FUNDING WATER UTILITY SYSTEM IMPROVEMENTS IN RURAL BRITISH COLUMBIA: HOW MUCH ARE RESIDENTS WILLING TO PAY?

by

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DEDICATION

This thesis is dedicated to my friends, family, and most importantly to my son, Travis. Thank-you all for your support and inspiration during this process.

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The generous contributions of individuals and organizations both internal and external to Thompson Rivers University have helped make the completion of this thesis a reality. The guidance, inspiration, and encouragement from Dr. Peter Tsigaris, my thesis supervisor, was invaluable and I wish to thank him, sincerely.

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Finally, I would like to acknowledge those who assisted me during the survey testing phase, as well as the residents of Savona who provided thoughtful and meaningful information during survey enumeration.

ABSTRACT

Water delivered by the Savona, BC utility system routinely fails to meet quality standards mandated by Health Canada resulting in extensive water quality advisories and boil water notices. By analyzing socioeconomic attributes such as household income and family size, in combination with environmental factors associated with water quality, the willingness to pay for improvements to the community delivery system was estimated. Using the contingent-valuation survey method, we determined that the majority of residents were unwilling to pay to improve municipal water quality and those that were willing, will on average pay an additional $8.36 in monthly fees. The presence of children in a household, income, and gender had a large impact on the probability that an individual would be willing to pay while the perception of water quality was less influential.

Key words: Contingent-valuation, averting expenditure, water utility, willingness to pay, water quality.

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LIST OF SYMBOLS

$\chi 2$	Chi-Square
ln	Natural Logarithm
π	Logit of Dependent Variables
β	Coefficient
ε	Error Term
R^2	Coefficient of Determination
P	Probability of Obtaining Significant Test Statistic

LIST OF DEFINITIONS

Anthropogenic factors: Consequences of human activities such as factory effluent that impact the quality of groundwater or surface water sources.

Bidding games: Also know as the iterative bidding method. This method provides a series of responses in either ascending or descending order and respondents then select multiple bids until their maximum WTP is reached.

Binary Logistic Regression: A statistical analysis technique that uses the natural logarithm of an odds ratio to determine the distribution of a dichotomous outcome.

Bounded Rationality: This concept is based on the notion that individuals make decisions on a limited amount of information and cannot arrive at an optimal solution. To reduce error in statistical analysis, bounded-rationality questions are used to determine consumer preferences rather than absolute values.

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Cross-Validation: Technique for assessing how the results of a statistical test apply to a data set. It is used mainly to predict the accuracy of a statistical model or hypothesis.

Cultural capital: A non-financial social asset.

Econometric: Quantitative statistical tool used in the analysis of economic relationships.

Embedding Effect: Error in statistical analysis concerning studies in environmental economics. Occurs when complimentary and substitute relationships with other government policies cause overlap in a contingent valuation study. I.e. Previous policies have influenced how people feel about the good in question.

Environmental economics: The empirical and theoretical analysis of economic impacts on environmental policy.

Environmental goods: Include clean air, clean water, biodiversity, landscapes, park space, etc.

Equity: Equity as it applies to the principle of fairness in the market place. Does not necessarily mean equal in a numerical or monetary context.

Externality: A cost or benefit incurred by a party that was not involved in the instigating market transaction.

Hedonic Price Method / Hedonic Regression: A method of estimating value or demand for goods that are not bought or sold in traditional markets. Values are derived by breaking the good or service down into its various characteristics and estimating the value of those characteristics based on existing market values. An attribute vector is then assigned to each characteristic or group of characteristics and regression is performed. Hedonic regression analysis can accommodate non-linearity, variable interaction, and other more complex scenarios.

Hypothetical bias: Occurs due to the hypothetical nature of surveys and WTP scenarios.

Iterative Bidding Method: Mathematical method using successive approximations to determine the solution to a problem beginning with an initial guess.

Log-Linear Hedonic Function: Uses the base of natural logarithms of quantifiable variables and approximates results using a linear equation to determine WTP for non-market goods.

Market Externality spillovers: Occur when consumers outside of a transaction for the sale of a good or service are affected by the transaction. These include positive and negative externalities. Negative Example: Pollution from a copper smelter lowers air quality in a neighbouring municipality. Positive example: Bee keeper harvests honeys but bees pollinate surrounding crops increasing yields for other local farmers. The goal of correcting spillovers is to internalize the externality. Example: Farmers pay bee keeper a fee based on yield increase.

Market research: An organized effort to gather information about markets and customers.

Multivariate Regression Model: Encompasses the simultaneous observation and analysis of more than one statistical variable. Used in a variety of different models and disciplines.

Non-Market Goods: Goods or services that do not have an established monetary value in the market place. Example of market good = camera or oil change. Example of non-market good = value of biodiversity in provincial parks. Contingency valuation surveys and hedonic regression are two types of econometric tools used in the valuation of non-market goods.

Open-ended: Responses to questions are provided through no means other than the explicit expression provided by the respondent.

Opportunity cost: The cost of a good as it relates to alternative mutually exclusive good and service choices.

Ordered Probit Model: Used in statistics to determine values for ordinal multinomial dependent variables. In regression analysis, the ordered probit model ranks and gives weight to the dependent variables in relation to the impact on the independent variables based on probability theory.

Ordinary least-squares: A statistical method of estimating unknown or exogenous parameters in a regression model. The method reduces the sum of squared distances between observations in a data set, and the fitted responses from a regression model.

