0.030	0.33	96.3	0.0	0.030	0.33	96.3	0.0	0.030	0.33	96.3
289	Strawberry River-3	0.036	0.08	102.4	0.0	0.036	0.08	102.4	0.0	0.036	0.08	102.4	0.0	0.036	0.08	102.4
290	Green River-2	0.065	0.14	114.8	16.9	0.076	0.16	134.2	0.0	0.065	0.14	114.8	-40.2	0.039	0.08	110.0
291	Lower Ashley Creek	0.148	0.15	104.5	17.9	0.174	0.18	123.1	0.0	0.148	0.15	104.5	-40.7	0.088	0.09	104.5
293	Brush Creek	0.020	0.51	117.6	0.0	0.020	0.51	117.6	0.0	0.020	0.51	117.6	0.0	0.020	0.51	117.6
297	Sheep Creek	0.010	0.08	108.0	16.9	0.012	0.09	126.2	0.0	0.010	0.08	108.0	-20.1	0.008	0.06	108.0
299	Blacks Fork	0.010	0.09	83.6	16.8	0.012	0.11	69.6	0.0	0.010	0.09	83.6	-40.1	0.006	0.06	90.0
300	Bear River-1	0.105	1.19	176.4	-21.1	0.082	0.94	139.2	-21.1	0.082	0.94	139.2	-21.1	0.082	0.94	139.2
301	Malad River-1	0.872	1.31	131.5	16.7	1.017	1.53	153.4	0.0	0.872	1.31	131.5	-40.0	0.523	0.79	110.0
302	Bear River-2	0.188	0.20	154.2	-21.0	0.149	0.16	121.9	-21.0	0.149	0.16	121.9	-21.0	0.149	0.16	121.9
303	Clarkston Creek	0.047	1.32	93.9	17.7	0.055	1.55	110.5	0.0	0.047	1.32	93.9	-40.6	0.028	0.78	93.9
304	Bear River-3	0.051	0.26	104.5	-20.7	0.041	0.20	104.5	-20.7	0.041	0.20	104.5	-20.7	0.041	0.20	104.5
305	Cub River	0.103	1.00	133.4	-21.6	0.081	0.79	110.0	-21.6	0.081	0.79	110.0	-21.6	0.081	0.79	110.0
306	Logan River-1	0.020	0.76	100.9	-21.6	0.016	0.59	100.9	-21.6	0.016	0.59	100.9	-21.6	0.016	0.59	100.9
307	Logan River-2	0.012	0.19	86.8	0.0	0.012	0.19	86.8	0.0	0.012	0.19	86.8	0.0	0.012	0.19	86.8
308	Little Bear River-1	0.114	1.13	87.4	-21.3	0.090	0.89	90.0	-21.3	0.090	0.89	90.0	-21.3	0.090	0.89	90.0
309	Blacksmiths Fork-1	0.021	0.45	93.0	8.6	0.023	0.49	101.0	0.0	0.021	0.45	93.0	-20.2	0.017	0.36	93.0
310	Left Hand Fork Blacksmiths For	0.010	0.18	100.5	0.0	0.010	0.18	100.5	0.0	0.010	0.18	100.5	0.0	0.010	0.18	100.5
