PHASE III REPORT

AREA VI RED RIVER CHLORIDE CONTROL PROJECT: PHASE III REPORT

Prepared for
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EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (USACE), Tulsa District, is reevaluating the Congressionally authorized Area VI of the Red River Chloride Control Project (RRCCP), which is designed to reduce chlorides contributed to the Red River by the Elm Fork of the river's North Fork. Chloride management would make the river's water more suitable for irrigation and could increase the acres of irrigable lands in and around Altus, Oklahoma. As part of the reevaluation, the Tulsa District is assessing how chloride management would affect Lake Texoma's striped bass population and associated recreational fishing industry. The purpose of this study is to estimate the economic impact of a potential change in the recreational fishery at Lake Texoma and evaluate the economic impact in the Altus region (located in southwest Oklahoma and northern Texas) related to the changes in agricultural practice from an increase in water suitable for irrigation.

The overall study has been divided into three phases to date. Phase I was completed in September 2007; this phase defined the study area, potential substitute recreation sites, sample design, economic valuation methods, and development of the survey instrument. Phase II was completed in December 2009; in this phase telephone surveys were conducted and econometric analyses were performed to develop willingness-to-pay (WTP) estimates for the striped bass fishery using the contingent valuation method. This report represents Phase III of the study which evaluated National Economic Development (NED) benefits (or losses), Regional Economic Development (RED) benefits (or losses), and a risk and uncertainty analysis of the recreation benefits considering potential changes to recreational fishing from implementation of the RRCCP in Area VI. RED benefits related to changes in agriculture in the Altus region from the implementation of the RRCCP in Area VI were also assessed.

Specifically, Phase III contains an economic evaluation of:

- NED impacts for the future with- and without-project conditions, which represent different scenarios to the striped bass fishery in Lake Texoma.
- RED impacts related to striped bass fishing in Lake Texoma for a potential range of negative impacts to the catch rate of striped bass.

- RED in the Altus region related to expected changes in agricultural practices from the implementation of Area VI.

Implementation of Area VI of the RRCCP may affect recreation on Lake Texoma, specifically striped bass fishing. Formed by the Denison Dam, Lake Texoma covers 86,910 acres and is located at the confluence of the Red and Washita Rivers, between Oklahoma and Texas. The Denison Dam is about 75 miles north of Dallas, Texas. The area around Lake Texoma is a popular destination for family reunions, camping, hiking, and golfing. Recreation on the lake itself includes fishing, sailing, wind surfing, power boating, waterskiing, and other personal watercraft activities. The dominant species of fish in Lake Texoma are gizzard shad, striped bass, threadfin shad, and freshwater drum (Gido and Matthews, 2000). Of particular interest is the striped bass fishing, which is considered some of the best in the country and draws people from all over the United States. Lake Texoma's striped bass fishery attracts an estimated 965,000 visits by anglers every year, with an annual recreation value of approximately $21.1 million. With anglers come all of the associated goods and services that directly benefit the local region, including bait and tackle shops, guide services, restaurants, and accommodations. The 965,000 annual fishing trips create 2,583 jobs and generate a total economic impact of $159 million in the region.

In Phase III, a hybrid travel cost method known as contingent behavior was selected to capture the effect of potential changes in the catch rate of striped bass. The contingent behavior approach is similar to the travel cost method and involves determining an individual's travel cost and travel time to Lake Texoma, describing a new recreation condition (i.e., a decrease in the catch rate), and asking whether the number of annual trips taken by an individual and the travel cost and travel time to Lake Texoma would change under that condition. The actual number of annual trips taken by an individual and the travel cost are used to develop the demand curve for recreation; in this case, recreational fishing on Lake Texoma. From the demand curve, WTP is calculated. The contingent behavior method links a potential change in the catch rate with the estimated change in the number of annual trips by anglers to Lake Texoma. Ecological modeling determined that Area VI of the RRCCP is not anticipated to have a measurable effect on the adult striped bass population in Lake Texoma. An expert panel was assembled to estimate the change in angler catch rates for striped bass resulting from changes in water quality. The experts supported the results of the ecological modeling and concluded that chloride management is not anticipated to have a measurable effect on the adult striped bass population in Lake Texoma. However, a key uncertainty is whether the RRCCP would influence recruitment of striped bass. Recruitment is defined as the number of new juvenile fish surviving to enter the fishery. If the implementation of Area VI of the RRCCP would adversely impact the recruitment of striped bass, the population of striped bass may decline over time. A minor to moderate change in fish abundance is not likely to influence the catch rate. However, if the population was continually decreasing over time, eventually the catch rate of striped bass would wane.

Since additional information is needed to determine the effect of Area VI on recruitment of striped bass, potential impacts to the catch rate for striped bass were evaluated under three scenarios. Because the maximum possible decrease in catch rate is not expected to exceed 30 percent as a result of implementation of Area VI, the first scenario considered a 10 percent reduction in the catch rate, the second scenario a 20 percent reduction in the catch rate, and the third scenario considered the most extreme case, a 30 percent reduction in the catch rate. The first scenario would result in 12,100 fewer annual trips and an annual NED loss of $265,000 (negative benefit). The second scenario would result in 24,200 fewer annual trips and an annual NED loss of $530,000. The third scenario would result in 36,400 fewer annual trips and an annual NED loss of $795,000.

The reduction in annual trips in each scenario was used to estimate RED benefits (or losses). In the first scenario, the reduction of 12,100 annual trips results in a loss of 5.3 jobs and an output loss of $312,600. In the second scenario, the reduction of 24,200 annual trips results in a loss of 10.6 jobs and an output loss of $590,900. In the third scenario, the reduction of 36,400 annual trips results in a loss of 15.9 jobs and an output loss of $937,800. Once it is determined how the RRCCP may affect recruitment and ultimately the catch rate of striped bass in Lake Texoma, the NED results could be finalized.

RED benefits or losses were estimated for the changes in irrigation due to Area VI. RED benefits were estimated using NED benefits presented in two papers by Oklahoma State University (OSU). The papers analyzed NED benefits for two alternatives, with implementation of Cable Mountain Reservoir and without implementation of Cable Mountain Reservoir. The construction of Cable Mountain Reservoir is proposed as a new reservoir on the North Fork of the Red River downstream of Lake Altus. Within each alternative, several scenarios were examined to account for differing weather conditions, electrical conductivity (EC) levels, and cotton prices. The electrical conductivity is a common measure of soil salinity and is indicative of the ability of water to carry an electric current. RED benefits were estimated for each of these conditions.

In the Without-Cable Mountain Reservoir alternative, total employment was estimated to increase by 88 jobs and output was estimated to increase by $9,864,100, given average weather conditions and an EC level of 1.5. In the With-Cable Mountain Reservoir alternative, employment was estimated to increase by 156 jobs and output was estimated to increase by $21,656,100, given an EC level of 1.5 and a cotton price of $0.54 per pound. However, these benefits are dependent on a fixed irrigation system cost of $200 per acre, which is low compared to other irrigation system designs. The fixed costs are likely to be significantly higher, which would create negative impacts in the study area since the costs of irrigation would be higher than the benefits.

At the time this report was completed, the OSU studies were in draft format. The RED impacts associated with the NED benefits in the With and Without-Cable Mountain RED inputs are subject to future changes as the OSU studies are finalized.

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LIST OF ACRONYMS

CASM	Comprehensive Aquatic Ecosystem Model
CASM-LT	Comprehensive Aquatic Ecosystem Model – Lake Texoma
EC	Electrical Conductivity
EPIC	Erosion Productivity Impact Calculator
GIS	Geographic Information Systems
GLS	Generalized Least Squares
NED	National Economic Development
NPV	Net Present Value
NRCS	Natural Resources Conservation Service
ODWC	Oklahoma Department of Wildlife Conservation
OLS	Ordinary Least Squares
OSU	Oklahoma State University
PDT	Project Delivery Team
RED	Regional Economic Development
RRCCP	Red River Chloride Control Project
TDS	Total Dissolved Solids
TPWD	Texas Parks and Wildlife Department
TSS	Total Suspended Solids
USGS	U.S. Geological Survey
USACE	United States Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WTP	Willingness-to-pay

Section One: Introduction

1.0 INTRODUCTION

The United States Army Corps of Engineers (USACE), Tulsa District, is reevaluating the effects of implementing Area VI of the Red River Chloride Control Project (RRCCP). The RRCCP is a multi-component initiative to reduce naturally occurring brine spring emissions from entering the Red River. Chlorides make up about one-third of the total dissolved solids (TDS) in the Red River. Sulfates and other solutes generated by the natural brine springs also impair the water quality. The high levels of chlorides, sulfates, and other TDS in the Red River, its tributaries, and Lake Texoma can render the water less desirable or even unsuitable for use as drinking water or for irrigation without prior treatment or demineralization.

Area VI is located on the Elm Fork of the Red River in Harmon County, Oklahoma. Approximately 4,400 tons of chlorides from natural sources enter the Red River and its tributaries on a daily basis. Of that amount, about 510 tons per day are contributed by Area VI. Chloride reduction measures in Area VI involve the construction of detention and evaporation basins that would prevent the brine spring emissions from entering the Elm Fork of the Red River. Area VI could increase the supply of suitable irrigation water and increase the acres of irrigable lands. An increase in irrigable lands would increase crop production and generate National Economic Development (NED) benefits and Regional Economic Development (RED) benefits. Implementation of Area VI is anticipated to have an effect on the agricultural lands in and around the Lugert-Altus Irrigation District.

Stakeholders have expressed concerns that chloride management from Area VI may affect the water quality and turbidity of Lake Texoma, as well as certain species of game fish. Ecological modeling of Lake Texoma was conducted to simulate the ecosystem of Lake Texoma and assess the potential impacts of chloride management. Of particular interest is striped bass fishing on Lake Texoma, which is considered some of the best in the country and draws people from all over the United States. The striped bass fishery attracts an estimated 965,000 visits by anglers to Lake Texoma every year. The ecological modeling was used to forecast changes in the striped bass populations in Lake Texoma in relation to chloride management.

Section One: Introduction

The Area VI Red River Chloride Control Project study is comprised of three phases:

- Phase I was completed in September 2007 and defined the recreation study area, identified potential impacts on recreational activities, inventoried existing recreational opportunities, and developed the survey instrument and economic valuation methods necessary to support Phase II.
- Phase II was completed in December 2009 and included telephone surveys and econometric analyses to develop lower-bound, upper-bound, and most-likely willingness-to-pay (WTP) estimates for the striped bass fishery (the report is still under review).
- Phase III provides an analysis of how Area VI would affect NED and RED in the Lake Texoma region, primarily related to recreational fishing of striped bass. It also includes the RED impacts in the Altus region from the anticipated increase in the agricultural water supply from Area VI.

This report represents Phase III, which was divided into two components: recreation and agricultural. The recreation component is covered in Sections 2, 3, and 4. The recreation NED impacts are presented in Section 2 and the recreation RED impacts in Section 3. A risk and uncertainty analysis for the recreation NED and RED results is available in Section 4. The RED impacts for the agricultural component are presented in Section 5. Since additional data are needed to complete the agricultural and recreational components, the suggested next steps to complete the economic evaluation are provided in Section 6. References are provided in Section 7. Appendix A contains the scope of work for Phase III of the study.

2.0 RECREATION NATIONAL ECONOMIC DEVELOPMENT

The U.S. Water Resources publication *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (1983) directs Federal agencies to balance economic development and environmental needs while addressing water resource problems. The Federal objective of water resource planning is to contribute to NED consistent with protecting the environment, in accordance with applicable laws and other Federal planning requirements. Consistent with the USACE Civil Works planning and recreational regulations, this econometric analysis estimates the NED impacts associated with the proposed project.

The RRCCP aims to improve water quality and benefit current and potential users of Red River water by reducing the amounts of chlorides, sulfates, and other TDS entering the river. Although managing chloride on the Red River would improve water quality, there is a concern that reduced chloride would lead to decreased sedimentation rates, increased turbidity, and reductions in primary production throughout the Lake Texoma food web and ultimately reduce populations of striped bass in the lake. Striped bass is the most sought after game fish in Lake Texoma. In fact, Lake Texoma is known for its striped bass fishing and is one of only seven inland reservoirs in the U.S. where striped bass reproduce naturally (NOAA, 2012). In addition to Lake Texoma, other inland reservoirs include: Kerr Reservoir in Virginia and North Carolina; Santee-Cooper Reservoir in South Carolina; Lake Powell in Utah and Arizona; Lake Mead and Lake Mohave in Nevada and Arizona, and Lake Havasu in Arizona and California. This section evaluates the NED impacts from potential changes in the striped bass fishery in Lake Texoma related to Area VI of the RRCCP.

2.1 Relevant Studies

There are four primary studies that contributed to Phase III of the RRCCP Recreational study. This section provides an overview of each study and how it relates to Phase III.

2.1.1 Area VI Red River Chloride Control: Recreation Study Phase I

Phase I of the RRCCP Recreational study refined the recreation study area, discussed potential recreation activities affected by the project, inventoried existing recreation opportunities, explained economic valuation methods, and developed a survey instrument to be used in Phase II.

The study area was defined using fishing license sales data for Lake Texoma. The inventory of recreational opportunities was facilitated by geographic information systems (GIS) and USACE project delivery team (PDT), lake managers, and local stakeholders. Recreational features inventoried focused on area lakes in Texas and Oklahoma. This inventory served to highlight the uniqueness of Lake Texoma, considering its size, location within the United States, and its use as a recreational sport fishery. The ability for striped bass to reproduce naturally and sustain a thriving population is perhaps the lake's most unique feature.

Evaluating the economic impacts through a telephone survey was determined to be the best method for estimating anglers' reaction to any potential changes in the recreational fishery. A telephone-based survey instrument was developed based on discussions with the PDT, lake managers, and local stakeholders. The survey instrument incorporated elements of both travel cost method and contingent valuation method to determine the economic impact of proposed changes to the recreational fishery. The survey was designed to capture angler WTP for changes in fish catches.

Two valuation methods, travel cost method and contingent valuation method, and several econometric models were used to determine the economic benefits associated with the implementation of Area VI. The theoretical and data-generating structure of these methods enabled calculation of the economic impact associated with recreation on Lake Texoma.

The Phase I report was provided to the Texas Parks and Wildlife Department (TPWD), U.S. Fish and Wildlife Service (USFWS), and Oklahoma Department of Wildlife Conservation (ODWC) in the fall of 2008. The agencies provided comments on the report. Those comments and accompanying responses were provided in the appendix of the Phase II report.

2.1.2 Area VI Red River Chloride Control: Recreation Study Phase II

Phase II of the RRCCP Recreational study focused on evaluating the value anglers place on Lake Texoma's striped bass fishery. Phase II included survey implementation, statistical and econometric analysis of the completed survey questionnaires, and a risk and uncertainty analysis of the WTP estimates.

Econometric analyses using the contingent valuation method were performed to develop lower-bound, upper-bound, and most-likely WTP estimates for the striped bass fishery. WTP ranged from $9 to $21 per year, with a most likely value of $17 per year for the survey sample. A methodology was developed and utilized for approximating the user population of anglers on Lake Texoma per year. The Oklahoma user population was estimated to be approximately 39,000 anglers per year and the Texas user population was estimated to be 62,000 anglers per year. Based on the calculated WTP values and the user population, the aggregate WTP for Lake Texoma's striped bass anglers ranges from $909,000 to $2,121,000, with a most likely value of $1,655,000 (all in 2009 dollars). In Phase II, the contingent valuation method was used, but for Phase III the contingent behavior method was selected to capture the effect of potential changes in the catch rate of striped bass; the approach is explained in Section 2.3.

2.1.3 Flow and Solute Concentrations Modeling

The *Area VI Reevaluation Concentrations Duration/Low Flow Study* (USACE, 2011) reevaluated the changes to flow and solute concentrations on the Elm Fork, North Fork, and entire main stem of the Red River if chloride reduction were implemented in Area VI. The study also summarized the impacts of implementing chloride reduction in the Wichita River (Areas VII, VIII and X) and Prairie Dog Town Fork (Area V) projects.

Five conditions were evaluated in the study (Table 2-1). The conditions include natural conditions, which represent no chloride reduction in the Red River Basin, and chloride reduction scenarios in the Red River Basin in the areas shown on the table. Condition 2, reduction of chloride in Areas V and VIII, has already been implemented. Conditions 3, 4, and 5 represent potential chloride reduction scenarios in the Red River Basin. The Low Flow Study estimated chloride, sulfate, and TDS loads for each condition. The study also evaluated two future actions that could potentially impact the Red River Basin: the reallocation of conservation storage in Lake Texoma and the construction of Cable Mountain Reservoir. These actions were evaluated separately.

Table 2-1: Conditions Investigated

Condition	Chloride Control Areas
1	Natural Conditions
2	Areas V and VIII
3	Areas V, VII, VIII, and X
4	Areas V, VI, and VIII
5	Areas V, VI, VII, VIII, and X

Source: Area VI Reevaluation Concentrations Duration/Low Flow Study (USACE, 2011)

The resulting estimated loads for each condition were used in this study as base data. Since Condition 2 has already been implemented, results associated with Condition 2 were considered as the Without-Project condition. Condition 4 assumes that Areas V, VI, and VIII are implemented. Since this condition represents the incremental addition of Area VI, Condition 4 was used when evaluating the impacts for the with-project condition. Conditions 2 and 4 are referred to as without-project and with-project, respectively, throughout the remainder of this report.

2.1.4 Ecological Modeling

The *Evaluation of Chloride Management Alternatives: Application of the Comprehensive Aquatic Ecosystem Model (CASM) to Lake Texoma* (Bartell et al., 2010) adapted the CASM to simulate the ecosystem of Lake Texoma (CASM-LT) to assess the potential impacts of chloride management on light availability, primary production, and food web dynamics for selected locations within Lake Texoma. Specifically, the CASM-LT forecasted changes in the striped bass populations in Lake Texoma in relation to chloride management.

The principal modeling objectives were to:

- Develop a Lake Texoma version of the CASM that simulated ecological production dynamics of producer and consumer populations consistent with measured production;
- Use the Lake Texoma CASM to examine the potential food web implications of alternative chloride management scenarios; and

- Examine the responses of modeled populations to chloride management in relation to annual environmental variability and longer-term loss of storage capacity of this larger reservoir.

The important hypothesis concerning chloride management in Lake Texoma is that reduced chloride would lead to decreased sedimentation rates, increased turbidity, and reductions in primary productivity. Chloride management could decrease TDS, which would reduce sedimentation rates in the reservoir; a corresponding increase in concentrations of suspended sediments might decrease primary production throughout the Lake Texoma food web and ultimately reduce populations of striped bass. Alteration of light availability may also promote the growth of golden algae (*Prymnesium parvum*) which is a concern since it produces a toxin that kills fish.

Comparing the with-project and without-project conditions over a 50-year period of analysis, the results suggest minimal impacts of chloride management on overall striped bass production in Lake Texoma. Furthermore, environmental variability produced greater year-to-year fluctuation in striped bass biomass than the expected reduction in TDS. Reductions of 4 to 16 percent in daily TDS concentrations did not translate to substantive impacts on striped bass production, especially when compared with the effects of environmental variability or the long-term sediment accumulation in Lake Texoma. Also, reductions in TDS concentrations did not result in dramatic increases in the modeled production of *Prymnesium parvum*.

2.2 Study Area

Formed by the Denison Dam, Lake Texoma covers 89,000 acres and is located at the confluence of the Red and Washita Rivers, between Oklahoma and Texas. The Denison Dam is about 75 miles north of Dallas, Texas. Anglers can purchase a State freshwater fishing license from either Oklahoma or Texas, or anglers can purchase a Lake Texoma fishing license. Anglers who only have a state license may only fish within the respective state boundaries, whereas the Lake Texoma fishing license allows anglers to fish anywhere on the lake. Previous phases were based on information from Lake Texoma fishing licenses purchased in Texas. During Phase III, ODWC provided zip codes for the residences of all

2006 and 2007 Lake Texoma fishing licenses purchased in Oklahoma. The regional map of the study area provided in Phase I was updated with the complete zip code information (Figure 2-1). The majority of the Lake Texoma licenses were purchased by Texas residents (61 percent) followed by Oklahoma residents (24 percent) and Kansas residents (7 percent). The remaining licenses (8 percent) were purchased by residents from other states, representing 48 states overall. A detailed analysis of the zip code information is included in Section 2.8.3.