Outliers: An observation in statistical analysis that is distant from the rest of the data. Outliers can be accurate observations but are often a measurement of error or indication of a heavy-tailed distribution. The method of least squares can be used to approximately solve for outliers and is often used in regression analysis.

Personal Preferences: Determine willingness to pay for a specific quantity of a good and is used in determining consumer surplus or utility.

Public Good: A good or service that is non-rival and non-excludable.

Rationality: Question format for the Contingent Valuation method. The rational decision is optimal and rational individuals act optimally to pursue goals. The debatable topic is whether or not people are actually “rational” and the impact of asymmetric information on their decision making. Bounded-rationality attempts to correct for errors associated with rationality.

Regression model: Statistical technique for analyzing relational causation between a dependent variable and one or more independent variables through experimentation.

Social benefits: Related to social welfare and the improvement of well-being based on individual needs.

Starting-point bias: Occurs when an individual’s response is influenced by the order and manner in which questions are presented.

Strategic bias: Occurs when a survey respondent believes they can influence policy decisions by providing a skewed and inaccurate response to a question.

Supply and demand theory: Economic model of determination that attempts to find equality between the quantity of a good produced and its price in the market.

Symbolic Capital: The resources available to consumers on the basis of honour, prestige, or recognition as it relates to cultural values. It typically cannot be converted to economic capital. Example: Sacred cattle in Hinduism are maintained for religious purposes, not economic or subsistence.

Water Quality: The physical chemical and biological properties of water that impact its usability as a natural resource for a variety of different uses.

Water Quantity: The amount of water that is available at a particular location.

Willingness to pay: The maximum amount an individual is willing to pay for a good or service based on their socioeconomic status and personal preferences and attitudes. The MWTP aids economists in determining net benefits to the consumer.

World Bank: An international financial institution that provides capital to developing countries in order to leverage investment in poverty reduction and trade.

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LIST OF DEFINITIONS

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Econometric: Quantitative statistical tool used in the analysis of economic relationships.

Embedding Effect: Error in statistical analysis concerning studies in environmental economics. Occurs when complimentary and substitute relationships with other government policies cause overlap in a contingent valuation study. I.e. Previous policies have influenced how people feel about the good in question.

Environmental economics: The empirical and theoretical analysis of economic impacts on environmental policy.

Environmental goods: Include clean air, clean water, biodiversity, landscapes, park space, etc.

Equity: Equity as it applies to the principle of fairness in the market place. Does not necessarily mean equal in a numerical or monetary context.

Externality: A cost or benefit incurred by a party that was not involved in the instigating market transaction.

Hedonic Price Method / Hedonic Regression: A method of estimating value or demand for goods that are not bought or sold in traditional markets. Values are derived by breaking the good or service down into its various characteristics and estimating the value of those characteristics based on existing market values. An attribute vector is then assigned to each characteristic or group of characteristics and regression is performed. Hedonic regression analysis can accommodate non-linearity, variable interaction, and other more complex scenarios.

Hypothetical bias: Occurs due to the hypothetical nature of surveys and WTP scenarios.

Iterative Bidding Method: Mathematical method using successive approximations to determine the solution to a problem beginning with an initial guess.

Log-Linear Hedonic Function: Uses the base of natural logarithms of quantifiable variables and approximates results using a linear equation to determine WTP for non-market goods.

Market Externality spillovers: Occur when consumers outside of a transaction for the sale of a good or service are affected by the transaction. These include positive and negative externalities. Negative Example: Pollution from a copper smelter lowers air quality in a neighbouring municipality. Positive example: Bee keeper harvests honeys but bees pollinate surrounding crops increasing yields for other local farmers. The goal of correcting spillovers is to internalize the externality. Example: Farmers pay bee keeper a fee based on yield increase.

Market research: An organized effort to gather information about markets and customers.

Multivariate Regression Model: Encompasses the simultaneous observation and analysis of more than one statistical variable. Used in a variety of different models and disciplines.

Non-Market Goods: Goods or services that do not have an established monetary value in the market place. Example of market good = camera or oil change. Example of non-market good = value of biodiversity in provincial parks. Contingency valuation surveys and hedonic regression are two types of econometric tools used in the valuation of non-market goods.

Open-ended: Responses to questions are provided through no means other than the explicit expression provided by the respondent.

Opportunity cost: The cost of a good as it relates to alternative mutually exclusive good and service choices.

Ordered Probit Model: Used in statistics to determine values for ordinal multinomial dependent variables. In regression analysis, the ordered probit model ranks and gives weight to the dependent variables in relation to the impact on the independent variables based on probability theory.

Ordinary least-squares: A statistical method of estimating unknown or exogenous parameters in a regression model. The method reduces the sum of squared distances between observations in a data set, and the fitted responses from a regression model.

Outliers: An observation in statistical analysis that is distant from the reset of the data. Outliers can occur by chance but are typically a measurement of error or indication of a heavy-tailed distribution. The method of least squares can be used to approximately solve for outliers and is often used in regression analysis.

Personal Preferences: Determine willingness to pay for a specific quantity of a good and is used in determining consumer surplus or utility.

Public Good: A good or service that is non-rival and non-excludable.

Rationality: Question format for the Contingent Valuation method. The rational decision is optimal and rational individuals act optimally to pursue goals. The debatable topic is whether or not people are actually "rational" and the impact of asymmetric information on their decision making. Bounded-rationality attempts to correct for errors associated with rationality.