311	Blackmiths Fork-2	0.010	0.27	103.2	0.0	0.010	0.27	103.2	0.0	0.010	0.27	103.2	0.0	0.010	0.27	103.2
312	Little Bear River-2	0.012	0.81	115.1	17.1	0.014	0.95	134.8	0.0	0.012	0.81	115.1	-40.3	0.007	0.48	110.0
314	Bear River-4	0.017	0.39	139.5	-20.4	0.013	0.31	111.0	-20.4	0.013	0.31	111.0	-20.4	0.013	0.31	111.0
316	Big Creek	0.040	0.12	166.0	16.8	0.046	0.14	193.8	0.0	0.040	0.12	166.0	-20.1	0.032	0.09	132.7
317	Woodruff Creek - 1	0.010	0.08	120.5	16.9	0.012	0.09	140.9	0.0	0.010	0.08	120.5	-40.2	0.006	0.04	110.0
318	West Fork Bear River	0.025	0.11	108.0	0.0	0.025	0.11	108.0	0.0	0.025	0.11	108.0	0.0	0.025	0.11	108.0
319	Bear River-6	0.010	0.10	101.0	0.0	0.010	0.10	101.0	0.0	0.010	0.10	101.0	0.0	0.010	0.10	101.0
320	Weber River-1	0.109	0.91	94.8	18.3	0.129	1.07	112.1	0.0	0.109	0.91	94.8	-41.0	0.064	0.54	94.8
322	Ogden River	0.026	0.60	106.5	17.5	0.030	0.71	125.1	0.0	0.026	0.60	106.5	-20.5	0.020	0.48	106.5
323	Wheeler Creek	0.010	0.35	116.9	0.0	0.010	0.35	116.9	0.0	0.010	0.35	116.9	0.0	0.010	0.35	116.9
324	South Fork Ogden River	0.015	0.61	107.8	0.0	0.015	0.61	107.8	0.0	0.015	0.61	107.8	0.0	0.015	0.61	107.8
325	Beaver Creek	0.010	0.27	106.4	0.0	0.010	0.27	106.4	0.0	0.010	0.27	106.4	0.0	0.010	0.27	106.4
326	Causey Reservoir Tributaries	0.010	0.45	111.1	0.0	0.010	0.45	111.1	0.0	0.010	0.45	111.1	0.0	0.010	0.45	111.1
327	Middle Fork Ogden River	0.010	0.41	71.2	17.3	0.012	0.48	58.9	0.0	0.010	0.41	71.2	-20.4	0.008	0.32	85.7
328	North Fork Ogden River	0.010	0.72	109.7	17.4	0.012	0.85	128.8	0.0	0.010	0.72	109.7	-40.5	0.006	0.43	109.7
330	Weber River-3	0.023	0.34	140.5	18.0	0.027	0.40	165.8	0.0	0.023	0.34	140.5	-40.8	0.013	0.20	110.0
332	East Canyon Creek -1	0.033	0.41	115.6	18.4	0.039	0.49	136.9	0.0	0.033	0.41	115.6	-41.0	0.020	0.24	110.0
333	Hardscrabble Creek	0.015	0.54	118.8	0.0	0.015	0.54	118.8	0.0	0.015	0.54	118.8	0.0	0.015	0.54	118.8