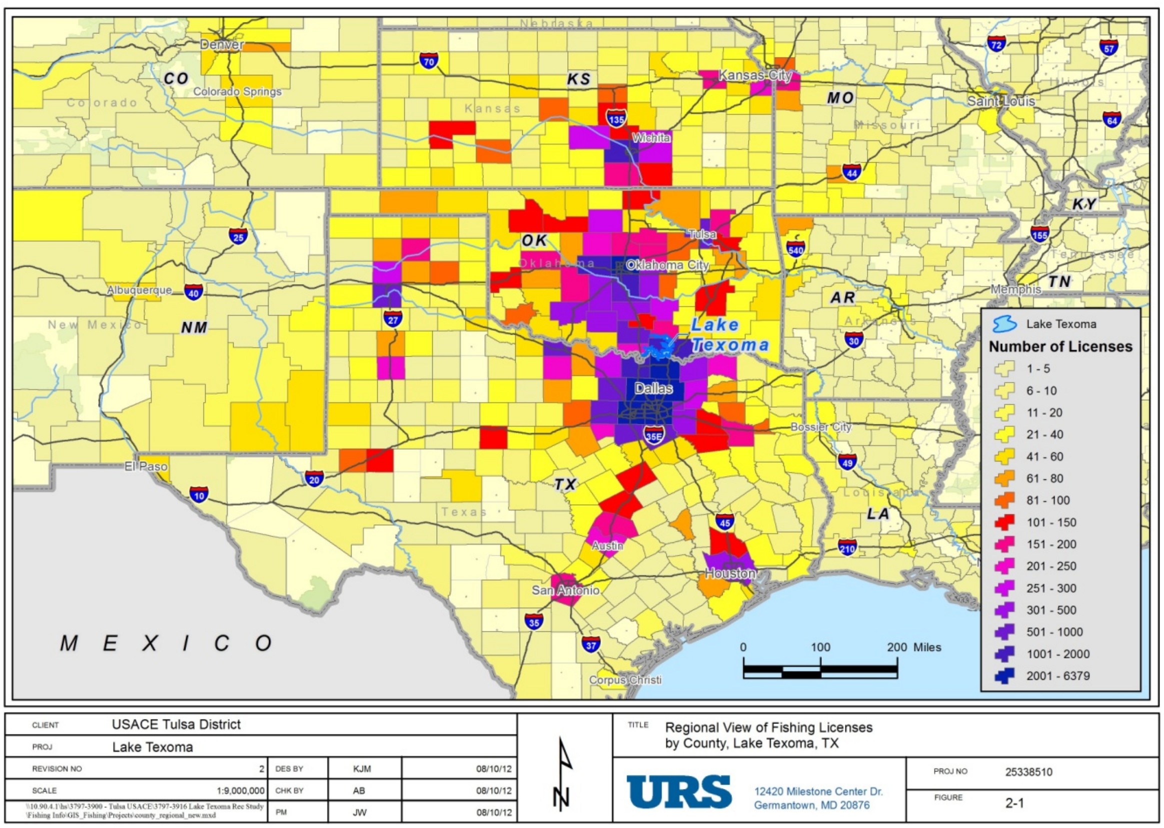


Figure 2-1: County Distribution of Lake Texoma Fishing Licenses (2007)

2.3 NED Approach

The recreation portion of the study evaluates the impacts of potential changes in the striped bass fishery in Lake Texoma related to the implementation of Area VI of the RRCCP. The recreation study was conducted in three phases, with each phase building on the results of the previous phase. In Phase I, the recreation study area was refined, the types of recreation that may be affected by RRCCP were identified, the existing recreational opportunities were inventoried, economic valuation methods were described, and a survey instrument was developed. A survey was determined to be the best method for estimating anglers' reaction to any potential changes in the recreational fishery and the associated economic impacts. Telephone surveys were selected as least invasive to an angler's recreational experience, and not subject to seasonal concerns. A detailed discussion of the survey methodology is provided in the Phase I report. The survey instrument, the implementation of the survey, and the survey results are explained in the Phase II report. This Phase III report includes statistical and econometric analysis of the completed survey questionnaires from Phase II, to estimate the value of recreational fishing on Lake Texoma considering a potential change in the striped bass fishery.

The standard theoretical measure of benefits and costs is WTP, defined as the maximum amount of money an individual would be willing to forgo to either obtain an improvement or to avoid an undesirable outcome. The WTP value is used to estimate the net economic value for recreational fishing in the study area. In Phase II, contingent valuation was used to develop lower-bound, upper-bound, and most-likely WTP estimates for the striped bass fishery. However, the biological impacts of the RRCCP within Lake Texoma were not finalized or validated at the time of survey development and implementation. Biologists performing the biological impact analysis were consulted to develop the catch rate percent decrease range used in the survey (zero to 30 percent). A 30 percent reduction is considered an extreme scenario, but it was used to bound the range used in the survey.

Understanding angler catch rates at Lake Texoma was essential to the completion of the Recreation Study. To help bridge the gap between information that currently existed and what was needed to complete Phase III, an expert-opinion elicitation process was employed. The primary reason for using an expert-opinion elicitation process is to deal with uncertainty relating to complex technical issues. For the Recreation Study, this process was used to understand how the implementation of Area VI would affect the catch rate of striped bass in Lake Texoma. The expert-opinion elicitation is explained in greater detail in Section 2.4 and meeting notes are available in Appendix B.

Section Two: Recreation National Economic Development

The experts agreed on the results of the ecological modeling (CASM-LT), that chloride management at Area VI would not be anticipated to have a measurable effect on the adult striped bass population. The expert panel also identified that it is uncertain how chloride management may affect recruitment of striped bass or catch rates. Recruitment is defined as the number of new juvenile fish surviving to enter the fishery. Consequently, hypothetical impacts to the catch rate for striped bass were evaluated under three scenarios that corresponded to the range of catch rates asked to survey respondents. The first scenario considered a 10 percent reduction in the catch rate, the second scenario a 20 percent reduction in the catch rate, and the third scenario a 30 percent reduction in the catch rate.

The survey results were reanalyzed using a combined travel cost and trip response demand model (Section 2.5) to estimate changes in demand for striped bass fishing in Lake Texoma (number of trips per year) when site features change (i.e., the catch rate for striped bass). The survey was initially developed to support both the travel cost method and the contingent valuation method for estimating the economic impact of proposed changes to the recreational fishery. In Phase II, the contingent valuation method was used, but for Phase III a hybrid travel cost method known as contingent behavior was selected to capture the effect of potential changes in the catch rate of striped bass.

The contingent behavior approach is similar to the travel cost method and involves determining an individual's travel cost and travel time to Lake Texoma, describing a new recreation condition (i.e., a decrease in the catch rate), and asking whether the number of annual trips taken by an individual would change under that condition. The actual number of annual trips taken by an individual and the travel cost are used to develop the demand curve for recreation; in this case, recreational fishing on Lake Texoma. From the demand curve, WTP is calculated.

During Phase III, new zip code information became available for Lake Texoma licenses that were purchased in Oklahoma. (Only information relating to licenses purchased in Texas was available during Phase I and Phase II.) Using the new zip code information and Census data, the travel costs for all Lake Texoma licenses purchased for the 2007 license year were estimated. The travel costs of all 2007 licenses holders was compared with the survey sample to ascertain whether the survey sample is representative of the whole user population.

The elasticity of demand for fishing trips based upon the catch rate was defined to predict the change in fishing trips resulting from changes in the catch rate. The catch rate elasticity was used to evaluate the relationship between the catch rate and the value of the striped bass fishery considering the three hypothetical scenarios of changes to the catch rate. The catch rate elasticity is discussed in Section 2.7.

The NED impacts for each scenario were calculated as the difference in the number of annual trips to Lake Texoma considering a change in the catch rate. The change in the annual number of trips indicates how anglers would respond to a change in the catch rate and how the value of the striped bass fishery may decrease. The WTP value per trip is elicited from the angler's travel cost to Lake Texoma for striped bass fishing. The mean WTP value was multiplied by the anticipated reduction in annual trips associated with each scenario. The annual number of trips was estimated by multiplying the mean number of annual trips in the survey sample by the annual user population. The annual user population of striped bass anglers was estimated in Phase II. The net NED impacts are the difference between the without-project and with-project conditions defined by each scenario; the results are available in Section 2.10.

The risk and uncertainty surrounding the NED impacts are discussed in Section 4. The catch rate, WTP, and the total number of annual trips were varied within the 90 percent confidence interval to evaluate the probability or likelihood of the possible NED results. A Monte Carlo simulation with 10,000 iterations was run to evaluate the likelihood and distribution of net NED impacts.

2.4 Expert-Opinion Elicitation

Expert-opinion elicitation is a formal process for capturing judgment or opinion from a panel of recognized experts regarding a defined problem that cannot be resolved solely by gathering information from sources including historical records, prediction methods, or literature review. The value of expert-opinion elicitation comes from its intended use as a heuristic tool for exploring vague and unknown issues. An expert-opinion elicitation supplements rigorous reliability and risk analytical methods. This expert-opinion elicitation was performed during a face-to-face meeting of experts convened specifically to estimate the change in the catch rate of striped bass in Lake Texoma with the implementation of Area VI of the RRCCP. The results of the expert-opinion elicitation are intended to supplement further analysis.

Prior to the meeting, panel members were provided with background information, objectives, and anticipated meeting outcomes. The information provided to the experts is included in Appendix B. This allowed the members to have a general idea of what was needed and expected from them before arriving. Once assembled, the process was explained and the experts were then asked to render opinions on the issues that were communicated to them prior to the meeting.

The panel of experts was recruited from around the country, with 22 individuals contacted as part of the expert panel member identification and recruitment process. Panelists were initially identified by contacting consultants and fisheries professors for recommendations and reviewing the resume of each potential panelist. The field of potential panelists was narrowed down to four members by matching an individual expert's background and experience to the appropriate skills needed to interpret biological modeling.

The expert panel represented a cross-section of industries and relevant backgrounds and members were selected based on their academic and professional credentials. Collectively, the selected panel members possessed expertise in the following subject areas: fisheries management, fisheries ecology, fisheries science, biology, wildlife management, limnology, fish recruitment, foraging ecology and competition, water management, and water resources. The panel consisted of four experts: Micheal Shawn Allen, Ph.D., John Van Conner, Ph.D., Brian D. S. Graeb, Ph.D., and John Richard Jones, Ph.D. Biographies of each selected panel member are available in Appendix C.

Observers from the USACE, ODWC, Texas Parks and Wildlife Department, and USFWS were in attendance during the panel. Observers contributed technical support and guidance to the panel of experts; only the experts provided answers to the questions on selected issues. The meeting notes and the full list of attendees (meeting attendees pictured in Figure 2-2) are available in Appendix D.

Back row from left to right: Jennifer Lavin, Andrea Bohmholdt, Warren Schlechte, John Van Conner, John Richard Jones, Micheal Shawn Allen, Greg Summers, Brent Bristow, Steve Bartell, and Matt Mauck. Front row from left to right: John Moczygemba, Matthew Tyler Henry, Jason Weiss, Tony Clyde, Bruce Hysmith, Brian Graeb, and Ed Rossman.

Figure 2-2: Expert Opinion Elicitation Meeting Attendees

Based on the results of the CASM-LT presented to the experts, it was agreed that chloride management is not anticipated to have a measurable effect on the adult striped bass population in Lake Texoma. However, a key uncertainty is whether the RRCCP project would influence recruitment of striped bass. If chloride management influences the recruitment of striped bass, then fish abundance and ultimately fishing effort would also be affected. More information was requested to determine if the change in flow and conductivity from chloride management could affect the recruitment of striped bass. During the meeting, three factors were identified as important for the recruitment of striped bass:

- Spawning occurred 40 to 60 miles upstream of Lake Texoma
- The most critical month for recruitment was April, followed by May
- Recruitment was dependent on flow and salinity levels (chloride levels)

The experts concluded that angler behavior and the catch rate are influenced by complex interactions including fish behavior (e.g., schooling) and fishing method (trolling versus casting), as well as the experience level of the angler. Thus, angler catch rate is not directly related to fish abundance but it is related indirectly. A minor to moderate change in fish abundance is not likely to influence the angler catch rate of striped bass. It is expected that anglers will adapt to changing conditions to maintain their catch rate. Anglers with knowledge of a lake may be able to change their techniques to maintain their catch rates. However, a declining population of striped bass over time would eventually influence the catch rate.

Following the meeting, additional information pertaining to flow and chloride concentrations during April and May in the spawning area of the river was provided to the experts. Since the critical area for striped bass spawning is 40 to 60 miles upstream of Lake Texoma, data were collected from the Gainesville and Terral Gages along the Red River. The Gainesville Gage (USGS Gage 07316000) is approximately 16 river miles from Lake Texoma, and the Terral Gage (USGS Gage 07315500) is approximately 97 river miles from Lake Texoma (Figure 2-3).

Section Two: Recreation National Economic Development

Figure 2-3: Location of Gainesville and Terral Gages

Since April and May are the most critical to striped bass recruitment, the data (flow and chloride levels) from the *Area VI Reevaluation Concentration Duration/Low Flow Study* were analyzed separately for those two months. The data was presented in annual probability exceedance tables for chlorides, sulfates, and TDS at the Gainesville and Terral Gage stations along the Red River. Table 2-2 provides probability exceedance estimates for flow and Table 2-3 presents probability exceedance estimates for chloride for the without-project (Condition 2) and with-project conditions (Condition 4). The with-project condition accounts for anticipated agricultural irrigation withdrawals from the Elm Fork branch of the Red River. Irrigation withdrawals would be anticipated to begin in May.

Table 2-2: Flow Probability Exceedance Estimates (With and Without-Project)

Month	Condition	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%
Gainesville Gage – Flow (cubic feet per second)												
April	Without	217	298	450	638	896	1,190	1,570	2,400	3,810	7,200	13,600
	With	217	298	450	638	896	1,190	1,570	2,400	3,810	7,200	13,600
May	Without	358	477	649	868	1,260	1,950	2,880	4,440	7,680	15,200	27,500
	With	179	241	334	503	856	1,434	2,362	3,910	7,146	14,662	26,962
Terral Gage – Flow (cubic feet per second)												
April	Without	158	227	327	411	571	765	1,070	1,600	2,640	5,610	9,950
	With	158	227	327	411	571	765	1,070	1,600	2,640	5,610	9,950
May	Without	256	338	429	581	909	1,290	1,930	3,230	5,650	11,300	21,300
	With	128	169	214	290	454	775	1,409	2,709	5,129	10,779	20,781

Table 2-3: Chloride Probability Exceedance Estimates (With and Without-Project)

Month	Condition	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%
Gainesville Gage – Chloride (milligrams per liter)												
April	Without	218	318	466	584	698	802	917	1,087	1,244	1,393	1,505
	With	195	285	417	523	625	718	822	973	1,114	1,248	1,348
May	Without	187	262	354	455	560	669	798	940	1,072	1,226	1,347
	With	183	260	348	474	611	794	1,089	1,397	1,744	2,068	2,268
Terral Gage – Chloride (milligrams per liter)												
April	Without	341	436	639	826	984	1,077	1,171	1,254	1,330	1,459	1,550
	With	298	381	559	722	860	942	1,024	1,097	1,163	1,276	1,355
May	Without	218	310	459	585	760	956	1,059	1,171	1,258	1,365	1,482
	With	201	295	456	621	938	1,343	1,756	2,011	2,182	2,365	2,578

In addition, the experts were provided flow (Table 2-4) and chloride (Table 2-5) tables for an alternative scenario, which is considered the most extreme scenario. The Bureau of Reclamation has proposed construction of the Cable Mountain Dam on the North Fork of the Red River downstream of Lake Altus if Area VI is implemented. Chloride management alternatives being evaluated by the USACE would not significantly change the flow in the Red River. However, the construction of the Cable Mountain Dam could potentially affect flows in the Red River Basin. Scenario 1 represents the natural conditions before the implementation of Areas V and VIII. Scenario 2 includes all existing and potential chloride control projects and Cable Mountain Dam.

Table 2-4: Flow Probability Exceedance Estimates (Alternative Scenarios)

Month	Condition	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%
Gainesville Gage – Flow (cubic feet per second)												
April	Scenario 1	217	298	450	638	896	1,190	1,570	2,400	3,810	7,200	13,600
	Scenario 2	108	149	225	348	525	770	1,071	1,829	3,215	6,346	12,825
May	Scenario 1	358	477	649	868	1,260	1,950	2,880	4,440	7,680	15,200	27,500
	Scenario 2	179	241	334	503	825	1,390	2,278	3,822	6,965	13,997	25,722
Terral Gage – Flow (cubic feet per second)												
April	Scenario 1	158	227	327	411	571	765	1,070	1,600	2,640	5,610	9,950
	Scenario 2	79	114	164	206	286	382	540	962	1,918	4,735	8,648
May	Scenario 1	256	338	429	581	909	1,290	1,930	3,230	5,650	11,300	21,300
	Scenario 2	128	169	214	290	454	679	1,279	2,498	4,626	9,732	19,334

Table 2-5: Chloride Probability Exceedance Estimates (Alternative Scenarios)

Month	Condition	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%
Gainesville Gage – Chloride (milligrams per liter)												
April	Scenario 1	242	353	517	648	775	890	1,018	1,206	1,381	1,546	1,670
	Scenario 2	201	303	477	654	855	1,036	1,314	1,694	1,984	2,282	2,433
May	Scenario 1	208	291	393	505	621	742	886	1,043	1,190	1,361	1,495
	Scenario 2	170	248	338	453	588	767	1,048	1,346	1,643	1,928	2,113
Terral Gage – Chloride (milligrams per liter)												
April	Scenario 1	386	493	723	934	1,113	1,218	1,325	1,419	1,504	1,651	1,753
	Scenario 2	321	423	748	1,099	1,396	1,654	1,857	1,998	2,126	2,322	2,480
May	Scenario 1	247	351	519	662	860	1,082	1,198	1,325	1,423	1,544	1,677
	Scenario 2	193	286	443	638	943	1,329	1,642	1,856	2,008	2,180	2,370

Based on the flow and chloride tables, the experts were asked if they expected the implementation of Area VI and the alternative scenario to affect the recruitment of striped bass, and what the expected impact would be on the striped bass population. The experts were not able to draw a conclusion about the anticipated effects of chloride management on recruitment from the information provided. The experts requested historical data that would link recruitment variability related to flow variability and accompanying variability in chloride concentrations. Additionally, the experts requested monitoring data for juvenile striped bass relative to river flow and chloride concentrations during the spring. During the earlier panel meeting, ODWC representatives stated that they conducted recruitment monitoring surveys for striped bass. The information was requested from ODWC; however, at the time this report was completed the information was not available.

2.5 Travel Behavior Theoretical Demand Model

A combined travel cost and trip response demand model was specified to predict the change in fishing trips resulting from changes in the catch rate and to estimate the net economic value (i.e., consumer surplus, WTP) for fishing. This intended behavior model combines revealed preferences (actual visitation behavior) and stated preferences (intended visitation behavior) when estimating a recreational fishing demand curve (Loomis, 1993; Teasley et al., 1994; USACE, 2001). The format of the combined actual and intended behavior model is shown in equation 1, with a description of the variables in Table 2-6 (Bergstrom et al., 1990):

$$TRIPS_{ij} = f\,(TC_{ij},\ CATCH_i,\ INC_i,\ SUBS_i,\ RET_i,\ EDU_i,\ MEM1_i,\ MEM2_i,\ RRCCP_i,\ AGE_i) \qquad (1)$$

Table 2-6: Description of Equation 1 Variables

Name	Description
$TRIPS_{ij}$	Two observations: 1) annual fishing trips by individual *i* to access site *j* with current catch rate, and 2) intended annual fishing trips by individual *i* to access site *j* given decreases in expected catch
TC_{ij}	Average round-trip travel cost for individual *i* to access site *j*
$CATCH_i$	Actual and scenario specific fish catch per trip for individual *i*
INC_i	Individual *i*'s household income
$SUBS_i$	Whether individual *i* has access to a substitute fishing site
RET_i	Whether individual *i* is retired or not
EDU_i	Years of education of individual *i*
$MEM1_i$	Whether individual *i* is a member of Sportsmen's Organization
$MEM2_i$	Whether individual *i* is a member of Environmental Organization
$RRCCP_i$	Whether individual *i* has knowledge of RRCCP
AGE_i	Age of individual *i* in years

2.5.1 Trip and Catch Variables

The demand model is used to measure the effects of recreational fish catch on the quantity of annual recreation fishing trips taken by anglers to Lake Texoma. The data set for the dependent variable $TRIPS_{ij}$ contains two observations for each respondent: the first observation corresponds to the actual annual trips taken at current catch, and the second observation corresponds to the intended annual trips assuming a decrease in expected catch with current trip cost held constant.

To estimate how the angler's number of trips would be affected by lower catch rates, the fishing $CATCH_i$ variable combines current catch and expected catch under alternative conditions. During the survey, respondents were presented with a scenario where catch per trip was specified to decrease between 5 and 30 percent. The specified percentage decrease in catch was compared with the current catch rate to estimate the expected change in catch rate under the alternative condition.

2.5.2 Travel Cost (Price) Variable

The travel cost variable TC_{ij} was calculated using a method which accounts for travel expenses and the opportunity cost of time, as specified in equation 2 (Loomis and Walsh, 1997; U.S. Water Resources Council, 1983). Respondents provided the number of miles to access Lake Texoma from home, how much time it takes to travel one way, and the typical number of people in the individual's group when fishing on Lake Texoma. The cost per mile allowance of $0.55, as set by the U.S. Internal Revenue Service as the standard mileage rate for 2008 (the year the survey was conducted) was used for the dollar per mile estimate.[1] The effective household wage rate is determined by dividing the annual income supplied by the respondent by the assumed number of work hours in a year (2000) and then by dividing this number by the number of individuals in the household. Dividing the wage rate by 3 provides a standard estimate of the opportunity cost of recreational travel time (Loomis and Walsh, 1997). The distance-to-cost conversion formula for car travel is shown in equation 2 below, with a description of the variables in Table 2-7.

$$TC_{ij} = [(2 \times DISTANCE_{ij} \times \$PERMILE) / GROUP + (2 \times TIME_{ij} \times (WAGE_i / 3))] \qquad (2)$$

[1] The IRS set a standard mileage rate of $0.505 for the first half of calendar year 2008 and $0.585 for the second half of the year; therefore, the average of the two rates was used for the analysis.

Table 2-7: Description of Equation 2 Variables

Name	Description
TC_{ij}	Average round-trip travel cost for individual *i* to access site *j*
$DISTANCE_{ij}$	One-way distance individual *i* traveled from home to access site *j*
$PERMILE	Cost per mile in dollars of operating a motor vehicle
$TIME_{ij}$	One-way travel time to access site *j* for individual *i*
$WAGE_i$	Effective household wage rate per hour for individual *i*
GROUP	Individual *i*'s group size per trip

2.5.3 Income (Budget) Constraint Variable

The income variable is the individual's reported household income. Household income serves as a total budget constraint to the amount of goods and services an individual can consume, including annual fishing trips. The expectation is that as income increases, consumption of goods and activities will increase unless the good or service is an inferior commodity.

There were 60 respondents who did not respond to the household income question. The model in equation 3 was used with the data from completed survey questionnaires to estimate the income (I) of the households that did not indicate household income:

$$I = (c + \beta_1\, Age + \beta_2\, Retired + \beta_3\, Student + \beta_4\, UE + \beta_5\, HH + \beta_6\, HS + \beta_7\, SC + \beta_8\, CG + \beta_9\, GA) \quad (3)$$

A description of the variables used in equation 3 is provided in Table 2-8.