Regression model: Statistical technique for analyzing relational causation between a dependent variable and one or more independent variables.

Social benefits: Related to social welfare and the improvement of well-being based on individual needs.

Starting-point bias: Occurs when an individual's response is influenced by the order and manner in which questions are presented.

Strategic bias: Occurs when a survey respondent believes they can influence policy decisions by providing a skewed and inaccurate response to a question.

Supply and demand theory: Economic model of determination that attempts to find equality between the quantity of a good produced and its price in the market.

Symbolic Capital: The resources available to consumers on the basis of honour, prestige, or recognition as it relates to cultural values. It typically cannot be converted to economic capital. Example: Sacred cattle in Hinduism are maintained for religious purposes, not economic or subsistence.

Water Quality: The physical chemical properties of water that impact its usability as a natural resource.

Water Quantity: The amount of water that is available for consumption at a particular location.

Willingness to pay: The maximum amount an individual is willing to pay for a good or service based on their socioeconomic status and personal preferences and attitudes. The MWTP aids economists in determining net benefits to the consumer.

World Bank: An international financial institution that provides capital to developing countries in order to leverage investment in poverty reduction and trade.

Chapter 1: The Economic Valuation of Fresh Water

1.1 Introduction

When assessing the feasibility of improving the quantity and or quality of fresh water infrastructure in a region, the issue of cost is often paramount. To develop water treatment facilities, reservoirs, or other improvements to system efficiency requires expensive planning and consultation before any construction begins. Utility managers are often forced to make trade-offs to reduce the risk of water shortages, whilst balancing cost with current and future benefits to the community.

Options for coping with limited supplies include imposing defined water restrictions and violation fines, encouraging the use of water efficient appliances through rebates and tax incentives, or redistributing supplies to maximize resource use (Hensher, Shore, & Train 2006). Alternative economic schemes include water-metering programs whereby consumers are charged per unit volume used, as well as a revenue neutral tax or additional levee to both reduce consumption and fund infrastructure projects that will improve efficiency. In order for resource managers to assess the value people place on water, an understanding of local environmental attitudes and preferences that influence consumer willingness to pay is required.

The value of water as an economic good can be inferred from market and non-market assessments. For example, the quantity and price of bottled water is determined largely by supply and demand theory; thus, water in this instance is a market good and a consumer's preference is revealed through market transactions. However, the preservation of lakes for recreational purposes, or willingness to pay for upgrades to municipal water delivery systems are considered non-market services and require more sophisticated econometric tools to estimate values. The contingent-valuation (CV) approach utilizes a survey whereby the estimated WTP of consumers for a particular service is contingent on the study results. This technique assesses the maximum willingness to pay of a population sample and is an example of a stated preference method. The averting expenditure method (AE) is another technique that establishes WTP. To avoid exposure to risk, for example health risks associated with consuming poor quality water, consumers will often adopt averting behaviours that incur an expenditure cost. Averting expenditures include goods and services such as bottled water and filtration systems, or labour associated with boiling water. The hedonic regression method estimates the value of a non-market good based on its bundled characteristics and thus estimates a hypothetical willingness to pay. This technique is common in estimating influences in the real-estate market due to the various qualities of property, such as lot size, location, crime rate, number of bedrooms, et cetera. Although hedonic models have been shown to underestimate actual WTP (Anselin, et al. 2008) the contingent valuation approach is an adequate means of assessing costs associated with human-environment interactions (Whitehead 2006). Numerous other techniques exist and are discussed at greater depth in this chapter under subsequent headings.

This research used a contingent-valuation survey combined with an assessment of averting expenditures to estimate WTP for water quality improvements in Savona, British Columbia. The rural community of approximately 660 residents is located in the Southern Interior of British Columbia, Canada. A total of 265 households are connected to a water utility system that draws water from the adjacent Kamloops Lake. Due primarily to high turbidity levels, the community spends most of the year under boil water advisories (TNRD 2009). During the 2011 summer an intake pipe was extended deeper into the lake in an effort to improve both quantity and quality; however, no direct measures have been taken to improve the filtration system which currently treats water solely through chlorination. The utility system is managed primarily by the Thompson Nicola Regional District (TNRD) with administrative assistance from the Savona Improvement District. Interest was expressed by the TNRD in this research due to their responsibility of balancing the costs and benefits of the water utility system. Savona residents are scheduled to pay a $5 per month increase in fees in 2012 and again in 2013. To ensure a sustainably managed system, an understanding of community attitudes and perceptions towards water quality and fees associated with system operation was required.

This thesis demonstrates the effective use of the contingent-valuation and averting expenditure methods in a water resource management application in Savona, British Columbia. The body of the document is comprised of seven chapters. The purpose of Chapter 1 is to summarize previously published refereed studies that are relevant to the valuation of water and provide an introduction into the economic valuation of water quality. Chapter 2 addresses the framework of econometric methodologies associated with stated and revealed preference methods. A greater number of studies have taken place in less developed countries throughout Latin America and Africa due to a general lack of water utility infrastructure and this bias is apparent in Chapters 1 and 2. Chapter 3 provides a physical and biological examination of Kamloops Lake that includes limnological characteristics as well as information on land-use, resource management, and water quality monitoring. Chapter 4 describes the community of Savona and explains all aspects of the research methodology in specific terms. Chapter 5 presents descriptive statistics derived from the survey. Chapter 6 focuses on econometric models and communicates the cause and effect relationship of WTP with socioeconomic and environmental variables. Chapter 7 provides a summary of key findings and research conclusions.