Table I-3: Current and projected future water quality parameters for rivers and streams

MAP ID	NAME	Current Conditions (Summer)			Future Conditions-Current Policy				Future Conditions-Nutrient Reduction Program w/ Maintenance				Future Conditions-Nutrient Reduction Program w/ Improvement			
		Ave TP (mg/L)	Ave TIN (mg/L)	Ave DOSAT (%)	Water Quality Change (%)	Ave TP (mg/L)	Ave TIN (mg/L)	Ave DOSAT (%)	Water Quality Change (%)	Ave TP (mg/L)	Ave TIN (mg/L)	Ave DOSAT (%)	Water Quality Change (%)	Ave TP (mg/L)	Ave TIN (mg/L)	Ave DOSAT (%)
334	East Canyon Creek-2	0.028	0.49	127.9	-23.9	0.021	0.37	110.0	-23.9	0.021	0.37	110.0	-23.9	0.021	0.37	110.0
335	Kimball Creek	0.018	0.44	112.7	18.2	0.021	0.52	133.2	0.0	0.018	0.44	112.7	-20.9	0.014	0.35	110.0
336	Weber River-6	0.550	0.87	132.1	17.4	0.646	1.02	155.1	0.0	0.550	0.87	132.1	-40.5	0.328	0.52	110.0
337	Lost Creek Lower	0.017	1.10	124.0	0.0	0.017	1.10	124.0	0.0	0.017	1.10	124.0	0.0	0.017	1.10	124.0
344	Weber River-7	0.038	0.38	118.5	-20.8	0.030	0.30	110.0	-20.8	0.030	0.30	110.0	-20.8	0.030	0.30	110.0
345	Echo Creek	0.038	0.19	112.2	0.0	0.038	0.19	112.2	0.0	0.038	0.19	112.2	0.0	0.038	0.19	112.2
347	Chalk Creek-1	0.012	0.70	101.8	-10.1	0.011	0.63	101.8	-10.1	0.011	0.63	101.8	-10.1	0.011	0.63	101.8
348	Chalk Creek-2	0.010	0.56	113.5	-10.1	0.009	0.50	110.0	-10.1	0.009	0.50	110.0	-10.1	0.009	0.50	110.0
349	South Fork Chalk Creek	0.010	0.25	143.0	0.0	0.010	0.25	143.0	0.0	0.010	0.25	143.0	0.0	0.010	0.25	143.0
350	Huff Creek	0.036	0.32	116.9	0.0	0.036	0.32	116.9	0.0	0.036	0.32	116.9	0.0	0.036	0.32	116.9
351	Chalk Creek-3	0.010	0.18	107.2	-10.1	0.009	0.16	107.2	-10.1	0.009	0.16	107.2	-10.1	0.009	0.16	107.2
352	East Fork Chalk Creek	0.010	0.08	97.7	0.0	0.010	0.08	97.7	0.0	0.010	0.08	97.7	0.0	0.010	0.08	97.7
353	Chalk Creek-4	0.010	0.22	104.3	-10.0	0.009	0.20	104.3	-10.0	0.009	0.20	104.3	-10.0	0.009	0.20	104.3
358	Weber River-8	0.038	0.29	106.0	17.6	0.045	0.34	124.6	0.0	0.038	0.29	106.0	-40.6	0.023	0.17	106.0
359	Silver Creek	1.516	5.44	96.2	21.0	1.835	6.58	116.4	0.0	1.516	5.44	96.2	-42.6	0.870	3.12	96.2
360	Weber River-9	0.324	0.27	109.1	17.1	0.380	0.31	127.7	0.0	0.324	0.27	109.1	-20.3	0.258	0.21	109.1
361	Weber River-10	0.010	0.14	105.4	0.0	0.010	0.14	105.4	0.0	0.010	0.14	105.4	0.0	0.010	0.14	105.4
362	Smith Morehouse River	0.010	0.16	96.6	0.0	0.010	0.16	96.6	0.0	0.010	0.16	96.6	0.0	0.010	0.16	96.6
363	Weber River-11	0.010	0.33	92.5	0.0	0.010	0.33	92.5	0.0	0.010	0.33	92.5	0.0	0.010	0.33	92.5
364	Beaver Creek-1	0.095	0.32	91.0	17.5	0.112	0.38	106.9	0.0	0.095	0.32	91.0	-20.5	0.076	0.26	91.0
370	Farmington Creek	0.051	0.25	101.5	20.9	0.062	0.30	122.7	0.0	0.051	0.25	101.5	-42.6	0.030	0.14	101.5