Table 2-8: Description of Equation 3 Variables

Name	Description	Units
I	Income of respondent, the mid-point of income category selected	Dollars ($)
Age	Age of the respondent	Years
Retired	Whether or not the respondent is retired	0/1 dummy
Student	Whether or not the respondent is a student	0/1 dummy
UE	Whether or not the respondent is unemployed	0/1 dummy
HH	Number of people presently living in the household of the respondent	Number of people
HS	If the highest level of education completed by the respondent is High School	0/1 dummy
SC	If the highest level of education completed is some college or technical school	0/1 dummy
CG	If the highest level of education completed is college	0/1 dummy

GA	If the highest level of education completed is a graduate or advanced degree	0/1 dummy

2.5.4 Substitute Fishing Sites

Although there are other lakes in the region that provide similar recreation resources to Lake Texoma, Lake Texoma is considered to have either no substitutes or significantly inferior substitutes. The lake is large, covering approximately 89,000 acres. Few lakes in the U.S. are this large. In addition to its size, Lake Texoma is one of the only U.S. lakes where striped bass can spawn naturally. Lake Texoma is a unique recreational resource and while people can fish elsewhere, the experience would not be a comparable substitution for fishing on Lake Texoma.

People travel from every state in the country to fish in Lake Texoma. The year before the survey was conducted, Lake Texoma was closed to recreational use for several weeks during the summer because of flooding. In the survey questionnaire, respondents were asked if they went to other locations to fish during the time of the closure. These responses identify anglers with access to substitute fishing sites. Of the 386 surveys, 27 percent named the place where they would go fishing when Lake Texoma was unavailable. Of the substitute fishing sites named, 71 percent of the locations were within 100 miles of the respondent's home and only 8 percent traveled further to their substitute site than they would to Lake Texoma. The surveys support the assertion that Lake Texoma is a unique resource that does not have a comparable substitute. Approximately 7 percent of the substitute sites provided were more than 500 miles from the respondent's residence. Table 2-9 provides a list of substitute fishing sites with the highest number of responses. All of the respondents who named a substitute fishing site contained in the table below reside in the Dallas/Ft. Worth metropolitan area or within 100 miles of the respective lake, except one, who lives 255 miles from Lewisville Lake.

Table 2-9: Substitute Fishing Sites Used When Lake Texoma was Closed

Fishing Site	Number of Responses	Location
Lake Tawakoni	8	East of Dallas (100 mi from Lake Texoma)
Lake Ray Roberts	8	North of Dallas (50 mi from Lake Texoma)
Lake Fork	6	East of Dallas (115 mi from Lake Texoma)
Lewisville Lake	4	Just outside Dallas (70 mi from Lake Texoma)

Lavon Lake	3	Just outside Dallas (80 mi from Lake Texoma)
Lake Murray	3	Near Lake Texoma (30 mi from Lake Texoma)
Lake Ray Hubbard	3	Just outside Dallas (90 mi from Lake Texoma)

Of the fishing sites appearing in Table 2-9, only Lake Tawakoni was rated by TPWD as having excellent striped bass fishing similar to Lake Texoma. Striped bass fishing in the other lakes were rated fair to good by TPWD and two of the lakes listed do not support striped bass. It is assumed that the lakes identified were substitutes for the fishing experience but not necessarily a substitute for Lake Texoma. It is expected that if the respondent has access to substitute fishing locations and the catch rate in Lake Texoma drops, the respondent is likely to reduce the annual number of fishing trips to Lake Texoma.

2.5.5 Demographic, Taste and Preference Variables

The demographic, tastes, and preference variables describing individual *i* can influence recreation trip behavior in a variety of ways. In general, demographic, tastes, and preference variables measure an individual's strength of preferences for recreational trips and attributes of these trips (e.g., catch). For the estimation of equation 1, the following variables were selected to represent demographics, tastes, and preferences: whether the respondent is retired, age, years of education, whether the respondent is a member of a sportsmen's organization, whether the respondent is a member of an environmental organization, and whether the respondent has knowledge of the RRCCP.

The amount of leisure time available to a person represents an overall time constraint influencing the number of annual fishing trips. As the amount of leisure time increases, a person can allocate more time to recreational activities, including fishing trips. For equation 1, a respondent's retirement status was used as a proxy for total leisure time. This variable was expected to be positively related to the number of annual fishing trips taken by the individual.

Strength of preferences for fishing may also be indicated by an individual's age. Preferences for fishing and other types of recreation would likely change as a person ages. Years of education, another general measure of strength of preferences, was used in the estimation of equation 1. As with age, the relationship between education and recreational behavior is difficult to predict. As a person obtains more years of formal education, preferences for certain types of outdoor recreation would likely change.

Certain people with strong preferences for outdoor recreation may be categorized as outdoor recreation enthusiasts. These enthusiasts are characterized by a high commitment to spending time outdoors engaged in recreational activities. For the estimation of equation 1, the degree of enthusiasm for outdoor recreation in general was measured by whether a respondent is a member of a sportsmen's organization. This variable is expected to be positively related to the annual number of fishing trips taken by an individual.

Interest and involvement in environmental issues may also be an indicator of strength of preference for fishing. For equation 1, the level of interest and involvement in environmental issues of the respondents was measured based on whether or not the respondent is a member of an environmental organization. Members of environmental organizations are likely to have strong interests in natural resource management issues and, therefore, may have strong preferences for outdoor activities, such as fishing.

Interest in natural resource management issues and familiarity in particular with water quality projects in the study area was measured by the respondent's knowledge of the RRCCP. As a person spends more time fishing in the study area, they are likely to become more aware and concerned about resource management in the study area. Therefore, knowledge of the RRCCP was expected to be positively correlated with the annual number of fishing trips taken by an individual.

2.6 Demand Model Estimation and Results

This section describes the estimation approach, issues related to dependent variable distribution, the results of the model and an interpretation of the results.

2.6.1 Issues Related to Dependent Variable Distribution

Data for estimating equation 1 was collected from current users of the study area who purchased a Lake Texoma fishing license. Therefore, nonusers have been truncated from the data set, meaning nonusers are not represented in the data set used to estimate equation 1.

Therefore, the estimation results from the truncated sample can only be applied to the population of current users.

The data set used to estimate equation 1 only includes positive observations of trips, meaning only surveys with at least one trip to Lake Texoma were included. Therefore, the data set is censored because part of the statistical range of variation in the dependent variable is omitted from the data set. Thus, Ordinary Least Squares (OLS) regression estimates of equation 1 are biased (Fletcher et al., 1990). The severity of the bias depends on how much of the statistical distribution of $TRIPS_{ij}$, as predicted by equation 1, would actually fall in the negative range. The negative range includes any observation less than zero, which would indicate negative trips. If the estimated demand model predicts a small number of negative trips, the potential bias caused by censoring would also be small and vice-versa.

2.6.2 Estimation Approach

With potential problems related to the distribution of $TRIPS_{ij}$ in mind, equation 1 was initially estimated with OLS regression. Assuming that the estimation results would only be applied to the population of current users, truncation of nonusers from the sample does not hinder the application of OLS. The estimated model also predicted very few negative trips. Thus, censoring did not appear to be a problem with respect to application of OLS. The empirical distribution of $TRIPS_{ij}$ in the sample is from zero to 275. Given this wide range, it appears reasonable to apply OLS as if the dependent variable is continuously distributed.

Equation 1 was estimated using OLS applied to alternative functional forms. Estimated alternative functional forms include: linear (linear dependent and independent variables); log-linear (logged dependent variable and linear independent variables); linear-log (linear dependent variable and logged independent variables); and log-log (logged dependent variable and logged independent variables).

Statistical tests indicated the presence of heteroskedasticity in the OLS results. Heteroskedasticity means that the regression model error variance is not constant as required by OLS (Kennedy, 1992). Positive serial correlation was also detected, meaning the error terms are correlated which affects the efficiency of the OLS estimators. With positive serial correlation, the OLS estimates of the standard errors will be smaller than the true standard errors. This leads to the parameter estimates appearing more accurate and precise than they actually are. Therefore, the models were re-estimated using a Generalized Least Squares (GLS) regression procedure and the variances were computed using White's covariance estimator to correct for heteroskedasticity and positive serial correlation.

Goodness-of-fit diagnostics including statistical significance of independent variable coefficients, consistency of independent variable coefficient signs with conceptual expectations, Akaike criterion, and R-square indicated that the log-log estimated demand function was superior to the other alternative functional forms. The log-log model was therefore selected for final presentation and application.

2.6.3 Results and Interpretation of Demand Model Results

The GLS estimation results of the combined travel cost and trip response demand model are presented in Table 2-10 and an interpretation of the results follows.

Table 2-10: Modeling Results for Fishing Trip Demand Function

Explanatory Variables	Coefficient Estimate	T-Value
Intercept	1.863647	1.035745
Natural Log of Travel Cost Per Person per Trip	-0.413634	-6.802215*
Natural Log of Catch of Striped Bass per Trip	0.125547	1.954097**
Natural Log of Household Income	-0.012138	-0.089171
Indicator Variable for Substitute Fishing Site Availability	0.366186	2.56656*
Indicator Variable for Retirement (1=Retired)	-0.103918	-0.623141
Natural Log of Years of Education	0.473996	1.050284
Indicator Variable for Member of Sportsmen's Organization	-0.113154	-0.833903
Indicator Variable for Member of Environmental Organization	0.094335	0.524154
Indicator Variable for Knowledge of RRCCP	0.500926	3.019554*
Natural Log of Age	-0.10355	-0.40665
N = 490		
R-Square = 0.379059		
Akaike Criterion = 2.697411		
Average Catch Elasticity = 0.1255		
Average Travel Cost Elasticity = -0.4136		
**Significant at 0.01 Level*		

***Significant at 0.05 Level*		

The signs of the coefficient for the natural log of travel cost per person per trip (the trip "price" variable) are statistically significant at the 0.01 level and negative, suggesting the demand function is downward-sloping, as would be expected from economic theory. There is an inverse relationship between the number of trips and the travel cost, meaning anglers with a lower travel cost will take more trips to Lake Texoma than anglers with a higher travel cost. As the travel cost of the trip increases, the total number of trips decreases.

Fish catch is an indicator of the quality of fishing trips and was expected to be positively related to annual trips. Thus, the positive coefficient associated with the catch variable for striped bass is consistent with conceptual expectations. The coefficient associated with the catch variable was statistically significant at the 0.05 level.

The monetary budget constraint represented by the natural log of household income was not statistically significant. In addition to a budget constraint, anglers also face an overall leisure time constraint. Whether or not an individual is retired was used as a proxy for the amount of leisure time available to an angler. The coefficient associated with whether a respondent was retired or not was not statistically significant.

Age and education may be general indicators of strength of preferences for fishing at Lake Texoma. Neither the age or education coefficients were statistically significant. Also, the coefficients on the indicator variable for membership in sportsmen organizations and for membership in environmental organizations were not statistically significant.

It was hypothesized that people who take more fishing trips to Lake Texoma are likely to be more knowledgeable and concerned about USACE projects in the study area. Thus, it was expected that knowledge of RRCCP would be positively related to annual fishing trips. The coefficient associated with the variable indicating whether or not a respondent was knowledgeable of RRCCP was statistically significant at the 0.01 level with a positive sign, as expected.

It was hypothesized that people who had access to a substitute fishing site would reduce the number of trips to Lake Texoma if the catch rate decreased. Thus, it was expected that the availability of a substitute site would be negatively related to annual fishing trips to Lake Texoma. However, the coefficient associated with the variable indicating whether or not a respondent has access to a substitute fishing site was positive and statistically significant at the 0.01 level. This implies that having access to other fishing areas does not adversely affect the number of fishing trips to Lake Texoma. Potentially, the anglers that went fishing at an alternative site during the temporary Lake Texoma closure may not change the number of total annual fishing trips, but may change locations based on the availability of the site and not necessarily the quantity of fish caught.

2.7 Catch Rate and Catch Elasticity

One of the purposes of the survey was to gain an initial understanding of how fishermen would respond to a change in striped bass fishery, either as a result of the implementation of the RRCCP or from the natural sedimentation of Lake Texoma. A minor to moderate change in fish abundance is not likely to influence the catch rate. It is expected that anglers would adapt to changing conditions to maintain their catch rate. However, if the population was continually decreasing over time, eventually the catch rate of striped bass would wane. The number of fish present at an angler's preferred spot can fall in the short-run because the change in salinity forces the fish to seek a more suitable location. Similarly, over the long-run recruitment success may be reduced, eventually lowering the population of striped bass in Lake Texoma. The catch rate is defined as the number of fish caught per person per hour. The average catch rate of striped bass in Lake Texoma during the survey was 0.45.

The travel behavior demand model converts the percent change in catch rate into a change in annual trips using the catch elasticity coefficient. Catch elasticity is defined as the total percentage change in trips resulting from a one-percent change in catch. Elasticity is a scale-free measure of the relationship between explanatory variables and the dependent variable. Evaluation of the elasticity near the mean of an explanatory variable provides an indication of the relative influence of the explanatory variable on the value of the dependent variable.

For the log-log estimation of equation 1, the catch rate elasticity is equivalent to the estimated coefficient on the catch variable. Average catch elasticity is equal to 0.1255 (from Table 2-10), which indicates that the demand for Lake Texoma fishing trips is relatively inelastic. Thus, number of fishing trips is not very responsive to changes in the catch rate. The average catch elasticity implies that for the user who takes an average number of annual fishing trips to Lake Texoma, a one percent decrease in catch per trip would induce the user to take 0.1255 percent fewer trips per year.

These coefficients assume that a change in the catch rate at Lake Texoma would last long enough that the angler would decide to change his or her behavior by fishing more or less, or by moving to another fishing area in attempt to maintain the current catch rate. It was also assumed that the elasticity coefficient would remain constant over the range of the potential changes in the catch rate that would occur at Lake Texoma.

2.8 Travel Cost and Travel Cost Elasticity

Each individual's travel cost (TC_{ij}) to Lake Texoma was calculated in Section 2.5.2; the average round-trip travel cost was $96.27 per person per trip after adjusting for inflation. The travel cost represents the value of access to the site and includes the opportunity cost of time for each trip to Lake Texoma. The lower bound of the 90-percent confidence interval for the travel cost estimate was approximately $5 and the upper bound was $354. A sensitivity analysis was conducted using zip code information for all Lake Texoma license holders and Census data.

2.8.1 Travel Cost Elasticity

The travel cost elasticity can be used to estimate the impact of an increase or decrease in the cost to travel to Lake Texoma on the number of annual trips. For the log-log estimation of equation 1, the travel cost elasticity is equivalent to the estimated coefficient on the travel cost variable (TC_{ij}). Average travel cost elasticity is equal to -0.4136 (from Table 2-10), which indicates that, as the travel cost of the trip increases, the total number of annual trips decreases. The average travel cost elasticity implies that, for the angler who takes an average number of annual fishing trips to Lake Texoma, a 1 percent increase in the cost to travel to Lake Texoma would induce the angler to take 0.4136 percent fewer trips per year.

2.8.2 Survey Data Analysis

TPWD provided information for Lake Texoma license holders who purchased a license in Texas; a random sample selected from this information comprised the survey pool. Since information for anglers who purchased a Lake Texoma fishing license in Oklahoma was unavailable during Phase I and Phase II, these individuals were not included in the survey. It was assumed that the behavior of individuals surveyed represented the entire user population.

Lake Texoma is about a 1- to 2-hour drive from the Dallas-Fort Worth metropolitan area. The survey may capture a higher proportion of people traveling from out of state (higher travel costs) since the nearest commercial airport is located in Texas; therefore, it is likely that people traveling by airplane would purchase a Lake Texoma license in Texas. A sensitivity analysis using GIS and Census data was performed to assess the likelihood that the travel cost of the survey sample was overestimated.

The median income from the 2010 U.S. Census was compared with the reported income from the survey. The average household income representing the zip codes of the survey respondents from the U.S. Census data was $67,157, whereas the average household income reported in the survey was $88,705. This means that overall, the survey respondents represent a higher than average income bracket compared to that reported in the Census.

The travel costs of the survey respondents were re-estimated using the median income from the 2010 U.S. Census and the travel distances and times calculated using GIS. The distance and time from the zip code to Lake Texoma tended to be longer than the distance claimed by survey respondents. The distance and time originates in the center of the zip code and uses the shortest route by road. Since Lake Texoma is a large lake, it is difficult to pinpoint where each angler would travel, but the method used to measure the distance provides an approximation to evaluate how travel costs may vary.

The average travel cost increased from $96 to $120 per person per trip using this method. Even though the average household income was lower than that reported in the survey, the increased time and distance calculated by GIS led to a higher average travel cost than that reported in the survey. Based on this sensitivity analysis, it appears that the travel cost calculated from the survey sample is not overestimated.

2.8.3 Zip Code Data Analysis

During Phase III, ODWC provided zip code information for all Lake Texoma fishing licenses purchased in Oklahoma for the 2007 season. For each zip code, median household income from the 2010 U.S. Census, along with an estimation of distance and time using GIS, were used to assess the travel cost for all anglers who purchased a Lake Texoma fishing license. This information was compared with the travel cost estimated from the surveyed anglers. The evaluation of the zip codes for all Lake Texoma license holders resulted in an average travel cost of $80.

Although many anglers traveling from out of state would probably fly rather than drive, it was assumed that all anglers drove to Lake Texoma, and the cost per mile was estimated to be $0.55, as set by the U.S. Internal Revenue Service as the standard mileage rate for the year the survey was conducted. The distance and time to travel to Lake Texoma was calculated using GIS as a straight line ("as the crow flies") from the center of the zip code to the nearest Lake Texoma point. The median income and income error for each zip code from the 2010 U.S. Census were used to estimate the household income for each license holder. It was assumed that the average household size was 2.8 people per household, based on the average household size of the survey. In the survey, the size of the group traveling to Lake Texoma together ranged from 1 to 30 people with an average group size of 5. A log-normal distribution of the group size was selected as the best fit for the data with a mean value of $80 per person per trip.

The average travel cost calculated from the survey ($96) was lower than the average travel cost calculated from the survey using GIS and Census data instead of survey responses ($120). However, the average travel cost estimated using only the zip code and Census information for all license holders resulted in a lower average travel cost ($80) than both calculation methods. The $96 per person per trip travel cost calculated using survey data of is approximately the average of all three estimates and is used to calculate WTP.

2.9 Willingness-to-Pay Value from the Contingent Behavior Method

The USACE *Principles and Guidelines* requires that NED benefits are measured as the additional amount the visitor would pay for the recreational experience over and above their current costs, also referred to as the consumer surplus or WTP (U.S. Water Resources Council, 1983). The actual trip expenditures contribute to RED and are discussed in Section 3. WTP was calculated in Phase II using the contingent valuation method. In the current phase, WTP is estimated using the Contingent Behavior method to define the relationship between the potential impacts to the catch rate and WTP.

The contingent behavior approach is similar to the travel cost method and involves describing a new recreation condition (i.e., a decrease in the catch rate) and asking whether the number of annual trips taken by an individual to Lake Texoma would change under that condition. The number of annual trips taken by an individual and the average travel cost is used to develop the demand curve for recreation; in this case, recreational fishing on Lake Texoma. From the demand curve, WTP is calculated.

The average WTP value is calculated using the estimated demand model and equation 4, where β_1 is the estimated coefficient on the travel cost variable from Table 2-10.

$$TRIPS = A - \beta_1 \ln(TC) \qquad (4)$$

To calculate the constant variable represented by A, the mean values for all the independent variables are multiplied by the respective estimated coefficients in Table 2-10, except for the travel cost variable, and then summed.

Using equation 4, WTP at the mean number of trips per individual is calculated by the integral:

$$\int_{pm}^{P*} \left[A - \beta_1 \ln(TC)\right] dTC \qquad (5)$$

The mean travel cost (P^m) is \$96.27 (from Section 2.8). The choke price (P*) is the maximum price a person would pay to travel to Lake Texoma for fishing. The log-log estimated demand function would theoretically have a choke price of infinity due to the non-linear curve of the demand function. To calculate WTP, it was necessary to select a reasonable choke price. The 90th percentile travel cost of $211.61 (from the empirical distribution of travel costs) was used as the choke price to calculate WTP. For the WTP uncertainty analysis (Section 4.1.2), the choke price is extended to the 95th percentile travel cost of $354.05 to calculate WTP.

The closed-form solution to equation 5 was used to calculate annual recreation benefits. Using the integral of equation 5 at the mean number of trips with the mean travel cost as the lower limit and the 90th percentile as the upper limit of the integration, the mean WTP per person per trip is $21.88. This WTP value is consistent with similar recreation fishing studies. The annual recreation value is calculated by multiplying the mean WTP estimate by the estimated annual number of trips.

In Phase II, the average annual user population (number of anglers) for Lake Texoma was determined based on the best available information, including fishing license data and game warden interviews, and was estimated to be 101,000. The total number of trips per year for the user population was extrapolated from the survey sample. It was assumed that the distribution of the number of annual trips per respondent in the survey sample was representative of the user population. Thus, the baseline level of annual fishing trips to Lake Texoma is approximately 965,000 annual trips.

The product of the mean WTP value of $21.88 per person per trip and 965,000 estimated annual trips equals an annual recreation value from striped bass fishing on Lake Texoma of $21.1 million.

Table 2-11: Lake Texoma Annual Recreation Value

Annual Fishing Trips to Lake Texoma	Travel Cost Per Person Per Trip	Total Annual Recreation Value
965,000	$21.88	$21.1 million

2.10 Recreational Benefits by Scenario

Area VI of the RRCCP was evaluated by comparing the with-project and without-project conditions, as described in Section 2.1.3. The without-project condition is the most likely condition expected to exist in the future in the absence of the project, whereas the with-project condition is the most likely condition expected to exist in the future with the implementation of the project.

The potential change in the annual recreational fishing benefit for striped bass was estimated based on the results of the survey and the travel behavior demand model. Three possible scenarios were considered to evaluate how potential impacts to the catch rate of striped bass in Lake Texoma may affect NED. The first scenario is a 10 percent decrease in catch rate, the second scenario is a 20 percent decrease in catch rate, and the third scenario is a 30 percent decrease in catch rate.