1.2 Determining value based on water quality and quantity

Water utility systems are designed to provide a known quantity of water based on locally available supplies. The demand for specific infrastructure varies with the quality and quantity of water resources vary across the planet. For example, infrastructure in the city of Canberra, Australia is sufficient; however, imminent conflicts with quantities are predicted given increasing urban demands and drought risk. To determine appropriate management strategies for the future, preferences for conservation practices amongst residents based on limited water quantity were examined by Hensher, Shore, & Train (2006). Similarly, marginal water quality has also been a source for concern as it continues to threaten recreational opportunities in Iowa, U.S.A. In research conducted by Egan, Herriges, Kling, and Downing (2008), WTP for improvements to water quality in order to preserve recreational opportunities is estimated. It is insufficient quality and or quantity that results in the commission of studies aimed at providing policy makers with new information to address future problems with water supplies. This section explores the roles of quality and quantity in determining WTP for management strategies using straightforward case studies.

In the 2006 paper by Hensher, Shore, and Train titled *Water Supply Security and Willingness to Pay to Avoid Drought Restrictions*, the author's attempt to estimate consumer WTP to avoid limits to access to fresh water. By avoiding drought restrictions, consumers will have more water available for consumption and sanitation, as well as the other benefits that accrue from reliable access to water such as property landscaping and recreation. Water utility managers must continually assess supply security which is defined as the likelihood of running out of water at a specific time in the future. Protecting supplies to minimize the risk of water shortages can be accomplished through a multitude of management strategies. At the end of the day, policy makers must decide on a practice that best balances the trade-offs of cost with ecological and resource sustainability. According to the author's, options for coping with limited supplies include augmenting available supplies to maximize efficiency through allocation, imposing explicit water restrictions on users, and finally harvesting and distributing alternative water sources such as rain water or recycled water. It is argued that these strategies have inadequately assessed consumer preferences for management directions in the past.

Hensher, Shore, and Train utilized a contingent valuation survey in October 2002 and April 2003 to determine management strategies in Canberra, Australia. The study demonstrated that consumers are largely not willing to pay to have low-level restrictions to the quantities available. However, there was a trend of willing to pay to avoid high-level restrictions to water use. For example, respondents indicated they were willing to pay up to 31% of their annual water bill (approximately US$239) to avoid daily year-round restrictions. In order to accept high level restrictions, the authors estimate that residents will need to be compensated US$227 per year ($19 per month). Ultimately the survey respondents stated they would prefer altering their water use to conserve resources, rather than paying higher water bills to discourage use. It appears that the inconvenience of low-level restrictions is offset by a "feel good" factor whereby consumers experience a novel effect from using water responsibly. Additionally, if low-level restrictions are sufficiently flexible to allow a continued high standard of living then they will be widely adoptable. The author's recommend that Canberra, Australia implement permanent low-level restrictions on urban water use; however, due to prolonged drought in the region, additional measures for augmenting existing supplies must be considered. This study helped to ensure that the perspectives and preferences of the community were taken into account when managing water quantity. The contingent valuation method has been used in similar situations where the value of a community's water resource was estimated based on scenarios that would restrict water use.

The impact of changes to the "reliability" of water resources on willingness to pay in three Colorado, USA cities is examined by Howe and Smith (1994). It was proposed that during the summer months of July, August, and September, residents would have their outdoor water use restricted to three hours, twice per week in order to protect their highly reliable supply from becoming unreliable. The study results showed that respondents were willing to accept between US$4.53 and $13.00 per month for the new conservation policy. The results also indicated that between 41% and 58% of residents are willing to accept a reduction in water supply security.

The results of a similar study by Griffin and Mjelde (2000) conducted in Texas' cities wielded similar results. Once again consumers were asked what amount they would be willing to pay to avoid a certain level of water restriction. The authors found that, on average, respondents had a WTP of $25.34 and $34.93 to avoid a 10% water use reduction policy. Interestingly, respondents also showed a willingness to contribute an additional 49.76 per month (26% of their water bill) to improve the security level of future supplies.

A parallel aspect of water resource management not discussed in Hensher, et al. (2006), Howe and Smith (1994), nor Griffin and Mjeldge (2000) is the effect of water quality on consumer perception. Air and water pollution have increased with industrial development and urbanization in North America. In the United States, 45% of arable acres are classified as impaired by some form of artificial contamination. This has resulted in the need for assessing consumer preferences with regards to remediation prioritization in many states. In order to accomplish this in an effective manner requires an understanding of how the local users value their water resources based on varying degrees of quality. In their 2009 paper *Valuing water quality as a function of water quality measures*, Egan, Herriges, Kling, & Downing attempt to estimate WTP for recreational lake usage based on improvements to physical parameters of water bodies.

In order to determine recreational demand patterns, Egan et al. examine a range of parameters for their logistic regression model and gathered preference values from three surveys. These include socioeconomic influences such as gender, age, education, and household size, in addition to water quality variables like pH and clarity, and finally lake characteristics consisting of travel cost and the presence of specific facilities. Measurements were carried out at 129 lakes in Iowa State. The results show that residents of Iowa preferred to improve a select number of lakes to superior water quality rather than improve all lakes beyond their “impaired” status. The author’s were also able to determine which variables impacting water quality had the largest affect on consumer preferences and attitudes. For example, a high level of clarity was shown to increase visits, while hazardous concentrations of cyanobacteria nutrients in a lake decreased recreational visits. This study was able to demonstrate that varying degrees of differing water quality variables have a strong impact on the number of visits to a lake. Although no specific WTP estimates were provided in the paper, it is implicitly apparent that consumers possess a higher preference for lakes with greater water quality due to the larger number of recreational visits observed.