373	Mill Creek-1	0.042	0.18	133.5	18.5	0.050	0.21	158.2	0.0	0.042	0.18	133.5	-41.1	0.025	0.11	110.0
380	Jordan River-1	0.740	3.83	68.2	-27.0	0.540	2.79	86.6	-27.0	0.540	2.79	86.6	-27.0	0.540	2.79	86.6
382	Jordan River-3	0.569	2.53	78.8	-26.9	0.416	1.85	90.0	-26.9	0.416	1.85	90.0	-26.9	0.416	1.85	90.0
385	Mill Creek-1	2.296	5.52	81.3	22.1	2.804	6.74	63.3	0.0	2.296	5.52	81.3	-43.3	1.303	3.13	90.0
387	Big Cottonwood Creek-1	0.056	0.33	83.3	25.3	0.070	0.42	62.2	0.0	0.056	0.33	83.3	-45.2	0.031	0.18	90.0
389	Little Cottonwood Creek-1	0.065	0.37	81.8	26.2	0.082	0.46	60.4	0.0	0.065	0.37	81.8	-45.7	0.035	0.20	90.0
390	Little Cottonwood Creek-2	0.010	0.21	87.4	17.7	0.012	0.25	71.9	0.0	0.010	0.21	87.4	-20.6	0.008	0.17	90.0
392	Jordan River-6	0.098	0.76	78.1	21.8	0.119	0.93	61.0	0.0	0.098	0.76	78.1	-43.1	0.056	0.43	90.0
393	Jordan River-8	0.107	0.36	78.8	19.9	0.128	0.43	63.1	0.0	0.107	0.36	78.8	-41.9	0.062	0.21	90.0
394	Bingham Creek	0.089	1.80	81.5	31.5	0.117	2.37	55.8	0.0	0.089	1.80	81.5	-48.9	0.045	0.92	90.0
395	Butterfield Creek	0.145	1.76	68.1	43.0	0.207	2.52	38.8	0.0	0.145	1.76	68.1	-55.8	0.064	0.78	90.0
400	Provo River-1	0.029	0.58	88.6	18.5	0.035	0.69	72.2	0.0	0.029	0.58	88.6	-21.1	0.023	0.46	90.0
401	Provo River-3	0.034	0.32	99.5	17.8	0.040	0.37	117.3	0.0	0.034	0.32	99.5	-40.7	0.020	0.19	99.5
402	South Fork Provo River	0.021	0.23	100.0	0.0	0.021	0.23	100.0	0.0	0.021	0.23	100.0	0.0	0.021	0.23	100.0
404	Provo Deer Creek	0.029	0.38	102.7	0.0	0.029	0.38	102.7	0.0	0.029	0.38	102.7	0.0	0.029	0.38	102.7
405	Main Creek-1	0.049	0.54	115.0	17.1	0.058	0.63	134.6	0.0	0.049	0.54	115.0	-40.2	0.030	0.32	110.0
406	Daniels Creek-1	0.037	0.76	111.9	17.6	0.043	0.89	131.7	0.0	0.037	0.76	111.9	-40.6	0.022	0.45	110.0
408	Snake Creek-1	0.024	0.77	115.4	19.5	0.029	0.92	137.8	0.0	0.024	0.77	115.4	-41.7	0.014	0.45	110.0
409	Provo River-4	0.034	0.28	104.7	18.2	0.040	0.33	123.8	0.0	0.034	0.28	104.7	-40.9	0.020	0.17	104.7
410	Heber Valley	0.062	0.14	105.1	8.5	0.068	0.16	114.0	0.0	0.062	0.14	105.1	-20.1	0.050	0.12	105.1
411	Provo River-6	0.023	0.13	98.4	0.0	0.023	0.13	98.4	0.0	0.023	0.13	98.4	0.0	0.023	0.13	98.4
413	South Fork Provo	0.052	0.32	84.4	0.0	0.052	0.32	84.4	0.0	0.052	0.32	84.4	0.0	0.052	0.32	84.4
423	Dry Creek-1	1.619	8.64	104.4	37.5	2.225	11.87	143.5	0.0	1.619	8.64	104.4	-52.5	0.769	4.11	104.4
425	Spanish Fork River-1	0.060	0.52	86.5	8.7	0.066	0.57	79.0	0.0	0.060	0.52	86.5	-20.2	0.048	0.42	90.0
426	Spanish Fork River-2	0.057	0.16	97.7	0.0	0.057	0.16	97.7	0.0	0.057	0.16	97.7	0.0	0.057	0.16	97.7
427	Diamond Fork-1	0.060	0.32	99.8	0.0	0.060	0.32	99.8	0.0	0.060	0.32	99.8	0.0	0.060	0.32	99.8