The NED benefits for each scenario were calculated as the difference in the number of annual trips to Lake Texoma considering a change in the catch rate. Survey respondents were asked how many fewer trips they would take to Lake Texoma if the catch rate declined between 5 and 30 percent, assuming travel cost remains constant. The change in the annual number of trips indicates how an individual would respond to a change in the catch rate and how the value of the striped bass fishery may decrease. The loss from the decrease in the number of trips is calculated by multiplying the average WTP value by the reduced number of annual trips.

In Phase II, the average annual user population for Lake Texoma was determined based on the best available information, including fishing license data and game warden interviews. The average annual number of anglers fishing in Lake Texoma was estimated to be 101,000. The total number of trips per year for the user population was extrapolated from the survey sample. It was assumed that the distribution of the number of annual trips per respondent in the survey sample was representative of the user population. Thus, the baseline level of annual fishing trips to Lake Texoma is approximately 965,000 annual trips.

Under the first scenario, if the catch rate decreased by 10 percent, it is estimated that the average respondent would take 1.3 percent fewer trips (the product of the catch rate elasticity and the percent decrease in the catch rate) and overall the total number of annual trips would be reduced by 12,100 trips. The reduced number of annual trips is the product of the percent decrease in annual trips and the total estimated annual trips. The change in the total number of annual trips translates to an annual net loss (negative benefit) of $265,000. The net loss is the reduced number of annual trips multiplied by the average travel cost per person per trip. Under the second scenario, if the catch rate decreased by 20 percent, it is estimated that the average respondent would take 2.5 percent fewer trips and overall the total number of annual trips would be reduced by 24,200 trips. The change in the total number of annual trips translates to an annual net loss of $530,000. Under the third scenario, if the catch rate decreased by 30 percent, it is estimated that the average respondent would take 3.8 percent fewer trips and overall the total number of annual trips would be reduced by 36,400 trips. The change in the total number of annual trips translates to an annual net loss of $795,000. The results are summarized in Table 2-12.

Table 2-12: Summary of Net Recreational Benefits by Scenario

Scenario	Decrease in the Catch Rate	Total Fewer Annual Trips	Net Benefit
1	10%	12,100	($265,000)
2	20%	24,200	($530,000)
3	30%	36,400	($795,000)

2.11 NED Summary

The NED analysis evaluated the future without-project and with-project conditions for different levels of the striped bass fishery. Based on ecological modeling and an expert-elicitation, Area VI of the RRCCP was not anticipated to have a measurable impact on the adult population of striped bass in Lake Texoma. However, the potential impact upon the recruitment of striped bass remains a key uncertainty. More information is needed to determine whether Area VI would affect recruitment.

Since data linking Area VI to a change in recruitment were not available, potential impacts on the catch rate for striped bass were evaluated under three scenarios. The three scenarios were evaluated to determine the annual net recreation loss associated with a potential reduction in the catch rate. Because the catch rate is not expected to decrease by more than 30 percent, the first scenario considered a 10 percent reduction in the catch rate, the second scenario a 20 percent reduction in the catch rate, and the third scenario a 30 percent reduction in the catch rate. The first scenario would result in an annual net loss of $265,000. The second scenario would result in an annual net loss of $530,000. The third scenario would result in an annual net loss of $795,000. Figure 2-4 illustrates the estimated relationship between a potential decrease in the catch rate and NED loss that may occur as a result of reduced annual trips to Lake Texoma.

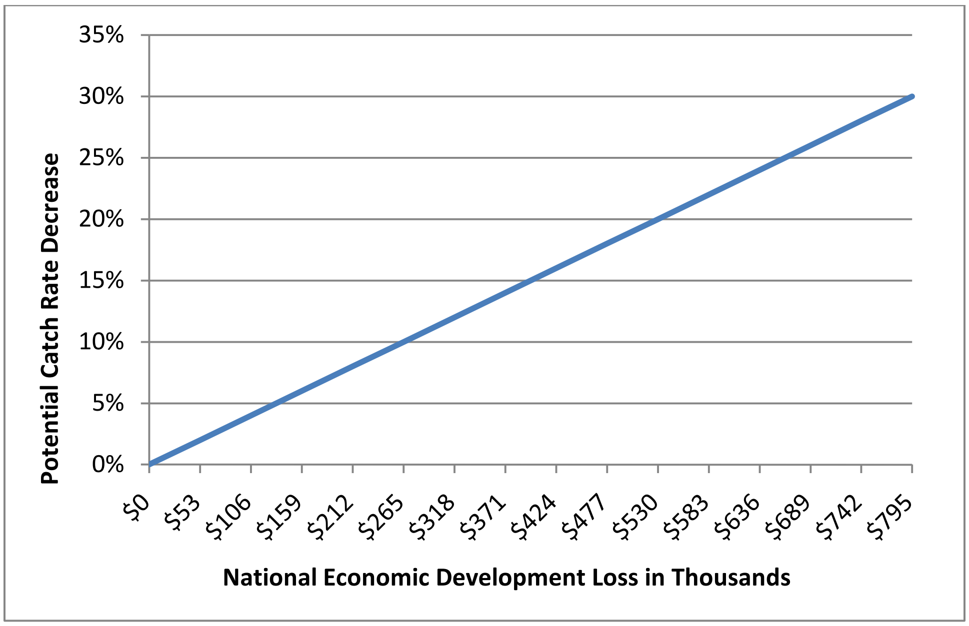


Figure 2-4: Effect of Catch Rate on National Economic Development

3.0 RECREATION REGIONAL ECONOMIC DEVELOPMENT

The results of the NED analysis presented in Section 2.9 and Section 2.10 were used to estimate the regional economic development benefits in the study area. The RED benefits were estimating using the MIG, Inc. IMPLAN modeling software. IMPLAN is used to analyze the indirect and induced effects of a change on the local economy. IMPLAN defines indirect effects as the impact of local industries buying goods and services from other local industries. IMPLAN defines induced effects as the response to a direct effect that occurs when an addition (or subtraction) of income causes re-spending (or reduced spending). Induced effects refer to the effects on households in the study area. The data can be analyzed on a national, State, county, or zip code level. For this analysis, the county level was used.

The study area is defined as those counties that would be affected by an increase or decrease in spending on fishing trips to Lake Texoma. It was assumed most of the spending would occur in the counties adjacent to Lake Texoma. These counties are Bryan, Carter, Johnston, Love, and Marshall Counties in Oklahoma, and Cooke and Grayson Counties in Texas.

3.1 RED Approach

The RED analysis looks at the overall effect on the region's economy. The analysis is based on the change in NED expenditures provided in the Area VI Red River Chloride Control: Recreation Study Phase II and the NED analysis in Section 2.

In Phase II, survey respondents were asked to provide the average amount they spend on each trip to Lake Texoma. Individual trip expenses were multiplied by the number of annual trips taken by each survey respondent and total trip expenses for each category were divided by the total number of annual trips to obtain the average annual trip cost for each category. The values in the survey were in 2008 values, so these were updated to 2012 dollars using the Consumer Price Index from the Bureau of Labor Statistics to adjust for inflation. Table 3-1 summarizes the average trip expenses at the 2012 price level.

Section Three: Recreation Regional Economic Development

Table 3-1: Average Trip Expenses per Year

Cost Category	Average Spent per Trip
Lodging	$31.23
Food & Beverage	$48.12
Transportation	$53.34
Activities/Entertainment	$19.40
Supplies/Equipment	$4.51
Miscellaneous Expenses	$6.71
Total	**$163.31**

Note: 2012 price level

The costs per trip were used as inputs to IMPLAN. The baseline and the three scenarios presented in Section 2 were input as three different models in the IMPLAN software. In the first scenario, a 10 percent decrease in catch rate reduces the total number of annual trips by 12,100 trips. In the second scenario, a 20 percent decrease in catch rate reduces the total number of annual trips by 24,200 trips. In the third scenario, a 30 percent decrease in catch rate reduces the total number of annual trips by 36,400 trips. The reduction in trips in each scenario was multiplied by the average cost per trip to estimate the baseline and the overall reduction in each cost category. Table 3-2 summarizes the baseline total travel expenses and the reduction in total travel expenses for each scenario due to the reduction in trip from reduced catch rates.

Table 3-2: Change in Travel Expenses for Each Scenario

Cost Category	Baseline	Scenario 1	Scenario 2	Scenario 3
Lodging	$30,152,700	($378,600)	($757,100)	($1,135,700)
Food & Beverage	$46,450,000	($583,200)	($1,166,300)	($1,749,500)
Transportation	$51,495,400	($646,500)	($1,293,000)	($1,939,500)
Activities/Entertainment	$4,354,500	($54,700)	($109,300)	($164,000)
Supplies/Equipment	$18,727,000	($235,100)	($470,200)	($705,300)
Miscellaneous Expenses	$6,479,700	($81,400)	($162,700)	($244,100)
Total	**$157,659,300**	**($1,979,300)**	**($3,958,700)**	**($5,938,000)**

Note: Values are rounded

Each cost category was matched to the appropriate industry category in the IMPLAN model and input as a reduction in that industry for the study area. Table 3-3 shows the IMPLAN industry that was matched to each of the cost categories in the model.

Table 3-3: Cost Categories and IMPLAN Industries

Cost Category	IMPLAN Industry	
Lodging	411	Hotels and Motel Services, Including Casino Hotels
Food & Beverage	324	Retail Services-Food and Beverage
Transportation	336	Transit and Ground Passenger Transportation Services
Activities/Entertainment	410	Other Amusements and Recreation Industries
Supplies/Equipment	328	Retail Services-Sporting Goods, Hobby, Book and Music
Miscellaneous Expenses	330	Retail Services-Miscellaneous

The following sections present the results from each of the IMPLAN models.

3.2 Baseline

The baseline level of annual fishing trips to Lake Texoma is approximately 965,000 annual trips. The baseline number of annual trips was input to an IMPLAN model as a comparison for the three scenarios. The total number of annual trips was multiplied by the costs spent per trip (Table 3-1) and entered into the IMPLAN model. Table 3-4 shows the results of the IMPLAN model.

Table 3-4: RED Summary for Baseline

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	2,133.8	$48,405,400	$69,843,800	$109,950,400
Indirect Effect	147.1	$6,028,900	$9,548,900	$17,173,000
Induced Effect	301.9	$10,656,500	$19,267,200	$31,918,100
Total Effect	**2,582.8**	**$65,090,800**	**$98,659,800**	**$159,041,500**

Note: Labor Income, Value Added, and Output values are rounded

In the baseline condition, the 965,000 annual fishing trips create 2,582.8 jobs. Labor income is $65,090,800 and the value added is $98,659,800. Total output for the study area from fishing trips is $159,041,500.

IMPLAN also estimates the impact a change to the local economy would have on taxes. The tax effect of a change in a local economy is summarized in IMPLAN at the state/local and federal level by showing the amount of revenue generated for the government from employee compensation, proprietor income, indirect business tax, households, and corporations. Employee compensation is the total cost paid by an employer to an employee, including the wage or salary, all benefits, and the payroll taxes paid by the employer. Proprietor income is the income received from self-employed individuals. The indirect business tax includes excise, sales, and property taxes and any associated fees, fines, licenses, and permits. Government revenue also includes revenues generated from taxes on households and corporations.

Table 3-5 shows the estimated impact on State, local, and Federal taxes. The results are shown as total tax impact, including direct, indirect, and induced effects. The 965,000 fishing trips produce tax income on both the State and local and Federal level.

Table 3-5: Baseline Total Tax Impact

Tax Impact Type	Employee Compensation	Proprietor Income	Indirect Business Tax	Households	Corporations	Total
State and Local	$195,100	$0	$9,502,500	$729,400	$383,700	$10,810,800
Federal	$6,446,400	$715,100	$1,251,500	$2,849,700	$915,600	$12,178,400
Total	$6,641,600	$715,100	$10,754,000	$3,579,200	$1,299,300	$22,989,200

Note: Labor Income, Value Added, Output, and Total values are rounded

3.3 First Scenario

Under the first scenario, if the catch rate decreased by 10 percent, it is estimated that the average respondent would take 1.3 percent fewer trips, and overall the total number of annual trips would be reduced by 12,100. The change in the total number of annual trips was multiplied by the costs spent per trip (Table 3-1) and entered into the IMPLAN model. Table 3-6 shows the results of the IMPLAN model.

Table 3-6: RED Summary for First Scenario

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	(40.2)	($931,200)	($1,399,900)	($1,837,800)
Indirect Effect	(2.2)	($88,900)	($142,200)	($255,300)
Induced Effect	(5.7)	($199,700)	($361,200)	($598,300)
Total Effect	**(48.1)**	**($1,219,800)**	**($1,903,300)**	**($2,691,400)**

Note: Labor Income, Value Added, and Output values are rounded

If the catch rate decreases by 10 percent, and total trips is reduced by 12,100 trips, total employment is estimated to decrease by 48.1 jobs. The labor income is estimated to decrease by $1,219,800, and the value added would decrease by $1,903,300. The overall effect on output is estimated to decrease by $2,691,400.

The top five industries that would be affected by the decrease in output are transit and ground transportation, retail store (food and beverage), hotels and motels, retail stores (sporting goods, hobby, book and music), and imputed rental activity for owner-occupied dwellings.

IMPLAN also estimates the impact a change to the local economy would have on taxes. Table 3-7 shows the estimated impact on State, local, and Federal taxes. The results are shown as total tax impact, including direct, indirect, and induced effects. The decrease in 12,100 fishing trips would result in a loss of tax income on both the State and local and Federal levels.

Table 3-7: First Scenario Total Tax Impact

Tax Impact Type	Employee Compensation	Proprietor Income	Indirect Business Tax	Households	Corporations
State and Local	($3,600)	-	($227,800)	($13,700)	($7,200)
Federal	($120,500)	($13,600)	($30,000)	($53,400)	($17,100)
Total	($124,100)	($13,600)	($257,800)	($67,100)	($24,200)

Note: Values are rounded

3.4 Second Scenario

Under the second scenario, if the catch rate decreased by 20 percent, it is estimated that the average respondent would take 2.5 percent fewer trips, and overall the total number of annual trips would be reduced by 24,200. The change in the total number of annual trips was multiplied by the costs spent per trip (Table 3-1) and entered into the IMPLAN model. Table 3-8 shows the results of the IMPLAN model.

Table 3-8: RED Summary for Second Scenario

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	(80.5)	($1,862,300)	($2,799,800)	($2,852,200)
Indirect Effect	(3.8)	($154,300)	($244,600)	($439,800)
Induced Effect	(11.2)	($394,900)	($714,000)	($1,182,800)
Total Effect	**(95.5)**	**($2,411,500)**	**($3,758,500)**	**($4,474,800)**

Note: Labor Income, Value Added, and Output values are rounded

If the catch rate decreases by 20 percent, and total trips is reduced by 24,200 trips, total employment is estimated to decrease by 95.5 jobs. The labor income is estimated to decrease by $2,411,500, and the value added would decrease by $3,758,500. The overall effect on output is estimated to decrease by $4,474,800.

The top five industries that would be affected by the decrease in output are transit and ground transportation, retail store (food and beverage), hotels and motels, retail stores (sporting goods, hobby, book and music), and imputed rental activity for owner-occupied dwellings.

Table 3-9 shows the estimated impact on State, local, and Federal taxes. The results are shown as total tax impact, including direct, indirect, and induced effects. The decrease in 24,200 fishing trips would result in a loss of tax income on both the State and local and Federal levels.

Table 3-9: Second Scenario Tax Impact

Tax Impact Type	Employee Compensation	Proprietor Income	Indirect Business Tax	Households	Corporations
State and Local	($7,200)	-	($452,300)	($27,000)	($14,000)
Federal	($238,100)	($27,000)	($59,600)	($105,600)	($33,500)
Total	($245,400)	($27,000)	($511,900)	($132,600)	($47,600)

Note: Values are rounded

3.5 Third Scenario

Under the third scenario, if the catch rate decreased by 30 percent, it is estimated that the average respondent would take 3.8 percent fewer trips, and overall the total number of annual trips would be reduced by 36,400. The change in the total number of annual trips was multiplied by the costs spent per trip (Table 3-1) and entered into the IMPLAN model. Table 3-10 shows the results of the IMPLAN model.

Table 3-10: RED Summary for Third Scenario

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	(120.7)	($2,793,500)	($4,199,700)	($5,938,000)
Indirect Effect	(6.8)	($279,000)	($447,700)	($803,100)
Induced Effect	(17.0)	($601,700)	($1,087,900)	($1,802,100)
Total Effect	**(144.5)**	**($3,674,200)**	**($5,735,300)**	**($8,543,300)**

Note: Labor Income, Value Added, and Output values are rounded

If the catch rate decreases by 30 percent, and total trips is reduced by 36,400 trips, total employment is estimated to decrease by 144.5 jobs. The labor income is estimated to decrease by $3,674,200, and the value added would decrease by $5,735,300. The overall effect on output is estimated to decrease by $8,543,300.

The top five industries affected by the decrease in output would be transit and ground transportation, retail store (food and beverage), hotels and motels, retail stores (sporting goods, hobby, book and music), and imputed rental activity for owner-occupied dwellings.

Table 3-11 shows the estimated impact on State, local, and Federal taxes. The results are shown as total tax impact, including direct, indirect, and induced effects. The decrease of 36,400 fishing trips would result in a loss of tax income on both the State and local and Federal levels.

Table 3-11: Third Scenario Tax Impact

Tax Impact Type	Employee Compensation	Proprietor Income	Indirect Business Tax	Households	Corporations
State and Local	($11,000)	-	($685,200)	($41,200)	($21,600)
Federal	($362,900)	($41,000)	($90,200)	($160,900)	($51,600)
Total	($373,900)	($41,000)	($775,400)	($202,100)	($73,200)

Note: Values are rounded

4.0 RECREATION RISK AND UNCERTAINTY

4.1 NED Risk and Uncertainty

There is a degree of uncertainty regarding the magnitude of the estimates of the annual number of trips and recreation benefits. This uncertainty is due to imperfect information or changing conditions surrounding the variable. However, the range and frequency over which the variable may occur can be estimated and represented by a probability distribution. Integrating variables and their probability distributions into a stochastic model that accounts for uncertainty provides results that indicate the probable outcomes of events. An uncertainty analysis was conducted to show possible NED outcomes. The analysis was performed using Monte Carlo simulations in the @Risk software distributed by Palisade Corporation.

The NED impacts calculated was a function of the equations, assumptions, and the probability distributions assigned to selected variables. The appropriate probability distributions for each variable were incorporated into the benefit model. The NED impact is calculated as the product of the percentage the catch rate could decrease and the number of annual trips to yield the number of fewer annual trips. Then the number of fewer annual trips is multiplied by mean WTP to calculate the NED loss. A simulation, consisting of 10,000 iterations, yielded a probability distribution defining the likelihood of any single outcome occurring.

The following variables were considered for the risk and uncertainty analysis:

- Catch Rate
- WTP
- Annual Trips to Lake Texoma

4.1.1 Catch Rate Uncertainty

Comparing the with-project and without-project conditions over a 50-year period of analysis, the results of the ecological modeling (CASM-LT) suggest minimal impacts of chloride management on overall striped bass production in Lake Texoma. The expert panel agreed that chloride management is not anticipated to have a measurable effect on the adult striped bass population in Lake Texoma. However, a key uncertainty is whether the chloride project would influence recruitment of striped bass. If the implementation of Area VI of the RRCCP would adversely impact the recruitment of striped bass, the population of striped bass may decline over time. A minor to moderate change in fish abundance is not likely to influence the catch rate. However, if the population was continually decreasing over time, eventually the catch rate of striped bass would wane. If chloride management influences the recruitment of striped bass, then the catch rate, and ultimately fishing trips to Lake Texoma, would also be affected. More information is needed to determine if chloride management would affect the recruitment of striped bass. At the time of this report, that information was unavailable.

A minor to moderate change in fish abundance is not likely to influence the angler catch rate of striped bass. Anglers may be able to modify their techniques to maintain their catch rates. But eventually, a decline in the striped bass population would reduce the catch rates of all anglers and presumably the annual number of trips taken to Lake Texoma. There is little research that defines the relationship between a change in the suitability of a fishing area for striped bass and the corresponding change in the catch rate at that location.

Since the PDT did not expect the negative impacts to the catch rate to reach the upper bound limit of a 30 percent reduction used in the survey, the catch rate elasticity was used to calculate the percentage decrease in the number of annual trips given a percent change in the catch rate. A 20 percent decrease in the catch rate would result in 2.5 percent fewer annual fishing trips and a 30 percent decrease in the catch rate would result in 3.8 percent fewer annual fishing trips to Lake Texoma. A triangular distribution was chosen as the best fit to represent the probability of fewer annual fishing trips resulting from a change in the catch rate.

A triangular distribution is composed of a minimum, maximum, and most likely value. This distribution assumes that the value most likely to occur has the greatest probability of being randomly selected, while the minimum and maximum values have a very small likelihood of occurring. The 20 percent change in the catch rate and 2.5 percent fewer annual fishing trips was chosen as the most likely value for the probability distribution, although it is uncertain what the most likely value would be until more information is obtained regarding the impact of Area VI on the recruitment of striped bass. The triangular distribution (Figure 4-1) of the potential percentage decreases in the number of annual fishing trips based on changes in the catch rate was incorporated into the NED net benefit model.