The articles discussed in this section provide a relatively simplistic overview of how water quality and quantity variables are measured econometrically. The subsequent pages of this document will examine, in more specific terms, the literature surrounding the multitude of tools available to environmental economists seeking to explain preferences and WTP for fresh water resources.

1.3 The valuation of fresh water through revealed preferences

When economists are attempting to assess value for environmental goods, conducting market research on existing products that are relatable to the good in question can be completed to estimate a price. The preferences consumers possess for this good are revealed through this market research; hence, the revealed preference method. Moreover, because these preferences are determined by existing supply and demand relationships, in combination with socioeconomic characteristics of the consumer, the need for conducting expensive and sometimes invasive contingent-valuation surveys is avoided. There are a number of revealed preference tools that are available to economists. Pearce, Atkinson, and Mourato (2006) describe the hedonic pricing, travel cost, averting behaviour or defensive expenditure, and costs of illness methods.

The hedonic price method (HPM), also known as hedonic regression, uses observed behaviour in the market place to determine an implicit value for a good. Although this method is widely used in labour and housing markets, new applications in the realm of environmental goods are beginning to emerge. Pearce, Atkinson, and Mourato (2006) use the example of enjoying peace and quiet in urban spaces. Since there is no market value for “peace and quiet”, this value is traded implicitly in the housing market. Consumers express their preference for this environmental good by paying a premium when purchasing a home in a quiet neighbourhood. Other HPM studies have assessed the value of air pollution, proximity to land fills, and water quality (Kim, Phipps, & Anselin, 2001; Hite, Chern, Hutzhusen, & Randall 2001). Despite being used in environmental economics since the 1920s (Waugh 1928), studies assessing water quality using HPM are relatively scarce but do exist. For example, Legget and Bockstael (2000) explore the role of poor water quality on residential land prices.

Leggett and Bockstael (2000) utilize HPM to demonstrate the impact of high fecal coliform concentrations on home values in Chesapeake Bay, Maryland. Using weekly sample data taken by the county health department, the authors are able to create a water quality variable for the regression model. Additional factors used in the model are the value of the structure, size of the lot, and travelling distance to nearby major cities. Regression results demonstrate that improvements in water quality only account for 40% of the variation in housing prices and were determined to be insignificant.

Despite the wide use of this method in the housing market, little has been done to assess the impact of water quality on home value. One explanation is that home owners are largely unfamiliar with the measures of water quality and any impact on housing prices is negligible. A second explanation lies in the difficulty of capturing the effects of water quality in a way that is methodologically sound. For this to occur, a large sample of houses that experience varying levels of water quality, but exist within a single housing market would be required (Pearce, Atkinson, Mourato 2006).

As was noted by Leggett and Bockstael (2000), a surge in the use of hedonic regression in environmental economics has resulted in the need for greater scrutiny over methods. Luc Anselin is a pioneer in the field of HPM and spatial econometrics and has written numerous books on the subject. Some of his more recent work has focused on diagnostic testing (1996), errors in hedonic regression variables (2009), and valuing fresh water (2008). In Anselin's 2008 working paper conducted in cooperation with the World Bank, a spatial hedonic approach applied to valuing access to water in Indian cities is presented. The locations of Bhopal and Bangalore are used to demonstrate the social welfare that results from investments to utility services and water supplies. Using a spatial hedonic regression model, the study tests the accuracy of stated preferences obtained from a willingness-to-pay survey. The results showed that their model underestimated actual WTP and social benefits, however, the inclusion of spatial variables related to high and low income neighbourhoods would enable policy makers focus their investments in high risk areas. The tests estimate that a 33% increase in water utility access by direct connections will increase monthly property rents by between CAN$2.12 and $4.23 (converted from Indian Rupees (INR)). This analysis does not account for equity concerns which the author's admit, may alter investment scheduling and affecting decisions regarding which neighbourhoods, affluent or poor, will receive priority for service upgrades. The authors were also able to show that HPM typically underestimates actual WTP and is most useful when utilizing the housing market to tease out the intrinsic price of water quality; therefore, alternative tools are required for different applications.

When assessing the value of water as an intrinsic environmental good in cases where recreation is a primary component, the travel-cost method (TCM) is a robust tool. Examples of recreational opportunities dependent on water resources include fishing, various boating activities, waterfall viewing and site seeing, as well as camping or hiking along a lake, river, or coastline. Preserving water bodies for the purpose of ecological protection is also important for many national parks and communities around the world. Such areas do not command a price from the market and as such the revealed preference tool of travel-cost is required when determining policy options. This theory was first put forth in Clawson and Knetsch's 1966 paper *Economics of Outdoor Recreation*. Fundamentally, the approach aggregates visitors to a recreational area based on their zone of origin, and then attempts to estimate variation between individuals based on socioeconomic characteristics and the characteristics of alternative sights (Willis & Garrod 2008). The benefit to this method is that values are based on observed behaviour and not stated preferences whereby visitors would express how they would behave. Although HPM and travel-cost have only limited uses when valuing non-market environmental goods, the averting behaviour and defensive expenditure method is a common tool used to estimate the perception of risk associated with inadequate water supplies.