428	Diamond Fork-2	0.027	0.21	95.7	0.0	0.027	0.21	95.7	0.0	0.027	0.21	95.7	0.0	0.027	0.21	95.7
429	Sixth Water Creek	0.058	0.24	76.0	0.0	0.058	0.24	76.0	0.0	0.058	0.24	76.0	0.0	0.058	0.24	76.0
430	Third Water Creek	0.055	0.12	98.1	0.0	0.055	0.12	98.1	0.0	0.055	0.12	98.1	0.0	0.055	0.12	98.1
446	Beer Creek	2.688	2.15	116.3	21.4	3.265	2.61	141.2	0.0	2.688	2.15	116.3	-42.9	1.536	1.23	110.0
449	Peteetneet Creek	0.040	0.66	92.3	0.0	0.040	0.66	92.3	0.0	0.040	0.66	92.3	0.0	0.040	0.66	92.3
500	Sevier River-25	0.347	0.43	92.7	0.0	0.347	0.43	92.7	0.0	0.347	0.43	92.7	0.0	0.347	0.43	92.7
501	Sevier River-24	0.034	0.60	96.6	-20.9	0.027	0.47	96.6	-20.9	0.027	0.47	96.6	-20.9	0.027	0.47	96.6
502	Sevier River-22	0.037	0.22	102.4	-20.9	0.029	0.18	102.4	-20.9	0.029	0.18	102.4	-20.9	0.029	0.18	102.4
503	Sevier River-20	0.025	0.39	101.4	-20.9	0.020	0.31	101.4	-20.9	0.020	0.31	101.4	-20.9	0.020	0.31	101.4
504	Sevier River-17	0.060	2.92	138.7	-21.0	0.047	2.31	110.0	-21.0	0.047	2.31	110.0	-21.0	0.047	2.31	110.0
505	San Pitch-1	0.017	1.26	104.1	17.8	0.020	1.49	122.6	0.0	0.017	1.26	104.1	-40.7	0.010	0.75	104.1
506	San Pitch-3	0.034	0.59	99.3	17.8	0.040	0.70	117.0	0.0	0.034	0.59	99.3	-40.7	0.020	0.35	99.3
507	San Pitch-5	2.538	0.58	108.5	17.7	2.989	0.69	127.8	0.0	2.538	0.58	108.5	-40.6	1.507	0.35	108.5
510	Lost Creek	0.010	0.30	133.0	0.0	0.010	0.30	133.0	0.0	0.010	0.30	133.0	0.0	0.010	0.30	133.0
511	Sevier River-8	0.041	0.39	96.4	17.4	0.048	0.46	113.2	0.0	0.041	0.39	96.4	-20.4	0.032	0.31	96.4
517	Clear Creek	0.021	0.29	144.0	0.0	0.021	0.29	144.0	0.0	0.021	0.29	144.0	0.0	0.021	0.29	144.0
518	Sevier River-6	0.085	0.45	117.1	8.6	0.092	0.49	127.2	0.0	0.085	0.45	117.1	-20.2	0.068	0.36	110.0
519	Sevier River-4	0.035	1.45	108.9	17.4	0.041	1.70	127.9	0.0	0.035	1.45	108.9	-40.4	0.021	0.86	108.9
520	East Fork Sevier River-3/4	0.052	0.31	102.3	0.0	0.052	0.31	102.3	0.0	0.052	0.31	102.3	0.0	0.052	0.31	102.3
524	Sevier River-3	0.026	0.26	99.2	-10.5	0.024	0.23	99.2	-10.5	0.024	0.23	99.2	-10.5	0.024	0.23	99.2
525	Sevier River-2	0.039	0.48	102.7	-10.5	0.035	0.43	102.7	-10.5	0.035	0.43	102.7	-10.5	0.035	0.43	102.7
527	Sevier River-1	0.019	0.16	104.1	-10.5	0.017	0.14	104.1	-10.5	0.017	0.14	104.1	-10.5	0.017	0.14	104.1
528	Mammoth Creek	0.044	0.25	94.7	0.0	0.044	0.25	94.7	0.0	0.044	0.25	94.7	0.0	0.044	0.25	94.7
529	Otter Creek	0.055	0.20	110.1	0.0	0.055	0.20	110.1	0.0	0.055	0.20	110.1	0.0	0.055	0.20	110.1
531	Beaver River-2	0.068	0.20	130.5	-21.1	0.054	0.16	110.0	-21.1	0.054	0.16	110.0	-21.1	0.054	0.16	110.0
532	Beaver River-3	0.024	0.32	93.7	0.0	0.024	0.32	93.7	0.0	0.024	0.32	93.7	0.0	0.024	0.32	93.7