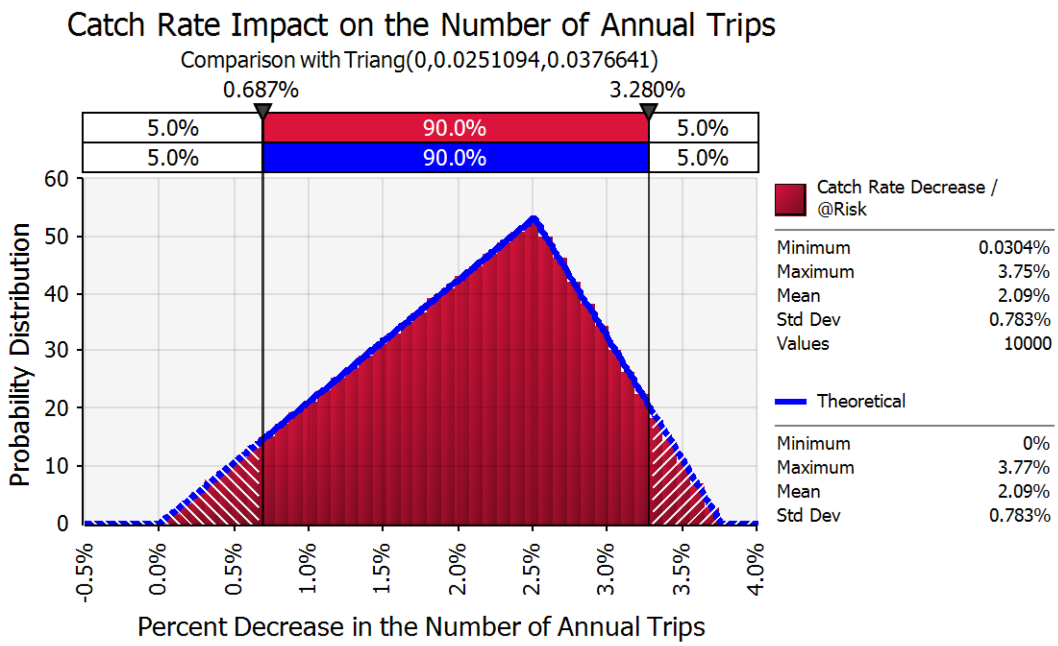


Figure 4-1: Probability of Percent Decreases in the Number of Annual Trips

4.1.2 Willingness-to-Pay Uncertainty

WTP was calculated (equation 5) using the mean travel cost of \$96.27 from Section 2.8 and a choke price of \$211.61, which is the 90th percentile travel cost. For the risk and uncertainty analysis, mean WTP is calculated using the higher choke price of \$354.05 from the 95th percentile travel cost.

Using the integral of equation 5 at the mean number of trips with the mean travel cost as the lower limit and the 95th percentile as the upper limit of the integration, the mean WTP per person per trip is \$51.27. The annual recreation value is calculated by multiplying the mean WTP estimate by the estimated annual number of trips. Multiplying the WTP estimate of \$51.27 per person per trip by 965,000 estimated annual trips, the annual recreation value would increase to \$49.5 million.

The mean WTP was allowed to vary from \$21.88 to \$51.27 using a uniform distribution. The uniform distribution (Figure 4-2) of the WTP variable was incorporated into the NED net benefit model. This distribution allows for each WTP value in the range to have an equal likelihood of being observed in the model.

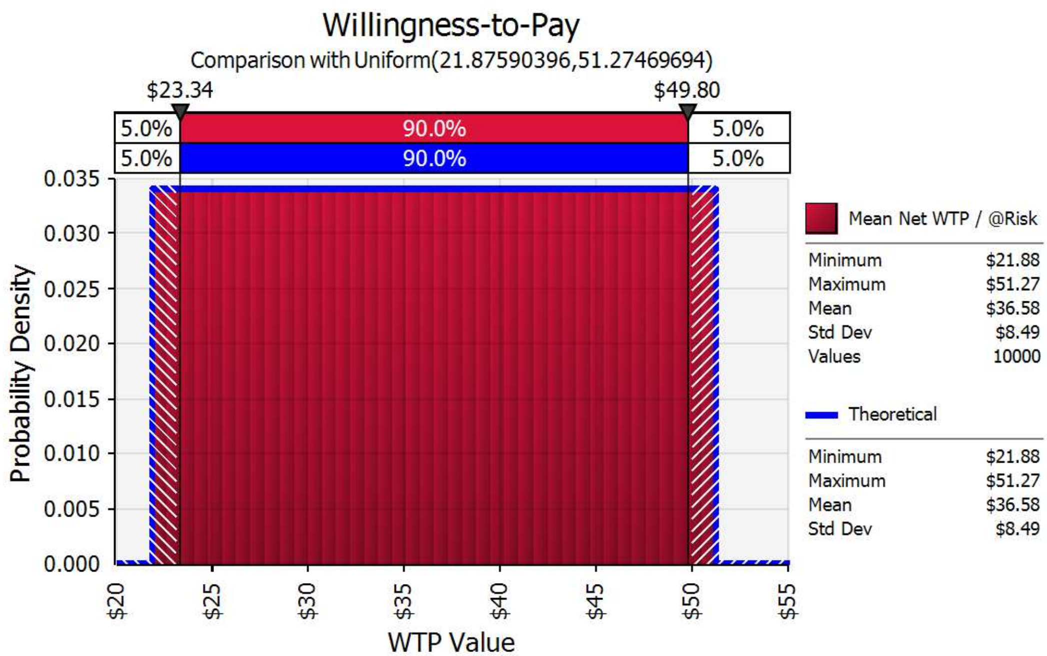


Figure 4-2: Willingness-to-Pay Probability Distribution

4.1.3 Annual Trips Uncertainty

The annual number of trips to Lake Texoma was calculated based on the number of annual users estimated during Phase II. The average annual number of anglers fishing in Lake Texoma was estimated to be 101,000. The baseline level of annual fishing trips to Lake Texoma was estimated to be 965,000 annual trips.

On average, survey respondents took 10 trips to Lake Texoma each year, excluding respondents who did not respond or did not take any trips to Lake Texoma. The actual average used to calculate the total number of annual trips was 9.55 trips but since it is not possible to take a fraction of a trip, the number was rounded up to 10 trips. In Phase II, the average number of annual trips was 7 trips, after removing protest bids from the survey responses. Protest bids were classified by “no” votes for the recreational improvement, not because the respondent cannot afford the payment or has no interest in the improvement, but because the respondent dislikes the payment vehicle or believes recreational improvements should be free. In Phase III, protest bids were not removed from the analysis since WTP was estimated using the travel cost method instead of contingent valuation. The number of annual trips were varied from 707,000 (7 average trips per user) to 1,010,000 (10 average trips per user) using a uniform distribution (Figure 4-3).

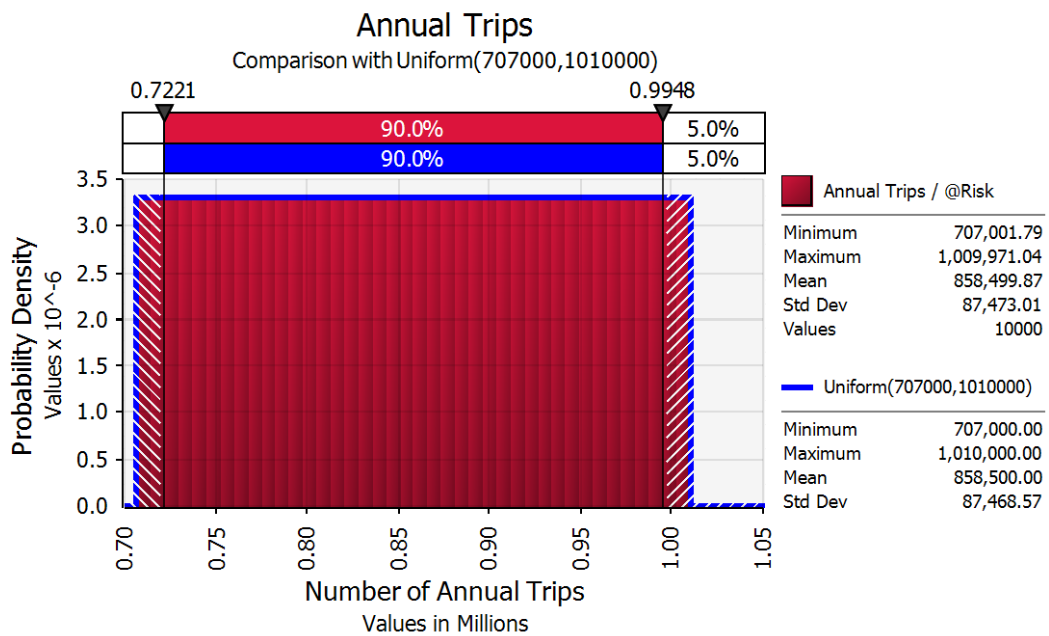


Figure 4-3: Probability Distribution of Total Annual Trips to Lake Texoma

4.1.4 Uncertainty Analysis Results

Once the probability distributions were identified for each variable, a simulation was run with 10,000 iterations. The simulation produced a distribution of the possible results for the negative NED impact.

The NED result hinges primarily on the impact to the catch rate. The more the catch rate decreases, the greater the decrease in annual trips to Lake Texoma. The NED impact is a product of the fewer annual trips and the WTP per individual per trip. The fewer annual trips were based on the reduction in the catch rate. The result was an average annual NED loss of $657,027. Using the 90-percent confidence interval estimates, the low estimate of the annual NED loss was $195,000 and the high estimate was $1,206,000. The decrease in the number of annual trips from a change in the catch rate had the largest impact on the results. The triangular probability distribution of the annual NED losses predicted from the combined risk and uncertainty analysis is presented in Figure 4-4.

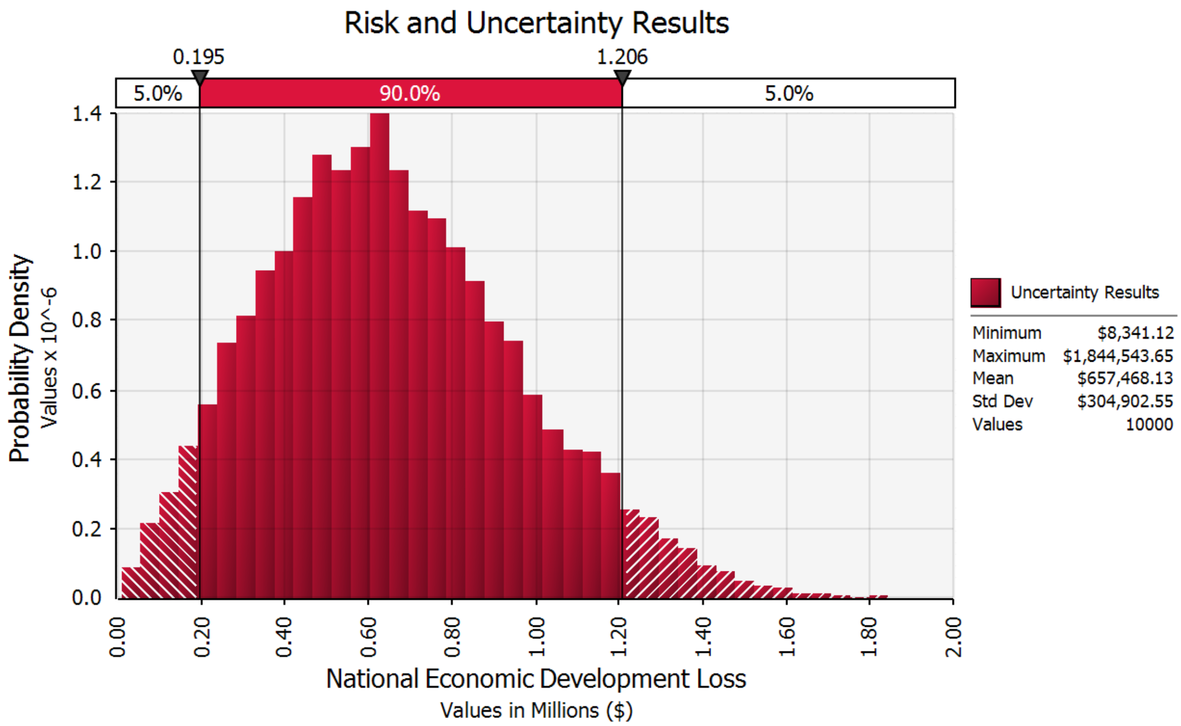


Figure 4-4: Risk and Uncertainty Analysis Results

4.2 Analysis Options

The results presented in Section 2-10 assumed that the without-project conditions would not change over time. However, it is likely that the increased sedimentation occurring in Lake Texoma would affect fish populations and ultimately the catch rate of striped bass over time, even without the project. The NED approach that was used considered the worst-case scenario by assuming that the without-project conditions would not deteriorate over time and that the potential impacts would happen the same year as implementation and span the entire study period of 50 years.

If chloride management affected the catch rate of striped bass, it would happen over a period of time but the rate of decline is unknown. If information were available for the estimated decrease in the catch rate and the rate of decline for the without-project conditions and the with-project conditions, then the with-project conditions would be compared to the without-project conditions to estimate the consumer loss. The consumer loss (NED loss) would be calculated as the area between the without-project and with-project curves in Figure 4-5.

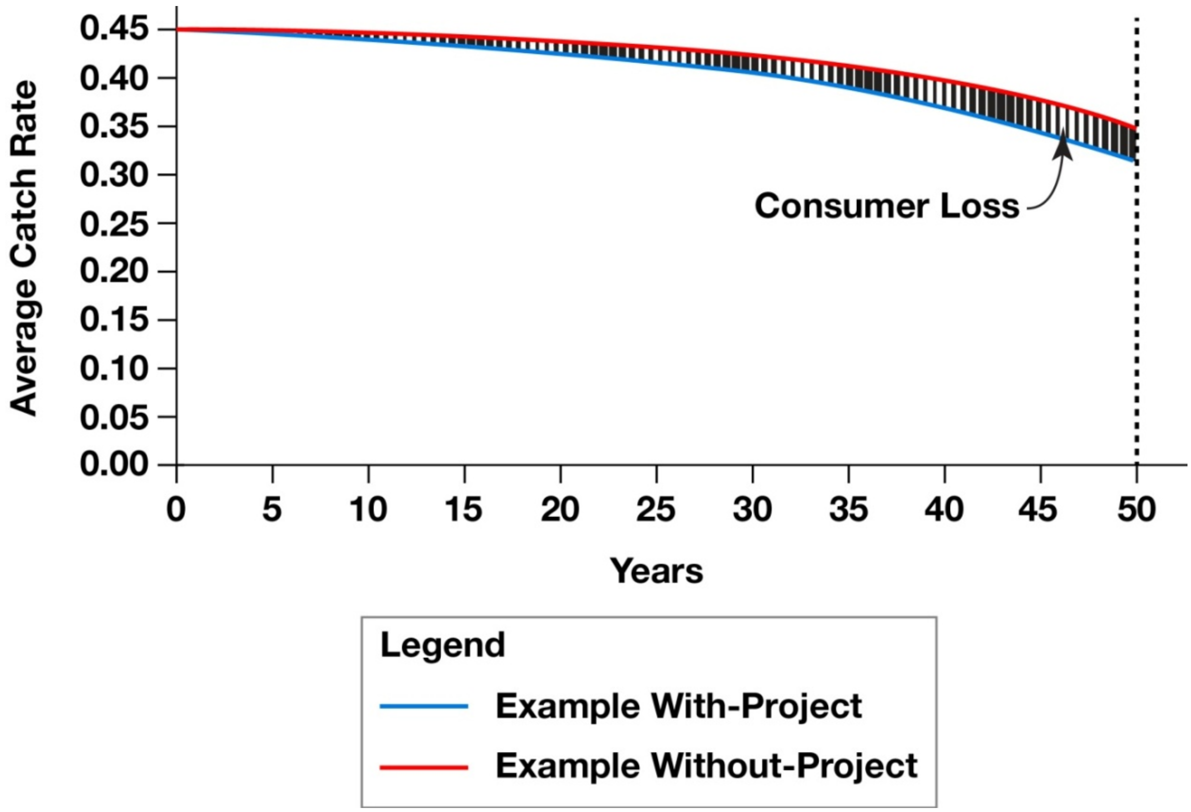


Figure 4-5: Example With-Project and Without-Project Conditions

Since the estimated decrease in the catch rate and the rate of decline for the without-project conditions and the with-project conditions are unavailable, there are several options for evaluating the NED impacts of chloride management. Assuming the catch rate does not change, the without-project conditions are represented by the flat black line at the average catch rate of 0.45 as shown in Figure 4-6. The NED approach used in this report is depicted as Analysis Option A in Figure 4-6 and is considered the worst-case scenario. Analysis Options B and C reflect a catch rate that declines over time. Analysis Options B and C would result in an NED loss that is significantly less than that estimated using Analysis Option A. The NED loss for each option would be the area between the line representing the option and the black.

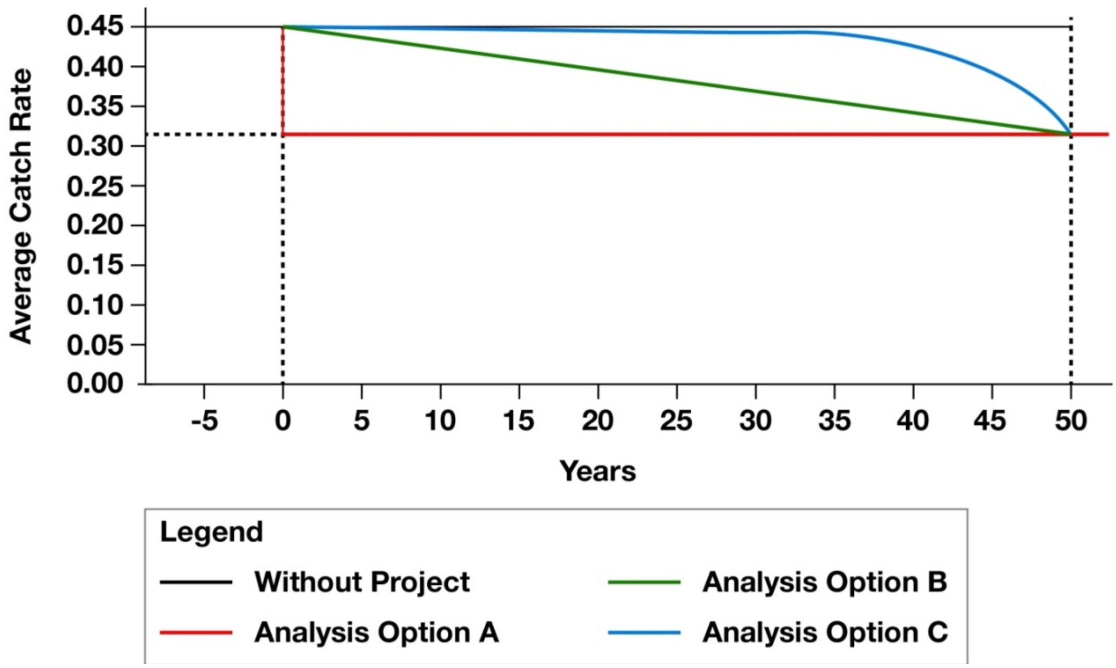


Figure 4-6: Analysis Options

4.3 RED Risk and Uncertainty

The risk and uncertainty regarding the annual fishing trips discussed in Section 4.1.3 were used to analyze the risk and uncertainty in the RED impacts associated with the change in the number of fishing trips. The number of annual trips was varied from 707,000 to 1,010,000 using a uniform distribution (Figure 4-3). The 90 percent confidence interval within this range was used in the RED analysis. With 90 percent confidence, the minimum effect on the catch rate is a 0.69 percent reduction, which is equivalent to 5,000 fewer trips; the maximum effect on the catch rate is a 3.28 percent reduction, equivalent to 32,600 fewer trips. These end points of the 90 percent confidence interval were entered into IMPLAN as two separate models. The results of the minimum are summarized in Table 4-1, and the corresponding tax impacts are shown in Table 4-2.

Table 4-1: RED Summary for Minimum of 90% Confidence Interval

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	(16.5)	($381,100)	($573,000)	($565,000)
Indirect Effect	(0.8)	($31,000)	($49,100)	($88,300)
Induced Effect	(2.3)	($80,700)	($145,900)	($241,700)
Total Effect	**(19.6)**	**($492,800)**	**($768,000)**	**($895,000)**

Table 4-2: Tax Impact of Minimum of 90% Confidence Interval

Tax Impact Type	Employee Compensation	Proprietor Income	Indirect Business Tax	Households	Corporations
State and Local	($1,500)	$0	($92,500)	($5,500)	($2,900)
Federal	($48,700)	($5,500)	($12,200)	($21,600)	($6,800)
Total	($50,100)	($5,500)	($104,700)	($27,100)	($9,700)

The results of the maximum of the 90 percent confidence interval are summarized in Table 4-3, and the corresponding tax impacts are shown in Table 4-4.

Table 4-3: RED Summary for Maximum of 90% Confidence Interval

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	(108.3)	($2,506,800)	($3,768,800)	($5,328,700)
Indirect Effect	(6.1)	($250,400)	($401,700)	($720,700)
Induced Effect	(15.3)	($539,900)	($976,200)	($1,617,200)
Total Effect	**(129.7)**	**($3,297,100)**	**($5,146,800)**	**($7,666,600)**

Table 4-4: Tax Impact of Maximum of 90% Confidence Interval

Tax Impact Type	Employee Compensation	Proprietor Income	Indirect Business Tax	Households	Corporations
State and Local	($9,900)	$0	($614,900)	($37,000)	($19,400)
Federal	($325,700)	($36,800)	($81,000)	($144,400)	($46,300)
Total	($335,500)	($36,800)	($695,900)	($181,400)	($65,700)

The results of the RED risk and uncertainty analysis demonstrate that the change in the number of annual fishing trips could have a varying impact on the study area. With 90 percent confidence, the change in the number of annual fishing trips could decrease employment by 19.6 to 129.7 jobs; labor income could decrease between $492,800 and $3,297,100; and total output could decrease between $895,000 and $7,666,600.

4.4 Cable Mountain Dam

Another source of uncertainty pertains to the with-project conditions and the Cable Mountain Dam. Construction of the Cable Mountain Dam has been proposed on the Elm Fork of the Red River downstream of Lake Altus if Area VI is implemented. The dam would capture relatively high quality water prior to its entering the main stem of the Red River and could affect the estimated chloride and TDS concentrations from those presented in the *Area VI Reevaluation Concentrations Duration/Low Flow Study* (USACE, 2011). Construction of the Cable Mountain Dam could potentially affect flows and water quality in the Red River Basin, but it is uncertain how Cable Mountain Dam would affect the striped bass fishery of Lake Texoma.