The concept of averting behaviour in environmental economics is rooted in the notion that individuals can insulate themselves from risks to health, lifestyle, or property by adopting different types of behaviour albeit at a premium price. Often this can be carried out through the purchase of what are known as defensive expenditures. In the context of fresh water resource management, defensive expenditures can include goods such as household water filtration systems or purchasing bottled water to avoid tap-water use. This approach has been one of the more popular methods used to evaluate groundwater protection legislation and drinking water safety (Um, Kwak, & Kim 2002). The theory of averting behaviour to avoid contact with some form of negative stimulus is not limited to natural resource economics. Studies following this methodology have been utilized in health service industries; for example, H.I.V. and cancer research (Johnson, Bekker, & Dorrington, 2007; Murdoch & Thayer, 1990). In their 2002 paper, *Estimating willingness to pay for improved drinking water quality using averting behaviour method with perception measure*, Um, Kwak, and Kim discovered that residents of Pusan, Korea boiled tap water, installed filters, drew from springs and groundwater, and bought bottled water to avoid drinking what was generally perceived to be polluted tap water even though its toxicity was within health-safety guidelines. The author's were able to provide resource managers with a better understanding of why the people of Pusan do not favour consuming tap water as well as an estimate of how much they will spend to avoid the risks of utilizing the municipal source. It was determined that citizens were willing to pay an additional $4.2 to $6.1 (USD) on their monthly water bills to improve tap water quality to acceptable levels. Groundwater contamination has been a focal point for researchers conducting studies on averting behaviour and defensive expenditures.

In an earlier 1992 study, Abdalla, Roach, and Epp discuss the role of averting expenditures due to groundwater quality degredation. Their paper concentrates on the costs bared by governments, businesses and households to avoid exposure to potentially harmful groundwater sources. A related article by Abdalla (1990) examines the substantial averting behaviour undertaken by residents of a Pennsylvanian community. The author examined municipal and individual economic losses that result from poor groundwater quality. Municipal losses include the additional resources government agencies must commit for increased monitoring, risk communication, and public notification. Human health impacts included increased morbidity or mortality, long-term chronic illnesses, and increased costs of medical treatment, loss of leisure time, and pain and suffering. Through the utilization of a mail-out survey, the averting expenditure was estimated to be between $252 and $383 (1987 dollars) per household per year. Abdalla notes that this method is valuable to resource managers when determining appropriate strategies on a case-by-case basis.

The final revealed preference method discussed in this paper is known as the cost of illness and lost output approach. In some instances, consumers require medical treatment as a result of exposure to harmful environmental pollutants. The cost of illness and lost output approach focuses on expenditures that relate specifically to goods and services purchased in response to negative health effects. The methodology allows for the valuation of impacts due to negative environmental externalities and is most common in air quality studies (Portney & Mullahy,1986; Quah & Boon 2003; Su, Sanon & Flessa 2007). The difficulty with this approach is that health affects, although induced by exposure to pollution, can arise from various background factors such as pre-existing health conditions (Pearce, Atkinson, & Mourato 2006). It can also be difficult for economic researchers to find meaningful data relating to exposure levels and the resulting impacts on human health. The cost of illness and lost output approach is, nonetheless, a beneficial revealed preference tool available to economists. In theory, a similar approach could be used to value the impacts of water quality on human health and the resulting treatment related expenditures they incur.

This section has assessed literature relating to several revealed preference methods. Economists have been able to develop a series of reliable techniques for measuring the value of non-market effects through the revealed preferences of the consumer. Ultimately, intangible impacts that arise from policy decisions and production in markets have measurable economic impacts on the quantity and price of environmental goods. The greatest hindrance of these methods - hedonic price, travel cost, averting behaviour, cost illness - is a lack of reliable evidence and information on the physical relationships that exist between the impacts of inadequate resource quality or quantity and consumer preferences in a given situation. More robust case-study specific econometrics utilizes stated preference analyses to overcome this information gap.

1.4 The valuation of freshwater through stated preferences

Stated preference methods are a more explicit approach to estimating actual WTP and typically involve the use of a survey or questionnaire. The two most common techniques are known as contingent-valuation (CV) and choice modelling (CM). By enumerating consumers directly, researchers are able to avoid complications with unreliable information relating to ambiguous market pricing. However, stated preference methods are in some ways infamous due to several inherent biases and complications that arise when individuals assign a preferred monetary value to a non-market good. When valuating fresh water resources, this becomes ever more complex due to the multitude of natural and anthropogenic factors influencing water quality and quantity, as well as the dire consequences that may result from a poorly managed water supply. Additionally, individuals value water for reasons beyond simple ingestion and sanitation and attitudes towards resource management are far from homogeneous. This section explores literature relating to CV and CM methods using freshwater case studies.

Dale Whittington is an expert in Contingent-Valuation methodology in developing countries with regards to water resource economics and has authored or co-authored numerous papers in a variety of journals on the subject (1990; 1991; 2002; and 2004). In an early case study, Whittington, Briscoe, Mu, and Barron (1991) examine WTP for water services in Southern Haiti. Their research objective was to overcome, through robust methodological testing, the strategic, starting-point, and hypothetical biases that are traditionally inherent in WTP surveys.[1] To do this the study contained two parts: The first is household surveys; and the second, is source observations. In order to complete a comprehensive survey, extensive training was provided to ten enumerators prior to field-testing. Focus groups were also held to gain an understanding of household decision making on water-related topics. After preparing a thorough survey distribution plan and field testing, survey enumeration took place.