Appendix J
Photographs of Streams Depicting a Range of Benthic Algae Conditions

APPENDIX J

Photographs of Streams Depicting a Range of Benthic Algae Conditions

These photographs were sent out for percent desirable responses as part of the economic evaluation survey. The survey was a multiple question brochure and the benthic algal percent desirable condition was only a portion of the survey. Photos are shown in same sequence as in survey. Benthic Chl a concentrations (mg/m^2) and total responses shown here were not available to recipients at time of survey. Participants were asked to respond to the following quest "Please review the photos of algae in rivers on both sides of the one-page insert included in this survey. For each photograph on the insert tell us if the level of algae would be desirable or undesirable for YOUR most common uses of rivers, if any. There are no correct answers; this is your opinion only. *Fill in one bubble for each number.*" Photos were used from Suplee et al. (2009) study.

Q10. Photograph 1

	Frequency	Valid Percent
Desirable	565	96.6%
Undesirable	20	3.4%
Total	585	100.0%
Total Missing	43	
Total	628	
Chl a mg/m^2	40	

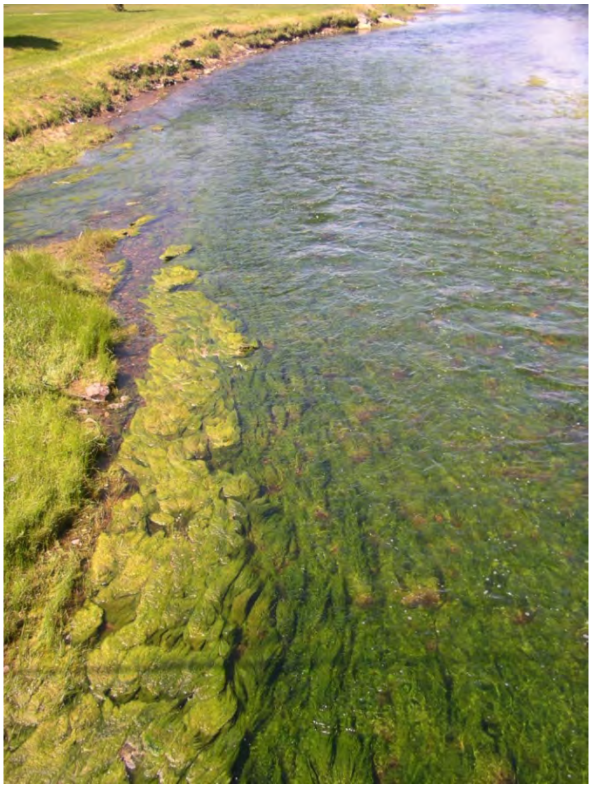
Q10. Photograph 2

	Frequency	Valid Percent
Desirable	177	30.6%
Undesirable	401	69.4%
Total	578	100.0%
Total Missing	50	
Total	628	
Chl a mg/m^2	240	

Q10. Photograph 3

	Frequency	Valid Percent
Desirable	84	14.7%
Undesirable	488	85.3%
Total	572	100.0%
Total Missing	56	
Total	628	
Chl a mg/m^2	400	

Q10. Photograph 4



	Frequency	Valid Percent
Desirable	48	8.3%
Undesirable	530	91.7%
Total	578	100.0%
Total Missing	50	
Total	628	
Chl a mg/m^2	1,280	

Q10. Photograph 5

	Frequency	Valid Percent
Desirable	97	16.8%
Undesirable	479	83.2%
Total	576	100.0%
Total Missing	52	
Total	628	
Chl a mg/m^2	200	

Q10. Photograph 6

	Frequency	Valid Percent
Desirable	343	59.4%
Undesirable	234	40.6%
Total	577	100.0%
Total Missing	51	
Total	628	
Chl a mg/m^2	150	

Q10. Photograph 7

	Frequency	Valid Percent
Desirable	539	92.8%
Undesirable	42	7.2%
Total	581	100.0%
Total Missing	47	
Total	628	
Chl a mg/m^2	110	

Q10. Photograph 8

	Frequency	Valid Percent
Desirable	82	14.1%
Undesirable	498	85.9%
Total	580	100.0%
Total Missing	48	
Total	628	
Chl a mg/m^2	300	