5.0 AGRICULTURAL REGIONAL ECONOMIC DEVELOPMENT

Implementation of Area VI is anticipated to have an effect on the agricultural lands in and around the Lugert-Altus Irrigation District. Area VI could potentially create an increase in suitable irrigation water and increase the acres of irrigable lands. An increase in irrigable lands could create NED and RED benefits in the area in the form of increased crop production. The potential NED benefits would result in RED benefits in the study area.

The NED benefits associated with the agricultural lands in the region due to Area VI were estimated by Oklahoma State University (OSU). OSU estimated NED benefits in two different scenarios: with and without implementation of Cable Mountain Reservoir. The construction of Cable Mountain Reservoir is proposed as a new reservoir on the North Fork of the Red River, downstream of Lake Altus. The reservoir would be located near Headrick, Oklahoma. Cable Mountain Reservoir has the potential to affect the flows and water quality in the Red River Basin. The resulting benefits differ because of a change in with-project water quality conditions with the implementation of Cable Mountain Reservoir.

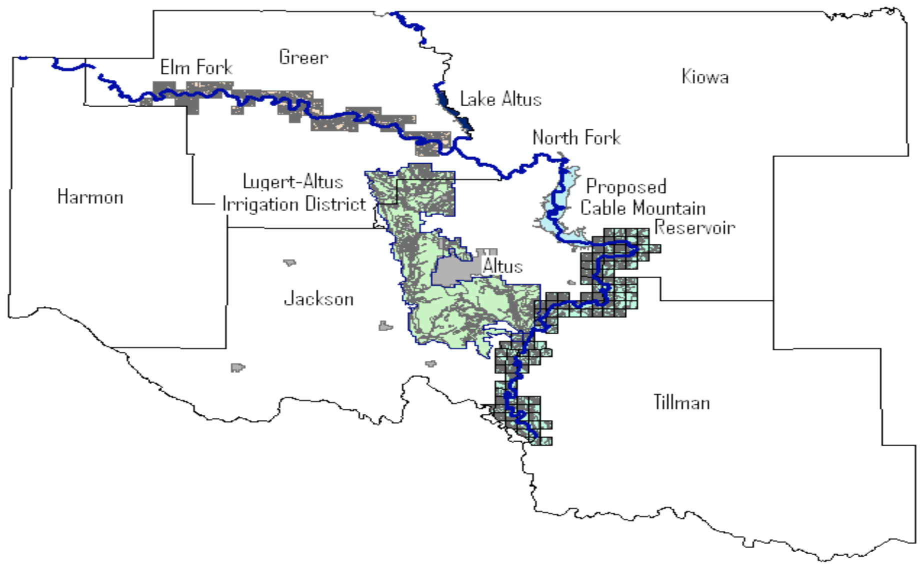
The results of the OSU studies were used to estimate the effect on RED in the study area. The study area, methodology, summary of the findings from the OSU studies, resulting RED benefits, and risk and uncertainty are presented in the following sections.

5.1 Without-Cable Mountain Reservoir

The OSU report “Chloride Control and Irrigation Management: GIS Integrated Approach to Economic Feasibility in Cotton with Center Pivot Irrigation” (Bhavsar et al., 2012) presents the Without-Cable Mountain Reservoir scenario. The purpose of the study is to estimate potential benefits of additional irrigated acres along the Elm and North Fork rivers.

5.1.1 Study Area

The study area considered is those areas that would benefit from Area VI without the implementation of Cable Mountain Reservoir. Area VI would reduce the chloride levels in the water in the Elm Fork below this control point. Figure 5-1 shows the study area. The potential irrigable agricultural areas are those areas within 1 to 2 miles of the Elm and North Forks of the Red River, as these are the lands that could draw water to use for irrigation.



Source: Bhavsar et al., 2012

Figure 5-1: Potential Irrigable Land Without Cable Mountain Reservoir

The study area includes Greer, Kiowa, Harmon, Jackson, and Tillman Counties in the State of Oklahoma.

5.1.2 NED Benefits

The objective of the OSU study was to determine the optimal allocation of desalinized water from the Elm and North Fork rivers to the soils along the Red River. NED benefits were estimated using GIS, the crop simulation model Erosion Productivity Impact Calculator (EPIC), and econometric and optimization models. A non-linear multi region, multi-period model was developed to evaluate the net benefits over a 50-year period for each individual parcel of land. The analysis calculated the net profits of each individual section of land. EPIC was used to simulate yields based on different components, such as soil Electrical Conductivity (EC), rainfall, and temperature. The electrical conductivity is a common measure of soil salinity and is indicative of the ability of water to carry an electric current. In the without-project condition, there is no implementation of Area VI and rainfall is the only source of water available to the crop. In the with-project, Area VI is implemented and a reduction in chlorides could create the opportunity to draw water from the Red River and increase irrigation systems.

The OSU study is based on the following key assumptions:

- As rainfall as the only source of water available to the crop, it was assumed there would be no effect of salinity on the dry land yields and net returns for the without-project estimates.
- Potential irrigable lands considered were Natural Resources Conservation Service (NRCS) classes I, IIe, IIw, IIIe, and IIIw, and had 10-meter slopes less than 3 percent.
- There are several possible irrigation systems that could be implemented in the area, but the study assumes center pivot irrigation would be used in any additional irrigable lands.
- The only crop that would be planted in the additional irrigable lands would be cotton. Cotton is currently the primary crop in the region and has a salt resistance up to a soil EC level of 7.7.
- The base price for normalized cotton prices is $0.54 per pound of lint.
- Net returns from dry land cotton are subtracted from the net returns of irrigated cotton to find the net agricultural benefits from adopting irrigation practices.

GIS was used to draw circles to represent center pivot irrigation systems, and the net present value was calculated for each circular parcel of land. Each parcel has 124 acres or less, with a quarter-mile center pivot. Aerial photographs were then used to ensure the absence of physical hazards that would make irrigation difficult or impossible. A total of 77 sections of irrigable soils without physical obstructions were found, for total irrigable acres of 7,867. The net present value was estimated for these sections.

Total costs were subtracted from the benefits of each section. Total costs include variable and fixed costs. Variable costs include pumping costs, input costs, labor, and interest on non-irrigation equipment. Variable costs were estimated using OSU's 2010 enterprise budgets. Variable costs were estimated to be approximately $480 per acre per year. The fixed costs include the cost of the wells, pumps, motors, and the buying of pivots. The OSU study did not break out construction costs as a separate cost from the equipment and operation to analyze as an RED benefit. The irrigation well is a one-time cost, but the irrigation systems and power sources have to be replaced at the end of their lives over the planning period.

Pivot systems have an average life of 17 years, and pumps have an average life of 11 years. These were discounted over the 50-year planning period using a 4 percent discount rate.

The net benefits for each of the 77 irrigation circles were calculated for the planning period. It was found that the higher the number of acres in a pivot, or the closer the pivot was to operating a full circle, the more likely the pivot is profitable. Irrigation circles with fewer acres and with greater amounts of clay in the soil were more likely to have lower net benefits. Table 5-1 shows the results for the dry land condition at different prices of cotton. At a price of $0.54 per pound of cotton lint, the estimated net present value is $5.35 million.

Table 5-1: Without Cable Mountain Reservoir Dry Land Returns of Cotton

Price	54 cents/lb	60 cents/lb	65 cents/lb
Net Returns above Variable Costs			
Net returns per acre	$62	$91	$115
Total	$24,358,473	$35,737,807	$45,291,352
50-year NPV* of Benefits	$23,421,609	$34,363,276	$43,549,377
Net Returns above Total Costs			
Net returns per acre	$14	$43	$67
Total	$5,561,972	$16,941,305	$26,494,850
50-year NPV of Benefits	$5,348,050	$16,289,717	$25,475,818

Source: Bhavsar et al., 2012
**NPV = net present value*

The net benefit was then estimated for the lands with irrigation. For the with-project condition, the study also takes into consideration the uncertainty associated with weather conditions and different EC levels. The study looks at average, above average, and below average weather scenarios. The above average weather scenario is considered a 10 percent improvement from the average weather scenario and a 10 percent increase in rainfall. The below average weather scenario is considered a 10 percent reduction in the average weather scenario and a 10 percent reduction in average rainfall. The results of this uncertainty analysis are presented in Table 5-2. The results are shown as the total net impact after subtracting dry land returns and investment costs.

Table 5-2: Lands with Irrigation Net Impact by Weather Condition and EC Level

Weather Condition	EC Level			
	0.9	1.5	2.2	3.0
-10% Weather				
NPV ($000)	$6,191	$1,015	--	--
Economically Feasible Acres	5,108	1,703	--	--
Feasible Pivot Fields	45	14	--	--
Average Weather				
NPV ($000)	$19,456	$8,706	$2,763	--
Economically Feasible Acres	7,597	6,733	2,670	--
Feasible Pivot Fields	73	62	23	--
+10% Weather*				
NPV ($000)	$35,237	$37,078	$13,443	$2,139
Economically Feasible Acres	7,811	7,867	7,147	5,059
Feasible Pivot Fields	76	77	67	32

Source: Bhavsar et al., 2012

* *Values for the +10% Weather were adjusted from the OSU study to show a net benefit from the dry land condition by subtracting the $5.35 million benefits in the dry land condition..*

In the below average weather scenario, the net impact is negative when the EC level is 2.2 or higher. Only 45 of the 77 irrigation circles are economically feasible when the EC level is 0.9. In the above average weather scenario, the net impact is positive at EC levels up to 3.0.

5.1.3 RED Benefits

The RED benefits were analyzed using the NED benefits estimated by OSU. The RED benefits were estimating using IMPLAN. IMPLAN is used to analyze the indirect and induced effects of a change on the local economy. IMPLAN defines indirect effects as the impact of local industries buying goods and services from other local industries. IMPLAN defines induced effects as the response to a direct effect that occurs when an addition (or subtraction) of income causes re-spending (or reduced spending). Induced effects refer to the effects on households in the study area. The data can be analyzed on a national, State, county, or zip code level. For this analysis, the county level was used. In the Without-Cable Mountain Dam scenario, Greer, Harmon, Jackson, Kiowa, and Tillman Counties were anticipated to benefit from an increase in irrigation. The IMPLAN model for this scenario was built using 2009 IMPLAN data for Greer, Harmon, Jackson, Kiowa, and Tillman Counties in Oklahoma.

Section Five: Agricultural Regional Economic Development

The NED analysis estimated the benefits of the with-project condition for three weather scenarios and four levels of EC. The net impacts of the scenarios presented in Table 5-2 represent the increase in cotton production after subtracting the total costs of that increased production. This NED benefit would have a regional benefit to the five counties the lands are located. Each of these scenarios was evaluated in the IMPLAN model. For each scenario, the benefits from Table 5-2 were input as a commodity change in the cotton sector. Table 5-3 presents the output from the model in 2012 dollars.

Table 5-3: RED Effects for Without-Cable Mountain

Weather Condition	EC Level	Impact Type	Employment	Labor Income	Value Added	Output
Below Average	0.9	Direct Effect	47.2	$1,816,400	$2,434,700	$5,367,400
		Indirect Effect	9.1	$295,300	$487,000	$989,200
		Induced Effect	6.8	$187,000	$398,500	$657,900
		Total Effect	*63.1*	*$2,298,700*	*$3,320,200*	*$7,014,500*
	1.5	Direct Effect	7.7	$297,800	$399,200	$880,000
		Indirect Effect	1.5	$48,400	$79,800	$162,200
		Induced Effect	1.1	$30,700	$65,300	$107,900
		Total Effect	*10.3*	*$ 376,900*	*$544,300*	*$1,150,000*
	2.2	Direct Effect	--	--	--	--
		Indirect Effect	--	--	--	--
		Induced Effect	--	--	--	--
		Total Effect	--	*$ -*	*$ -*	*$ -*
	3.0	Direct Effect	--	--	--	--
		Indirect Effect	--	--	--	--
		Induced Effect	--	--	--	--
		Total Effect	--	*$ -*	*$ -*	*$ -*
Average	0.9	Direct Effect	148.5	$5,708,400	$7,651,500	$16,867,700
		Indirect Effect	28.5	$928,000	$1,530,400	$3,108,700
		Induced Effect	21.2	$587,500	$1,252,400	$2,067,600
		Total Effect	*198.2*	*$7,223,900*	*$10,434,300*	*$22,044,000*
	1.5	Direct Effect	66.4	$2,554,300	$3,423,800	$7,547,800
		Indirect Effect	12.8	$415,200	$684,800	$1,391,100
		Induced Effect	9.5	$262,900	$560,400	$925,200
		Total Effect	*88.7*	*$3,232,500*	*$4,669,000*	*$ 9,864,000*
	2.2	Direct Effect	21.1	$810,700	$1,086,600	$2,395,400
		Indirect Effect	4	$131,800	$217,300	$441,500
		Induced Effect	3	$83,400	$177,900	$293,600
		Total Effect	*28.1*	*$1,025,900*	*$1,481,800*	*$3,130,500*
	3.0	Direct Effect	--	--	--	--
		Indirect Effect	--	--	--	--
		Induced Effect	--	--	--	--
		Total Effect	--	*$ -*	*$ -*	*$ -*

Weather Condition	EC Level	Impact Type	Employment	Labor Income	Value Added	Output
Above Average	0.9	Direct Effect	164.1	$4,836,000	$11,580,000	$21,753,800
		Indirect Effect	30.8	$896,500	$1,628,300	$3,198,000
		Induced Effect	21.2	$582,800	$1,254,700	$2,058,900
		Total Effect	*216.1*	*$6,315,300*	*$14,463,000*	*$27,010,800*
	1.5	Direct Effect	282.9	$10,878,700	$14,581,700	$32,145,300
		Indirect Effect	54.3	$1,768,500	$2,916,600	$5,924,400
		Induced Effect	40.5	$1,119,700	$2,386,700	$3,940,300
		Total Effect	*377.7*	*$13,766,900*	*$19,885,000*	*$42,010,000*
	2.2	Direct Effect	102.6	$3,944,200	$5,286,700	$11,654,600
		Indirect Effect	19.7	$641,200	$1,057,400	$2,147,900
		Induced Effect	14.7	$406,000	$865,300	$1,428,600
		Total Effect	*137*	*$4,991,300*	*$7,209,500*	*$15,231,100*
	3.0	Direct Effect	16.3	$627,600	$841,200	$1,854,400
		Indirect Effect	3.1	$102,000	$168,300	$341,800
		Induced Effect	2.3	$64,600	$137,700	$227,300
		Total Effect	*21.7*	*$794,200*	*$1,147,100*	*$2,423,500*

Table 5-3 highlights that, as with the NED benefits, generally, the lower the EC level and the more ideal the weather condition (more rain), the higher the RED benefits. However, the above average weather condition and EC level of 1.5 scenario has higher benefits than the above average weather condition with EC level of 0.9. The scenario with EC level of 1.5 has a total effect of an increase in 377 jobs, increase in labor income of $13,766,800, and an increase in output of $42,009,900. The NED benefits for this scenario are the highest of all the scenarios because all of the 77 pivots are economically feasible.

Table 5-4 present the RED effects on a per acre basis. The NED analysis found that there are 77 feasible pivot irrigation circles with a total of 7,867 acres. These per acre estimates can be used in the future as OSU conducts further analysis and review.

Table 5-4: RED Effects for Without-Cable Mountain per Acre

Weather Condition	EC Level	Impact Type	Employment	Labor Income	Value Added	Output
Below Average	0.9	Direct Effect	0.006	$231	$309	$682
		Indirect Effect	0.001	$38	$62	$126
		Induced Effect	0.001	$24	$51	$84
		Total Effect	*0.008*	*$292*	*$422*	*$892*
	1.5	Direct Effect	0.001	$38	$51	$112
		Indirect Effect	0.000	$6	$10	$21
		Induced Effect	0.000	$4	$8	$14

Weather Condition	EC Level	Impact Type	Employment	Labor Income	Value Added	Output
		Total Effect	*0.001*	*$48*	*$69*	*$146*
	2.2	Direct Effect	--	--	--	--
		Indirect Effect	--	--	--	--
		Induced Effect	--	--	--	--
		Total Effect	--	*$ -*	*$ -*	*$ -*
	3.0	Direct Effect	--	--	--	--
		Indirect Effect	--	--	--	--
		Induced Effect	--	--	--	--
		Total Effect	--	*$ -*	*$ -*	*$ -*
Average	0.9	Direct Effect	0.019	$726	$973	$2,144
		Indirect Effect	0.004	$118	$195	$395
		Induced Effect	0.003	$75	$159	$263
		Total Effect	*0.025*	*$918*	*$1,326*	*$2,802*
	1.5	Direct Effect	0.008	$325	$435	$959
		Indirect Effect	0.002	$53	$87	$177
		Induced Effect	0.001	$33	$71	$118
		Total Effect	*0.011*	*$411*	*$593*	*$1,254*
	2.2	Direct Effect	0.003	$103	$138	$304
		Indirect Effect	0.001	$17	$28	$56
		Induced Effect	0.000	$11	$23	$37
		Total Effect	*0.004*	*$130*	*$188*	*$398*
	3.0	Direct Effect	--	--	--	--
		Indirect Effect	--	--	--	--
		Induced Effect	--	--	--	--
		Total Effect	--	*$ -*	*$ -*	*$ -*
Above Average	0.9	Direct Effect	0.021	$615	$1,472	$2,765
		Indirect Effect	0.004	$114	$207	$407
		Induced Effect	0.003	$74	$159	$262
		Total Effect	*0.027*	*$803*	*$1,838*	*$3,433*
	1.5	Direct Effect	0.036	$1,383	$1,854	$4,086
		Indirect Effect	0.007	$225	$371	$753
		Induced Effect	0.005	$142	$303	$501
		Total Effect	*0.048*	*$1,750*	*$2,528*	*$5,340*
	2.2	Direct Effect	0.013	$501	$672	$1,481
		Indirect Effect	0.003	$82	$134	$273
		Induced Effect	0.002	$52	$110	$182
		Total Effect	*0.017*	*$634*	*$916*	*$1,936*
	3.0	Direct Effect	0.002	$80	$107	$236
		Indirect Effect	0.000	$13	$21	$43
		Induced Effect	0.000	$8	$18	$29
		Total Effect	*0.003*	*$101*	*$146*	*$308*

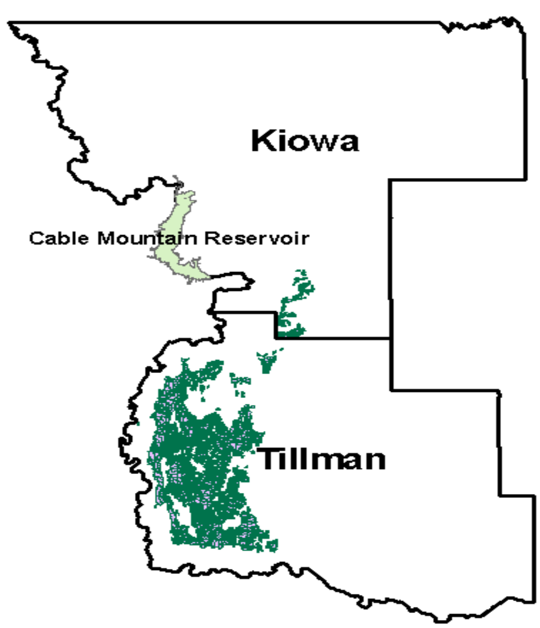
The top five industries by employment affected by the change in cotton production are cotton farming, support activities for agriculture and forestry, monetary authorities and depository credit intermediation activities, real estate establishments, and food services and drinking places.

5.2 With-Cable Mountain Reservoir

The report Feasibility Study of Irrigation Development from Cable Mountain Reservoir to Tillman Terrace Areas and Southwestern Kiowa County (Ghimire et al., 2012) presents the With-Cable Mountain Reservoir scenario. Cable Mountain Reservoir's storage capacity can be used to irrigate lands at lower elevations of the reservoir in Tillman and Kiowa Counties. The purpose of the study was to assess the profitability of additional irrigation development in Tillman and Kiowa counties due to Cable Mountain Reservoir.

5.2.1 Study Area

The study area consists of Tillman County and the southern part of Kiowa County in Oklahoma (Figure 5-2). GIS was used to determine potential irrigable acres in the study area.



Source: Ghimire et al., 2012

Figure 5-2: Irrigable Areas in Tillman and Kiowa Counties

5.2.2 NED Benefits

The study is based on the following key assumptions:

- Soil types examined in the analysis include prime and non-prime, dry land capability, and irrigated capability I and II with a 10 meter slope and elevation.
- Only lands with a slope of less than or equal to 3 percent were used.
- The proposed Cable Mountain Reservoir would be 420 meters above sea level, so only land with elevations less than 420 meters above sea level were used.
- Areas of irrigable soils less than 10 acres were removed from the analysis, assuming it is not economical to irrigate areas smaller than 10 acres.
- The total area of irrigable soils is 68,275 acres (Figure 5-2).
- This study assumed pivot irrigation would be the only irrigation system used on the irrigable areas.

The total area was then analyzed for feasible areas for pivot irrigation. GIS was used to find pivot circles with areas of 125.6 acres and a quarter mile radius; 543 pivot circles without any physical obstacles for irrigation systems were found in the study area.

Fixed project costs include the cost of the pipes, earthwork, and pump. The fixed costs were obtained from RS Mean Construction Data (2009), and include labor cost, material cost and the total cost of the pipe. The OSU study did not break out construction costs as a separate cost from the equipment and operation to analyze as an RED benefit. EPANET software was used to find different designs of irrigation systems to deliver water to each of the 543 pivots. Four different designs were found to be cost effective. A summary of the fixed costs of the designs is presented in Table 5-5.

Table 5-5: Aggregate Fixed Cost and Cost per Acre of Four Designs of Irrigation Systems

Categories	Design 1A	Design 1B	Design 2	Design 3
Total pipeline cost	$32,651,074	$31,419,763	$25,990,640	$16,954,914
Total cost of pumps	$151,748	$171,291	$122,912	$103,848
Total cost of pivots	$3,412,362	$3,412,362	$3,412,362	$3,412,362
Total cost of valve			$211,026	$211,026
Total Cost	**$43,428,780**	**$35,003,416**	**$29,736,940**	**$20,682,150**
Cost/acre	$533	$515	$437	$304
Cost/125.6 acre	$66,892	$64,653	$54,926	$38,201

Source: Ghimire et al., 2012

Variable costs include the costs of cotton production, pivot irrigation system, and labor. Total variable costs for irrigable lands are estimated at $536 per acre. Total variable costs for dry land cotton production are estimated at $246 per acre (Table 5-6).