The second component of the survey, source observations, was completed to verify that responses provided in the survey were consistent with real-life behaviour. To accomplish this, local residents were hired to observe the number of visits, amount of water collected, and whether individuals bathed or did laundry at local water sources. Households participating in the survey were identified with a ribbon or identification card. Out of the 119 observations, 101 (85%) were consistent with survey responses. The results showed that households participating in the study provided serious and thoughtful responses. Additionally, the use of bidding games in WTP elicitation was easily understood and reported by enumerators to be a comfortable method for respondents given its likeness to bargaining in Haitian markets. In summary, the authors note that they were able to demonstrate, with reasonable success, that a CV survey can be accurate even when carried out amongst a very poor and illiterate population. They also report that there was no major problem with starting point or hypothetical bias, although problems with strategic bias were less conclusive. This study was important in breaking the stigma that contingent-valuation surveys were essentially useless due to the biases previously discussed. From this time forward, researchers have continued to conduct CV surveys in underdeveloped regions and draw on the earlier work of Whittington. For example, Casey, Khan, and Rivas (2006) conducted similar research in Manaus, Amazonas, Brazil.

Unlike the smaller Whittington, et al. (1990) study that utilized only 119 questionnaires, a study by Casey, Khan, and Rivas (2006) administered 1,625 household surveys over a two week period in 2001 in a Brazilian urban hub. The in-person

[1] McComb (2002), and Wedgewood and Sansom (2003) discuss additional details relating to biases inherent in poorly planned CV studies as well as strategies for reducing their influence during the planning process.

interviews were comprised of a four part assessment that included demographic, health, and infrastructural queries in addition to the contingent valuation experiment. To ensure accuracy of the CV component, four elicitation formats were used. These include open-ended with preliminary augmenting, open-ended with no preliminary augmenting, and both ascending and descending bidding-games. Households surveyed were divided into four equal groups based on these elicitation methods. Through the utilization and comparison of different formats, the study uncovered that the open-ended and bidding game formats displayed nearly identical mean WTP and standard deviation values. It is also noted, that, although variability is minimal, the descending bidding-game method elicited the highest WTP and the highest variance around the mean. Multivariate analysis was subsequently completed and included variables relating to socioeconomic status and demography, as well as threat of disease and cost of electricity and water. Casey, Khan, and Rivas determined that residents of Manaus, Amazonas, Brazil were willing to pay considerably more than what is currently being charged for water utility services should they be improved in the areas of quality and quantity delivered. On average, $72 per annum was expressed as the maximum WTP which equates to 2.5% of household income.

The case of Kanye, Botswana wielded similar results (Mbata 2006). The contingent-valuation approach was used to obtain data relating to WTP for a private water connection. The impacts of exogenous variables such as incidence of water-borne disease, distance from water source, as well as socioeconomic and demographic attributes were estimated using ordinary least-squares regression. The WTP component of the survey utilized the iterative bidding method, also known as ascending bidding game, for a private household connection. It was then determined through multiple-regression modeling that the main determinants of WTP for this service were income, status of employment, level of education, and distance from existing sources. As a policy recommendation, the author’s write that proposals on future water utility projects should focus on community demand, rather than supplies. The willingness to pay bids to add a private connection ranged from $0.47 and $88.33 (CAD). This is significant given that the average household income was CAN$196. Accounting for socioeconomic and ecological conditions present in rural populations is also important when determining connection fees as WTP varies across regions and demographic groups.

Although most CV studies exist in underdeveloped regions where water supply infrastructure is either non-existent or unreliable, a study conducted on a Winnipeg, Manitoba water treatment facility provides some insight into applicable CV techniques for more affluent societies. In his study, McComb (2002) attempts to determine the financial feasibility and consumer adoptability of a large-scale water utility system improvement. The study assumes that citizens make their choices regarding WTP based on imperfect and incomplete information, a concept known as bounded-rationality. It was therefore necessary for McComb to develop a WTP scenario that the consumers in Winnipeg were able to relate to. To accomplish this, the survey presented a hypothetical shopping experience at a local Winnipeg mall whereby water of varying quality is offered at different prices. Respondents are asked to choose to purchase either a jug of water that contains water that is of the same quality they currently consume at a baseline price, or a jug of water that is high quality at a premium price. An iterative bidding process is then used to elicit the respondent's maximum willingness to pay for the higher quality jug of water. The method is similar to choice modelling which seeks to model the decision process of a group or individual given a specific set of circumstances, or a scenario. The response rate for the study was 56% and resulted in 125 useful surveys being completed. The mean willingness to pay as a contribution to a new water treatment facility was determined to be $9.60 per month. This cost was sufficient to cover the $20 million cost of improving the municipal treatment facility. Another interesting component of the study was a "retrospective report" provided on the final page. Here, respondents were provided a space to make notes about the decision making process they went through in order to arrive at their respective WTP bids. Some common responses included topics relating to water filter use, income, water quality, and politics or government. A behavioural anomaly noted by the author is evident in a high proportion of respondents choosing the $10 bid over all others. Despite this inexplicable result, other problems such as symbolic or starting point biases were not found and the valuation question is described by McComb (2002) as performing relatively well under experimental conditions. This case study provides an example of CV methodology in the Canadian water resource sect and utilizes a unique scenario that is not necessarily applicable to developing countries.