Table 5-6: Variable Costs for Dry land and Irrigable Cotton Production

Operating Input	Dry Land	Irrigation
Seed	$13	$21
Fertilizer	$20	$10
Pesticide	$27	$42
Growth Regulators/Harvest Aids	$8	$29
Crop Insurance	$10	$10
Annual Operating Capital	$6	$11
Machinery Labor	$16	$21
Irrigation Labor	$0	$2
Machinery Fuel, Lube, Repairs	$92	$107
Ginning/Processing	$38	$110
Other Expense	$16	$22
Pumping Cost	$0	$223
Returns from Seed	$0	$72
Total Variable Cost	**$246**	**$536**

Source: Ghimire et al, 2012

The net impact was estimated for each individual pivot circle using a 50-year period and 4 percent discount rate, and the profitability of dry land and irrigated cotton was assessed.

An average yield of 390 pounds of cotton per acre and a cotton price of $0.54 per pound of lint was assumed in the analysis. Dry land cotton production generates $256 in revenue per acre, and total costs equal $294, for a return of -$37.91 per acre. The net impact was calculated for different prices of cotton (Table 5-7). Dry land cotton production is only profitable when the cotton price is greater than or equal to $0.65 per pound of lint.

Table 5-7: Total and per Acre Dry Land Net Returns for Different Prices of Cotton

Dry Land Returns	Price of Cotton			
	54 cents/lb	**50 cents/lb**	**60 cents/lb**	**65 cents/lb**
Net Returns above Variable Costs				
Returns per acre	$10	($6)	$33	$53
Total	$33,664,080	($19,375,920)	$113,224,080	$179,524,080
50-year NPV	$32,369,308	($18,630,692)	$108,869,308	$172,619,308

Dry Land Returns	Price of Cotton			
	54 cents/lb	50 cents/lb	60 cents/lb	65 cents/lb
Net Returns above Total Costs				
Returns per acre	($38)	($54)	($15)	$5
Total	($128,889,920)	($181,929,920)	($49,329,920)	$16,970,080
50-year NPV	($123,932,615)	($174,932,615)	($47,432,615)	$16,317,385

Source: Ghimire et al., 2012

The net return was also assessed for irrigated cotton. With a variable cost of $540 per acre and the fixed costs presented in Table 5-5, none of the four designs had a positive net return, that is, the cost per acre of the irrigation system is greater than the benefits from irrigated cotton. Irrigated cotton is only profitable if the fixed cost of irrigation is $200 or less per acre (Table 5-8). At a fixed cost of $200 per acre, the net benefits for the total 68,000 acres of land in the study area is $19,685,524.

Table 5-8: Aggregate Net Return of Irrigated Cotton

No of Pivots	Total Net Impact	Impact/acre
543	**$19,685,523**	**$289.49**

Source: Ghimire et al., 2012
Note: Results are for a fixed cost of $200 and variable cost of $540 (initial EC=1.5 and price of cotton= $0.54/lb)

It should be noted that the benefits shown in Table 5-8 are dependent on a fixed cost of irrigation of $200 per acre. The four designs of irrigation systems ranged from $304 to $533 per acre (Table 5-5). A fixed cost per acre of $200 for an irrigation system is an unlikely fixed cost. If any of the four designs of irrigation systems are considered, the cost of irrigating is higher than the benefits.

5.2.3 RED Benefits

The RED benefits were estimating using IMPLAN. In the With-Cable Mountain Reservoir scenario Kiowa and Tillman Counties were anticipated to benefit from an increase in irrigation. The IMPLAN model for this scenario was built using 2009 IMPLAN data for Kiowa and Tillman Counties in Oklahoma. The NED analysis estimated the benefits of the with-project condition for four levels of cotton prices. However, the costs of the irrigation systems were greater than the benefits. The study concluded if fixed costs were only $200 per acre, there would be a positive net return of $19,685,524. This net return represents the increase in cotton production after subtracting the total costs of that increased production. This NED benefit would have a regional benefit to the two counties the lands are located. This scenario was evaluated in the IMPLAN model. The net impact was input as a commodity change in the cotton sector. Table 5-9 presents the output from the model in 2012 dollars.

Table 5-9: RED Effects for With-Cable Mountain

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	119	$4,969,700	$7,741,700	$17,066,600
Indirect Effect	20.3	$747,600	$1,413,600	$2,785,800
Induced Effect	17.4	$482,100	$1,127,400	$1,803,700
Total Effect	**156.7**	**$6,199,300**	**$10,282,700**	**$21,656,100**

Total employment in the study area is estimated to increase by 156.7 jobs. Total labor income is estimated to increase by $6,199,300 and total output is estimated to increase by $21,656,100.

Table 5-10 shows the IMPLAN results for the With-Cable Mountain Reservoir scenario on a per acre basis. These per acre estimates can be used in future analysis as more information on the total irrigable acres becomes available.

Table 5-10: RED Effects for With-Cable Mountain per Acre

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	0	$73	$114	$251
Indirect Effect	0	$11	$21	$41
Induced Effect	0	$7	$17	$27
Total Effect	**0**	**$91**	**$151**	**$318**

The top five industries by employment affected by the change in cotton production are cotton farming, monetary authorities and depository credit intermediation activities, wholesale trade businesses, support activities for agriculture and forestry, and food services and drinking places.

It should be noted that the benefits in Tables 5-9 and 5-10 are dependent on a fixed irrigation system cost of $200 per acre. This cost is low compared to the irrigation system designs analyzed in the OSU study, and appears to be an unrealistic value compared to the range of $304-$533 fixed cost per acre of the four design systems analyzed. If any of the four irrigation system designs are implemented, the benefits of irrigation are lower than the costs and the total impact is negative in the study area in the With-Cable Mountain Reservoir scenario.

RED benefits can also be estimated for the effect of the change in variable costs. Farmers have an increase in expenditures when they switch from dry land cotton production to irrigated cotton production. This increase in expenditures is estimated by subtracting the dry land variable costs of $246 from the irrigable variable costs of $536 (Table 5-6). The difference of $291 was modeled as an industry change in IMPLAN to estimate the RED effect of the increase in farmers' expenditures (Table 5-11). These estimates are on a per acre basis and can be used in future analysis as more information on the total irrigable acres becomes available.

Table 5-11: RED Effects for Increase in Farmers' Expenditures per Acre

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	0	$85	$132	$291
Indirect Effect	0	$13	$24	$47
Induced Effect	0	$8	$19	$31
Total Effect	**0**	**$106**	**$175**	**$369**

The top five industries by employment affected by the change in cotton production are cotton farming, monetary authorities and depository credit intermediation activities, wholesale trade businesses, support activities for agriculture and forestry, and food services and drinking places.

5.3 Agricultural Risk and Uncertainty

There is risk and uncertainty associated with the RED benefits in Sections 5.1 and 5.2. At the time this report was completed, the OSU studies were currently in draft format. The RED impacts associated with the NED benefits in the With and Without-Cable Mountain Reservoir scenarios are subject to future changes and revisions in the OSU studies and could be higher or lower depending on finalization of the studies.

The With-Cable Mountain Reservoir indicates increases in irrigation would have positive impacts on the study area. However, these impacts are dependent on a set fixed cost of $200 per acre. This value is low compared to four designs of irrigation systems analyzed in the study. Actual RED impacts would be lower or even negative if an irrigation system with a fixed cost higher than $200 is implemented.

The OSU studies included costs of the irrigation systems. In the Without-Cable Mountain Reservoir analysis, the costs only included costs of the equipment and no costs of construction or labor. In the With-Cable Mountain Reservoir analysis, the costs included the costs of material, pipes, and labor, but did not separate out the cost of labor or construction. The initial construction of the irrigation systems would create a one-time impact to the study area during the period of construction. If these costs were separated from the cost of materials or added to the OSU studies, this would increase the RED benefits in the study areas.

6.0 NEXT STEPS

To complete the recreation study, more information is needed to determine whether Area VI of the RRCCP would affect the recruitment of striped bass. Historical data is needed which would link recruitment variability related to flow variability and accompanying variability in chloride concentrations. Another uncertainty which needs to be addressed is the expected impact from Cable Mountain Dam on the striped bass recreational fishery of Lake Texoma. Ecological modeling would need to be conducted to determine how the anticipated effects to water quality and flow in the Red River Basin from Cable Mountain Dam would affect the recruitment of striped bass in Lake Texoma. It is anticipated that the additional information would lead to a conclusion on whether Area VI of the RRCCP would affect recruitment and to what degree.

Once it is determined how the RRCCP may affect recruitment and ultimately the catch rate of striped bass in Lake Texoma, the NED results could be finalized. The catch rate elasticity would be used to determine how an anticipated change in the catch rate would affect the number of annual trips to Lake Texoma. Then, the WTP value would be used to value the change in recreational fishing. The RED results would need to be calculated based on the anticipated change in annual trips.

At the time of this report, the OSU agricultural studies were still in draft format. In the future, as these studies are finalized, the RED impacts would need to be revised and updated if any changes to the NED benefits are made.

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APPENDIX A

SCOPE FOR PHASE III

Appendix A: Scope for Phase III

Area VI Red River Chloride Control Study
Recreation Study Phase III
Scope of Work—FINAL
Contract No. W912BV-10-D-1000
Task Order No. 0004
July 2010

I. INTRODUCTION

The Area VI project will impact the water quality of the Red River, Elm Fork, OK tributary, and Lake Texoma by removing the naturally occurring chloride salts. By doing so, the water will be more suitable for municipal, industrial, and agricultural purposes. Though there is uncertainty in degree, the reduction of chlorides might change the water quality and turbidity of Lake Texoma in a way that will impact certain species of game fish. As a result, some anglers at Lake Texoma, those who sell goods and services to those anglers, resource agencies, and those with interests in local economic development have expressed concern about any changes to the fishery.

The USACE, Tulsa District (SWT) requires services to develop the baseline condition for Regional Economic Development (RED). This phase of economic evaluation of the project calls for an in depth analysis of:

a. RED in the Lake Texoma region related primarily to recreation.

b. RED in the Altus region (southwest Oklahoma and north Texas) related to the changes in agricultural practice.

c. National Economic Development (NED) for the future with project and future without project conditions. Discuss the elasticity of willingness-to-pay (WTP) or NED for different levels of the fishery.

In addition to this analysis, report should include tools for future evaluation done by The Army Corps of Engineers:

a. Working regional economic models for RED at both locations.

II. PURPOSE

SWT requires the application and analysis of the regional tools for contribution to final Corps decision documents (EIS and General Reevaluation Report) for the Area VI Red River Chloride Control Project. This scope-of-work is to identify the activities to be performed for this recreation study and the report that is due upon completion of this task order. All work conducted under this task order shall be in compliance with pertinent USACE Civil Works planning and recreational regulations. **The product of Phase III is a detailed analysis of RED at the Lake Texoma location and the agriculture area on the Red River, as well as an NED effect curve for the Texoma recreation area to be utilized later with the NED**

agricultural affect in the Red River area to determine the net impact on NED. The outputs of the analysis will be used with the outputs (both positive and negative) across all four accounts to determine the net benefits and costs of all alternatives.

- **Locations for RED analysis**

The RED affected area should include the counties surrounding Lake Texoma. Counties of direct contact to the lake and any county that theory suggests will be affected. Example of counties mostly affected by fisherman's expenses would be Bryan OK, Marshall OK, Johnson OK, Love OK and Grayson TX. The benefit of suitable water is deemed to be realized outside this region. Thus the only affects measured in the recreation study will be those of absent fisherman expenses due to any change in the habitat. The area will be further refined in coordination between the Corps and contractor.

The second area affected is the agricultural area set to benefit from the increase in suitable irrigation water in and around the Altus, Oklahoma Irrigation District. These areas are mostly around the Red River and Elm Fork River below Altus Dam. Tillman OK, Love OK, Cotton OK, Jefferson OK, Wichita TX, Clay TX are a few of the effected areas. This study area will also be refined in coordination between the contractor and the Corps.

III. ACTIVITIES

The contractor will perform the following activities for this phase:

Regional Economic Development Related Activities:

- **Evaluation of a RED model to be used at any level of expenditures**. Build and evaluate a workable model from the Corps approved model. Either IMPLAN or an IMPLAN based REAS model. Model should show the Tulsa District a change in Output, Income, Local Tax Revenue, and Employment due to a change in expenditures. Model must include household income and value added effects. Model needs to cover all direct, indirect and induced effects (type II multipliers). Model will need to use current expenditure effect to get its output and also be able to be changed for any additional expenditure effects.

- **RED Model presentation**. Present a model with current estimated expenditure affects. Suggested models are IMPLAN or REAS, which will accurately portray guided fishing as its own industry with its own spending patterns, or REAS. These models will need to be adapted to accommodate guided fisherman's unique spending pattern. Analysis needs to present the overall effect on the Region's economy based on the change in NED expenditures provided in Area VI Red River Chloride Control: Recreation Study Phase II. Model should be based on mathematics and be able to calculate for a variety of changes in the fisheries population. Model should provide, at a minimum:

i. Tax revenue effects. If there is information to attribute the loss to each particular city/county. Otherwise a general idea of total lost.
ii. A type of output measurement. (e.g. Gross Regional Product)
iii. Employment lost/gained. Direct: Employment for the particular industry (guided fishing). Indirect: Industries supplying that group/industry. Induced: ex. coffee pots and lodging.
iv. Income effect: median income

- **Oklahoma and Texas Agricultural Water Supply.** Use a regional economic model or a justified multiplier to evaluate the RED effect for the second agricultural region of Texas and Oklahoma in close proximity to the Red River. Examples of affected counties are: Tillman OK, Love OK, Cotton OK, Jefferson OK, Wichita TX, and Clay TX.

National Economic Development Activities:

- **NED with-out project conditions**. NED loss curve presenting the caliber of possible changes for Texoma recreation. Should report future with-out project and future with project conditions. Further analysis of different levels of WTP may be appropriate. Curve should evaluate all possible WTP scenarios to show the elasticity between catch rate loss and the value of the fishery at Lake Texoma from a total loss to a natural degradation loss. This may also include further econometric analysis for different WTP. Note: Actual biologist's information may be available, if not contractor will analysis as many as three possible scenarios.

Risk and Uncertainty Analysis. Confidence intervals around the new WTP point estimates to allow the presentation of a statistically-based range of possible WTP values for each evaluated recreational feature. Third risk item will need a confidence interval around each account of RED framework. Note and discuss all assumptions with the use of a regional model such as IMPLAN.

Independent Technical Review (ITR). ITR will be ongoing throughout the study. Contractor will provide for one presentation of the report to support SWT's Quality (QA) Assurance Program.

Meetings and presentations related to project. The Contractor shall be available for a kick-off meeting, mid-project progress review, and response to comments meeting. The Contractor shall also make one presentation of this report to support SWT's QA Program. One of these meetings shall be face to face, while others can be performed via teleconference.

I. DELIVERABLES

Draft and final reports are due upon completion of all work activities and they will include the following as a minimum:

Appendix A: Scope for Phase III

1. **Documents.** The contractor will provide two products; a detailed document reflecting the results of RED analysis at the hypothetical conditions including the discussion on NED curve; and working RED models adapted for this unique consumer.

The NED and RED documents will include:

- Discussion and theory behind adaptation of RED models.
- Description of the model specification and procedures.
- Descriptive and graphical presentations of the results.
- Copy of the database where the collected information is stored.
- Compare and contrast the two RED areas.
- Discussion of the risk and uncertainty in the NED curve and the results.

The RED model will include:

- Reference to the adaptive framework for the unique spending habits on an IMPLAN or REAS based model.
- Descriptive and graphical presentations of the results
- Any source reference on research of such consumer patterns.

2. **Electronic Files.** The contractor will provide electronic files containing data, report documents and executable files for both the document and working model.

The reports are to be generated in an electronic media compatible with Microsoft Office and the Corps' communications format. Modeling files will be in a format that is compatible with existing Corps software. The Initial Drafts shall include five (5) hard copies and the electronic versions. The Final Drafts shall include five (5) hard copies and the electronic versions.

3. **Status Report.** The contractor shall provide monthly status reports on the progress of the study. The reports can be e-mail messages providing a short description of the status of the task order work and any problems or delays that need to be addressed. Billing statements shall coincide with status reports to the POC.

II. MATERIALS AND SUPPORT PROVIDED BY SWT:

Corps will provide all relevant documents, data, maps and other information to the contractor. Informal briefings from SWT staff regarding current SWT activities planned or existing in the recreational study area are to be coordinated through the POC listed at end of this document.

III. SCHEDULE

Start work- No Later Than (NLT) 10 days following **Award**.

Initial Draft Report (5 hard copies and electronic copy) - [est.] 360days after **Award**

Appendix A: Scope for Phase III

SWT review of initial draft and return comments to contractor; draft document presentation by contractor takes place during this time. (via teleconference)—390 days after **Award**

Final report (5 copies and electronic copy) - [est.] 30 days after receipt of SWT initial draft report's comments.

IV. POC

The SWT representative will be: +
Tyler Henry.
Phone: 918-669-7001
Email: Matthew.T.Henry@usace.army.mil

Within 10 days of **Award**, the contractor shall provide SWT a contractor POC for this work.

APPENDIX B

MATERIAL FOR THE EXPERT-OPINION ELICITATION PANEL

Appendix B: Material for the Expert-Opinion Elicitation Panel

US Army Corps of Engineers
Tulsa District **BUILDING STRONG®**

Area VI Red River Chloride Control Study — November 18, 2011
Recreation Study Phase III — 8:00 a.m. – 5:00 p.m.
Expert-Opinion Elicitation Panel — Sherman, Texas

Draft Agenda

8:00 – 8:30 a.m.	Arrival	
8:30 – 8:45 a.m.	Welcome and Project Overview	*Tony Clyde/ Tyler Henry*
8:45 – 9:15 a.m.	Expert Panel and Observer Introductions	
9:15 – 9:30 a.m.	Agenda, Process, and Expected Outcome	*Jennifer Lavin*
9:30 – 9:45 a.m.	Recreation Study Presentation	*Andrea Bohmholdt*
9:45 – 10:30 a.m.	Comprehensive Aquatic System Model – Lake Texoma (CASM-LT) Presentation	*Steve Bartell*
10:30 – 11:00 a.m.	Open Floor for Project-Related Questions	
11:00 – 11:15 a.m.	*Break*	
11:15 a.m. – 12:00 p.m.	Questions for Consideration Regarding Estimation of Future Angler Catch Rates Using CASM-LT Model Output	
12:00 – 12:30 p.m.	*Lunch*	
12:30 – 3:00 p.m.	Continuation of Discussion and Establishment of a Metric to Calculate Average Catch Rate per Year	
3:00 – 3:15 p.m.	*Break*	
3:15 – 3:45 p.m.	Open Floor for Discussion-Related Questions	
3:45 – 4:45 p.m.	Expert Panel Conclusions	
4:45 – 5:00 p.m.	Closing Remarks and Next Steps	*Tony Clyde/ Tyler Henry*

Appendix B: Material for the Expert-Opinion Elicitation Panel

US Army Corps of Engineers
Tulsa District BUILDING STRONG®

Project Overview

The U.S. Army Corps of Engineers (USACE), Tulsa District (SWT), is conducting a reevaluation of the Congressionally authorized Area VI project designed to reduce chlorides that the Elm Fork contributes to the Red River's North Fork. The chlorides impact the water quality of the Red River, Elm Fork, the Oklahoma tributary, and Lake Texoma. The purpose of the Red River Basin Chloride Control Project is to reduce naturally occurring chlorides that limit or preclude the use of Red River waters for municipal, industrial, or agricultural purposes.

The project involves reevaluating Area VI alternatives, costs, benefits, and cumulative impacts to the environment, which include the impact on recreation due to changes in chloride levels in Lake Texoma and the entire Red River Basin. In accordance with USACE regulations, SWT is conducting the Area VI Red River Recreation Study to address the potential socioeconomic impacts of changing chloride levels in the Red River Basin.

As part of the reevaluation, SWT is assessing how a change in chloride levels would affect the recreational fishery of Lake Texoma. The reduction of chlorides could change the water quality of Lake Texoma in a way that could impact certain species of game fish, though to what degree is uncertain. Of particular interest to the Recreation Study is striped bass fishing on Lake Texoma, which is considered some of the best in the country and draws people from all over the United States. The Recreation Study will address how a change in the catch rate of striped bass would affect the recreational fishing industry on Lake Texoma.

The Area VI Red River Recreation Study has three phases:

- Phase I was completed in September 2007 and defined the recreation study area, identified potential impacts on recreational activities, inventoried existing recreational opportunities, and developed the survey instrument and economic valuation methods necessary to support Phase II.
- Phase II was completed in December 2009 following telephone surveys and econometric analyses to develop lower-bound, upper-bound, and most-likely willingness-to-pay (WTP) estimates for the striped bass fishery (the report is still under review).
- Phase III will provide an analysis of how Area VI would affect National Economic Development (NED) and Regional Economic Development (RED) in the Lake Texoma region, primarily as they relate to recreational fishing.

Understanding angler catch rates at Lake Texoma is essential to the completion of the Recreation Study. To help bridge the gap between information that currently exists and what is needed to complete Phase III of the Recreation Study, an expert-opinion elicitation process is being employed. The expert-opinion elicitation will estimate the change in angler catch rates for striped bass resulting from changes in water quality.

Appendix B: Material for the Expert-Opinion Elicitation Panel

Relevant Studies

Evaluation of Chloride Management Alternatives: Application of the Comprehensive Aquatic System Model to Lake Texoma

The Comprehensive Aquatic System Model was adapted to simulate the ecosystem of Lake Texoma (CASM-LT) in order to assess the potential impacts of chloride management alternatives on light availability, primary production, and food web dynamics for selected locations within Lake Texoma. Specifically, the CASM-LT forecasts changes in the striped bass populations in Lake Texoma in relation to chloride management.

The principal modeling objectives were to:

- Develop a Lake Texoma version of the CASM that simulated ecological production dynamics of producer and consumer populations consistent with measured production
- Use the Lake Texoma CASM to examine the potential food web implications of alternative chloride management scenarios
- Examine the responses of modeled populations to chloride management in relation to annual environmental variability and longer-term loss of storage capacity of this larger reservoir

The important hypothesis concerning chloride management in Lake Texoma is that reduced chloride would lead to decreased sedimentation rates, increased turbidity, and reductions in primary productivity. Decreased primary production is anticipated to propagate throughout the Lake Texoma food web and ultimately reduce populations of striped bass. An additional contention is that alteration of light availability might promote the growth of *Prymnesium parvum*.

Area VI Red River Chloride Control: Recreation Study Phase I Report

Phase I refined the recreation study area, discussed potential recreation activities affected by the project, inventoried existing recreation opportunities, developed economic valuation methods, and developed a survey instrument to be used in Phase II of this project. The Study Area was defined using fishing license sales data for Lake Texoma.

The inventory of recreational opportunities was facilitated by geographic information systems and interviews with USACE, lake managers, and local stakeholders. Recreational features inventoried focused on area lakes in Texas and Oklahoma. This inventory served to highlight the uniqueness of Lake Texoma, considering its size, location within the United States, and its use as a recreational sport fishery. The ability for striped bass to reproduce naturally and sustain a thriving population is perhaps the lake's most unique feature.

Evaluating the economic impacts through a telephone survey was determined to be the best method for estimating anglers' reaction to any potential changes in the recreational fishery.

Appendix B: Material for the Expert-Opinion Elicitation Panel

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URS Group, Inc. (URS), USACE's contractor for the study, developed a telephone-based survey instrument based on discussions with USACE, lake managers, local stakeholders, and data collected. The survey instrument incorporated elements of both travel cost method (TCM) and contingent valuation method (CVM) to determine the economic impact of proposed changes to the recreational fishery. The survey was designed to capture angler WTP for changes in fish catches.

Two valuation methods, TCM and CVM, and several limited dependent variable econometric models were presented as means for determining the economic benefits associated with alternative recreational opportunity enhancement plans. The theoretical and data-generating structure of these methods enabled calculation of the economic benefits associated with recreation on Lake Texoma. Moreover, application of these valuation methods permitted an economic comparison of alternative enhancement plans.

Area VI Red River Chloride Control: Recreation Study Phase II Report

Phase II included survey implementation, statistical and econometric analysis of the completed survey questionnaires, and a risk and uncertainty analysis of the WTP estimates. Econometric analyses using Tobit models were performed to develop lower-bound, upper-bound, and most-likely WTP estimates for the striped bass fishery. The user population was estimated to be 101,000 anglers on Lake Texoma per year based on information collected from Oklahoma and Texas. Estimates from Phase II are preliminary and subject to change during the review process. All information pertaining to Phase II should be treated in a confidential manner until the final report is released publically.

Overview of the Expert-Opinion Elicitation Process

Expert-opinion elicitation is a formal process for capturing judgment or opinion from a panel of recognized experts regarding a defined problem. The value of expert-opinion elicitation comes from its intended use as a heuristic tool for exploring vague and unknown issues. In this case, expert-opinion elicitation will be performed during a face-to-face meeting of a panel of experts constituted specifically to address issues defined by a team of analysts. The results of the expert-opinion elicitation are intended to supplement the overall study.

The following panelists have agreed to participate and to be queried about their opinions related to future angler catch rates:

- Michael Shawn Allen, Ph.D.(Fisheries Management and Statistics), Professor at the University of Florida
- Brian D. S. Graeb, Ph.D. (Biological Sciences, Fishery Science Specialization), Assistant Professor at South Dakota State University
- John Richard Jones, Ph.D. (Zoology, Limnology Specialization), Chair, Department of Fisheries and Wildlife Sciences, University of Missouri

- John Van Conner Ph.D. (Biology), Senior Consulting Ecologist, URS

Observers representing the USACE, United States Fish and Wildlife Service, Oklahoma Department of Wildlife Conservation, and Texas Parks and Wildlife Department and others who are fisheries management experts for Lake Texoma have been invited to participate in the expert-opinion elicitation process. Observers are envisioned to provide guidance to the panel of experts and answer questions related to both the sport and non-game fisheries present at Lake Texoma.

All reports and information provided to the experts and observers as part of the expert-elicitation process which have not been released publicly should be considered confidential. Dissemination, distribution, or copying of the reports, information, or findings of the expert panel is prohibited.

Expected Outcome of the Expert Panel

Understanding angler catch rates at Lake Texoma is essential to the completion of the Area VI Red River Chloride Control Recreation Study. The CASM-LT was adapted to simulate the ecosystem of Lake Texoma in order to forecast changes in striped bass populations resulting from chloride management. Further discussion is required to link CASM-LT model results with anticipated changes in fishing catch rates of striped bass resulting from chloride management.

The CASM-LT focuses on the food web implications of reductions in total dissolved solids (TDS) as the result of chloride management, particularly the effect on the production of striped bass. The assembled panel of experts will use CASM-LT model output to estimate future angler catch rates at Lake Texoma based on a range of potential chloride, sulfate, and TDS concentrations (see Table B-1 and Table B-2).

Table B-1: Average Annual Concentrations, Upper Lake Texoma (mg/l), Gainesville Gage

	Natural Conditions	Lower Bound
Chloride	973	732
Sulfate	525	444
TDS	2,465	1,945

Table B-2: Average Annual Concentrations, Lower Lake Texoma (mg/l), Denison Gage

	Natural Conditions	Lower Bound
Chloride	338	254
Sulfate	229	198
TDS	985	799

The expert panel will establish a metric to calculate the average estimated catch rate per year based on the most appropriate indicator available. The results of the expert-opinion elicitation will be documented in a summary report and incorporated into Phase III of the Recreation Study.

APPENDIX C

BIOGRAPHIES OF EXPERTS

Appendix C: Biographies of Experts

The expert panel consisted of four experts in their respective fields: Micheal Shawn Allen, Ph.D., John Van Conner, Ph.D., Brian D. S. Graeb, Ph.D., and John Richard Jones, Ph.D. Biographies of each panel member are provided below.

Micheal Shawn Allen, Ph.D. Professor, University of Florida
Dr. Allen has been teaching at the University of Florida since 1997. His research program addresses fish population and community responses to changes in fishing mortality, habitat, and species interactions. He has worked on a variety of fish and fisheries issues in lake, reservoir, river, and marine environments. His approach utilizes a combination of field collections and population modeling to predict how fish populations respond to fishing regulations and variation in habitat quantity and quality. Dr. Allen has a doctorate degree is fisheries management and statistics, a master's degree in fisheries management, and a bachelor's degree in fisheries ecology.

John Van Conner, Ph.D. Senior Consulting Ecologist, URS
Dr. Conner has more than 43 years of experience in consulting, environmental management, research, and teaching. His direct experience includes management and technical direction of regulatory compliance programs; regulatory review/interpretation; impact assessments and siting studies for a variety of development projects; CERCLA, RCRA, and state superfund site assessment (RI/FS ecological risk); field ecological research and teaching at two state universities. Areas of expertise include aquatic ecology, fishery biology, wetland ecology, National Environmental Policy Act siting studies, and natural resource damage assessment. Dr. Conner possesses a doctorate degree in biology, a master's degree in fisheries science and a bachelor's degree in wildlife management and journalism.

Brian D. S. Graeb, Ph.D. Assistant Professor, South Dakota State University
As a fisheries ecologist, Dr. Graeb employs ecological theory and approaches to answer management questions. His research ranges from basic (e.g., foraging ecology) to applied (e.g., harvest regulation evaluation) and from controlled experiments to observational research, but are generally linked in a larger context. Dr. Graeb has many interests in fisheries ecology, many of which pertain to factors affecting populations (particularly recruitment and mortality of fishes), communities (e.g., food web ecology), and landscapes

and ecosystems (e.g., the influence of large reservoirs on riverine landscape). Integration of information across multiple scales allows Dr. Graeb to build models to better predict effects of management actions and to better understand ecological processes. Dr. Graeb has a doctorate degree in biological sciences with a fishery science specialization, a master's degree in natural resources and environmental sciences and a bachelor's degree in fishery biology.

John Richard Jones, Ph.D. Chair, Department of Fisheries and Wildlife Sciences, University of Missouri
Dr. Jones has been a professor of limnology since 1975. He is known for his work on algal-nutrient relationships in lakes and streams and how land cover and other factors determine the trophic state of Missouri reservoirs. These findings, developed with Midwest data, were compared with a broad range of lakes, from those influenced by the Asian monsoon to pristine lakes in Alaska and Minnesota, to assess the generality of the patterns. Additional work quantified the frequency and duration of algal blooms in Missouri reservoirs and determined the likelihood of these extreme events to produce natural toxins. In 2008, he was honored as a Senior Fulbright Fellow to teach in Nepal. With over 125 publications, Dr. Jones has been associate editor of the Journal of Lake and Reservoir Management Editor-in-chief of Inland Waters the new journal of the International Society of Limnology. Dr. Jones possesses a doctorate and master's degree with major in zoology (limnology) and minor in water resources, and a bachelor's degree with major in biology and minor in chemistry.

APPENDIX D

EXPERT-OPINION ELICITATION PANEL MEETING NOTES

Appendix D: Expert-Opinion Elicitation Panel Meeting Notes

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Area VI Red River Chloride Control Study
Recreation Study Phase III
Expert-Opinion Elicitation Panel
Notes from meeting on November 17, 2011, in Sherman, Texas

Attendees

Name	Position/Organization	E-mail
Expert Panelists		
Micheal Shawn Allen, Ph.D.	Professor, University of Florida	msal@ufl.edu
Brian D. S. Graeb, Ph.D.	Assistant Professor, South Dakota State University	brian.graeb@sdstate.edu
John (Jack) Richard Jones, Ph.D.	Chair, Department of Fisheries and Wildlife Sciences, University of Missouri	jonesj@missouri.edu
John Van Conner, Ph.D.	Senior Consulting Ecologist, URS	john.conner@urs.com
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Facilitator		
Jennifer Lavin	URS	jennifer.lavin@urs.com

Summary

Based on the information presented to the experts, it was agreed that chloride management is not anticipated to have a measurable effect on the adult striped bass population in Lake Texoma. However, a key uncertainty is whether the chloride project would influence recruitment of striped bass. If chloride management influences the recruitment of striped bass, then fish abundance and ultimately fishing effort would also be affected. More information is needed to determine if the change in flow and conductivity from chloride management could affect the recruitment of striped bass. Angler behavior and the catch rate is influenced by complex interactions including fish behavior (e.g., schooling) and fishing method (trolling versus casting), and thus, angler catch rate is not expected to be directly related to fish abundance. A minor to moderate change in fish abundance is not likely to influence the angler catch rate of striped bass. It is expected that anglers will adapt to changing conditions to maintain their catch rate. However, a declining population over time would influence the catch rate.

Presentations

- Expert–Opinion Elicitation Process, Jennifer Lavin
- Comprehensive Aquatic System Model - Lake Texoma (CASM-LT), Steve Bartell
- Overview of the Recreation Study, Andrea Bohmholdt

Discussion Topics

Characteristics of Lake Texoma

- Striped bass have been reproducing naturally in Lake Texoma since 1974.
- According to the 1999 Survey Report for Lake Texoma (Hysmith et. al., 2000), approximately 200 guides operate on Lake Texoma, and guided trips account for about 60 percent of the directed effort for striped bass. The fish per acre harvested ranges between 5.3 (55 percent effort) and 13.9 (66 percent effort), with an average of 9.6 fish harvested per acre per year. Catch per unit effort averages 11.6 from gill netting.
- A Lake Texoma fishing license is affordable, only $12 per year.
- Currently, there is no evidence that striped bass are being over-exploited.
- Future reallocation of water for other purposes is not likely, however increased use of existing allocations of water is anticipated in future with-project conditions.

Suggestions for improvements to the CASM-LT

- CASM-LT worked to establish a food web and the connectivity of the food web to chloride changes, but additional information could improve the model.
- Link CASM-LT output with Creel Study results (Hysmith et. al., 2000) to test whether the striped bass biomass in the CASM-LT suggest reasonable rates of exploitation.
- Linkage between biomass and recruitment trends.
- Link flow and concentration regimes to recruitment.

- Compare Downing meta-analysis paper that links fish biomass and productivity to CASM-LT results (Downing, 1999).
- Using existing information:
  1) Compare the rates of recruitment to inter-annual changes in flow using historical recruitment records and flow data. Develop relationship between flow and recruitment.
  2) Compare the CASM-LT predicted recruitment to the observed recruitment. Test whether the model is sufficiently capturing the magnitude and variability of recruitment, the correct pattern of peaks and troughs, and whether the timing is synchronous.

Mixed water column

- Chloride management is expected to cause minor changes in mineral turbidity in the mixed water column that is probably negligible to primary production in the reservoir. There can actually be fairly high chlorophyll concentrations in waters that are fairly brown, if they are mixed.
- Where does the water with the highest salinity enter, and does it plunge along the bottom? Are these solids really delivered below the photic zone, and if so, what difference does it make if the water that comes into the reservoir plunges below the chemocline, which is fairly characteristic?
  - There is a plunge point in the Red River; in the Washita River it is not as pronounced, but there is a definitive plunge point in the Red River Arm and it has been moving down reservoir as sedimentation has increased over time.
  - What you generally see in Lake Texoma, from a plunge point vertical salinity gradient, is that water plunges as it comes into the reservoir.
  - The chemocline is based on minute difference in pH and conductivity, with increases in conductivity as you cross the chemocline. Hydrology from the main stem of the reservoir drives a lot of what's going on in Lake Texoma. In low flow years, the densities across that chemocline are dependent on salinity gradients, and they are very small. In high flow years, a thermal gradient stabilizes the chemocline. Salinity core temperature drives stability.
- The spatial gradient is distinct; it is highest in the Red River arm, then decreases in the transition zone, and decreases even further in the main lake body. It increases a little bit in the Wichita River and stabilizes there, which is a function of mixing (figures and maps were shown and explained).
- If you change the salinity, there would be an increase in suspended solids, based on settling rates in a beaker. When there is a real suppression in algal biomass per

nutrient and light etc., it's episodic in strength. If you have a mixed water column, modest levels of turbidity and higher levels of inorganic suspended solids in your system may not be a factor. However, if you have internal wind-driven maintenance of suspended solids, you may not be able to discern a change in mineral turbidity in Lake Texoma even though you've changed the salinity.

- It is not expected that this minor change in chloride is going to change inorganic suspended solids.

Climate change

- The CASM-LT does not account for climate change. In 2006, the effort began to adapt the CASM to Lake Texoma, and at the time, regional climate change modeling was not available for Oklahoma and Texas.
- There may be opportunities to include the effects of climate change in the model, depending on funding.
- Future changes to Lake Texoma could result more from climate change than chloride management.
- Expected impacts from climate change: western Oklahoma is predicted to be drier; less frequent weather events but more precipitation in any single event.

Population of striped bass in Lake Texoma

- The CASM-LT forecasted minimal effects on the aquatic populations in Lake Texoma, using a range of 4 to 16 percent reductions in daily total dissolved solids (TDS) concentrations, which is a broader range than what is expected from chloride management. The impacts on the striped bass population resulting from chloride management are expected to be minimal.
- Egg/larval development in fish can be sensitive to changes in salinity. Because the project could alter salinity, more information is needed to assess the impacts of chloride management on striped bass recruitment at the system.
- On Lake Oahe, a reservoir on the Missouri River, there was a crash of the walleye population in one of the worst-case scenarios, and it turns out that the biomass or population of the predator wasn't as important for catch rates as to the abundance of prey. If the prey went away, it didn't matter if biomass was high or low, catch rates would go up substantially (Graeb, 2008).
- There is a strong link between predator and prey in Lake Texoma; however, chloride management is not expected to impact the abundance of primary prey.
- Based on CASM-LT, the change in chloride is going to have such a small influence on total suspended solids (TSS) as to not change primary productivity.

- It is not expected that the gizzard shad or threadfin would be influenced by chloride management activities.
- At some point, the recreational fishery would be affected if there is an impact on the standing stock of striped bass, but it is uncertain whether this would occur.
- As sediment increases over time, the volume of the lake will decrease, which will ultimately have a negative impact on the striped bass population.

Effect of flow and salinity concentrations on striped bass recruitment

- Information provided by Tony Clyde: Flow information for the Carl gage on the upper Elm Fork and the Headrick gage on the North Fork: under existing conditions, 26 days had less than or equal to 0 cubic feet per second (cfs) flow and 397 days had less than or equal to 1 cfs flow; with condition 5 (implement all plans & irrigation), 616 days had less than or equal to 0 cfs flow out of 16,436 total modeled days, and less than or equal to 1 cfs flows increased from 397 to 947.
- The critical area for striped bass spawning is 40 to 60 miles upstream of Lake Texoma.
- There is a relationship between flows (which transport young) and salinity (which facilitates egg buoyancy) for striped bass recruitment.
- The salinity level of Lake Texoma has not changed significantly over time.
- Information is available from State agencies regarding rate of recruitment in any given year, annual gill net catches, catch per effort, and age classes and size classes for various species, including striped bass.
- Recruitment seems to be more affected by flow than salinity.
- April is when flow is the most critical to striped bass recruitment.
- Low flow and high flow can both be detrimental; moderate flow tends to result in successful year classes.
- According to an FAO Manual (Setzler, 1980), reproduction of the species requires a flow of 1 foot per second and 50 miles of unimpeded waterway before reaching the reservoir (TPWD stated).
- Low flow tends to lead to higher salinity concentrations, and high flow leads to lower salinity concentrations.
- Chloride management alternatives being evaluated by the USACE would not significantly change the flow in the Red River. However, the construction of Cable Mountain Dam could impact the flow in the Red River.
- If the project was implemented and the striped bass fishery was negatively affected by chloride management, adaptive management techniques could be employed to lessen the impacts.

Fishing effort and angler catch rate

- It is anticipated that the average angler catch rate would remain high or unchanged across a moderate change in fish abundance because experienced anglers can find the schooling fish. The experienced anglers would keep returning; however, some of the inexperienced anglers may drop out. Thus, total effort could change even if average angler catch rate does not. Angler catch rate therefore may not reflect adult fish abundance.
- Even with a strong year class, other factors can affect the catch rate, such as number of hours spent fishing and temperature (e.g., a hot summer may lead to a reduced number of trips).
- The existing data from the creel study for total effort and how effort relates to strong year classes that have happened in the past should be evaluated to look for trends in effort in response to changes in fish abundance (via gill net surveys or other indices).
- Generally, there is a strong relationship between effort and the number of fish harvested, because one leads to the other.
- Lake Texoma is the type of fishery where effort tends not to change much. According to the Creel Study, the data are fairly consistent from one year to the next.

Conclusions and Suggestions

- The consensus of the group was that the implementation of Area VI would have negligible impacts on the adult striped bass population based on the CASM-LT model, and given the lack of relationship between angler cpue and effort, there probably won't be an impact from a modest change in angler catch rate of striped bass.
- The potential impact on recruitment from chloride management needs to be analyzed in more detail. Empirical data are needed from State agencies. Data are needed for hydrology, salinity, turbidity, and productivity.
- Characterize the flow and salinity in years that have above-average and below-average striped bass recruitment to see if a potential changes in chloride could cause a shift from a good year to a bad year.
- See if there is a relationship between effort and biomass, based on the information available. If not, estimate biomass and track effort.
- Whether the fish abundance will change the catch rate is really site specific. There are several examples where fishing effort doesn't respond to changes in abundance (e.g., fisheries near population centers), and those where fishing effort is very responsive to changes in abundance (e.g., fisheries where anglers have many alternate sites to

choose from). Thus, there is a need to identify how changes in striped bass abundance influence fishing effort at this system. Evaluate fishing effort relative to adult striped bass abundance indices.

- There are subtle variances within Lake Texoma; we don't know if the subtle historical variance is strong enough to indicate the overall scenario is valid, but probably not. What we're talking about is an alteration of the system so minor that it could not be discerned in any of the monitoring data collected. The only caveat is that we don't understand the role flow and salinity management might be on the recruitment of the fish, and that might be the biggest question that we face today.
- This is a very resilient fishery and you may never be able to distinguish the impacts from Area VI from variation in other natural conditions. Jack explained that the changes in hydrology probably cannot be measured by typical monitoring.
- Fish can live in quite varied salinities until the point where they definitely could be physiologically stressed. However, it doesn't sound like the salinity changes that are being explored are approaching those for the other parts of the life stages.

Next Steps

- The expert panelists will review existing information available and evaluate whether further analysis is required. If all are comfortable with existing information, scenarios will be identified for the economic modeling.
- USACE will take the lead to obtain data from State agencies and share information to bridge data gaps. Information obtained will be shared with the experts to get feedback and direction on scenarios.

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Additional Information Provided by Attendees after the Meeting

- Information provide by Bruce Hysmith, TPWD:
  - Recruitment is more affected by flow than salinity; however, enough salinity must be maintained to insure adequate buoyancy of the striped bass eggs as they travel downstream at approximately 1 foot per second. High flows (greater than 1 foot per second) could transport the eggs to slack water in the

upper reservoir before incubation is complete thereby requiring some salinity to maintain their buoyancy until they metamorphose into motile larvae (fry). Other aquatic organisms benefit from the elevated salinity in Red River/Lake Texoma even though they have different spawning requirements.

- Information provided by Matt Mauck, ODWC:
  - Texoma is well known for quality black bass (largemouth and smallmouth), trophy catfish, as well as, white bass, crappie, and other common species. Texoma has hosted several Oklahoma state record smallmouth bass and blue catfish as well as a former world-record blue catfish.
  - A big part of the Texoma angler draw is the ability to catch many fish.
  - Catch per unit effort averages 19.3 from gill netting using data from 1993 to 2011.
  - Flow requirements may vary slightly with egg size.
  - Percent of hours seeking striped bass is fairly consistent; however, angler visits can be quite variable among years.