Stated preference methods offer a direct survey approach and are able to capture the various benefits that accrue from fresh water consumption. Since the earlier work of Whittington, et al. (1991), stated preference methodology has continuously been tested and improved, providing an econometric tool that is useful when seeking values for non-market environmental goods and services. The result is a scientific technique that has been proven to be reliable and valid when best practices and a robust research methodology are followed (Pearce, Atkinson, Mourato 2006).

1.5 Equity and the distribution of capital

Fresh water as a natural resource serves a magnitude of purposes beyond food production, ingestion, and sanitation. Moreover, the attitudes that individuals possess towards this resource are far from homogeneous. A fresh water angler who values water for recreational purposes, for example, will have a greater preference for preserving fish bearing streams than someone of a comparable socioeconomic situation that rarely visits such streams. That being said, two freshwater anglers, with diverging socioeconomic situations will also have dissimilar preferences for the amount they are willing to pay to preserve the same stream. An individuals willingness to pay for a good or service is based on personal preferences and attitudes, hence, accounting for WTP in situations concerning fresh water can become very complex due to its range of qualities valued by consumers.

In their paper *Equity re-examined: A study of community-based rainwater harvesting in Rajasthan, India*, Cochran and Ray (2009) define and discuss the role of equity in resource planning and management.[2] Equity is distinct from the concept of equality which signifies being equal in quantity, for example the division of a profit. Equity, in contrast, involves the inclusion of fairness and justice when assessing value for goods with ethical or cultural significance. According to the author's, this concept has been overshadowed by a focus on the economic efficiency of resource development.[3] On a fundamental level, this means that cost considerations have taken precedence over the fair and even distribution of resources that would improve the well-being of the local beneficiaries. The goal of Cochran and Ray was to determine the role of equity in a rainwater harvesting program in India.

Their case study examined a Johad rainwater harvesting structure that will capture and store water during the wet season and provide supplies during the dryer summer months. The willingness of community members to contribute to the construction and maintenance of the Johad presented a series of challenges to the definition of equity. Although villagers were willing to pay equal per household cost contributions, it was understood that the resource could not be allocated equally in order to ensure the efficient use of stored supplies for food production, cooking, and sanitation. The researchers were left asking, how can equity be explained in this instance? For answers, the concept of cultural capital was explored. Cultural capital was first outlined by Bourdieu (1977) as being a cost or a benefit that extends conventional economic theory of what is valued, and what is equitable. Cochran and Ray argue that, in the context of the Johad project, symbolic capital can explain why some individuals are willing to contribute equally for a lesser economic gain. One major non-economic consideration is related to the fulfillment of religious duty. In Hinduism, the sacred bovine is provided with food and water but is never harvested for economic gain. Instead, the animal provides a source of cultural or

[2] The role of equity in freshwater resource allocation is discussed at greater length in Fauconnier (1999); and Musgave and Musgave (1984). Vertical equity relates to the "ability to pay" principle, whereby individuals are charged an amount for a good or service based on their income, or what they can afford. Conversely, horizontal equity requires individuals to pay based solely on the level of benefit they receive from consumption.

symbolic capital, thus increasing net benefits to consumers that support the Johad. The community also found agreement in that all stand to benefit equally, so all should contribute equally monetarily. One participant in the author's study placed his justification in the context of opportunity cost; that is to say, everyone stands to lose equally if the Johad is not constructed.

As a collective group, the community's point of view both defies and supports the notion of horizontal equity. It is understood that some individuals will use more water in the fulfillment of their religious duty and benefit to a greater extent while others will use only minimal daily amounts and ultimately benefit less from consumption. This defies the horizontal equity principle which states individuals should pay based on the amount of benefit they receive. However, villagers view the Johad as a community resource and therefore feel it is necessary to forego some individual economic equity and contribute equally in order to protect the cultural and symbolic benefits that the resource provides.

The paper concludes that natural resources simultaneously provide economic and symbolic value. An understanding of these values, as well as their interaction, is required in order to determine consumer preferences and effectively manage water supplies. The concept of equity in fresh water resource allocation is concerned with not only the state of having, but also the state of giving, or willing to give, in a community. Additionally, when cost allocation is determined strictly through economic practices, it is often seen as a burden rather than a source of symbolic capital. Ultimately, it is critical that, during the valuation of fresh water resources in a community, albeit for purposes of infrastructural development or conservation, the concept of equity must be grounded in the economic and symbolic benefits that will potentially result. The revealed and stated preference methods can be used to determine equitable natural resource policies.

1.6 Discussion and Conclusion

Due to global pollution, booming populations, and the industrialization and urbanization of third-world countries, available fresh water resources are becoming increasingly threatened. Health risks associated with the contamination of drinking water sources with parasites, heavy metals, bacteria, and disease are usually a result of breaches in treatment facilities highlighting the need to not only improve infrastructure, but also remediate surface and groundwater sources (Davies & Mazumder 2003). Likewise, agricultural, industrial, and urban demands are placing immense strain on the quantity of water that is available in many regions. In order to address these problems an understanding of not only the environmental aspect, but also economic, social, and cultural implications is required.

As was demonstrated by the numerous case studies in this paper, water provides an array of benefits to society that extends beyond simple sanitation and consumption. The preferences for, and attitudes towards, these benefits are also highly heterogeneous across individuals, communities, and cultures. For this reason, the inclusion of equity is of paramount importance when assessing utilitarian fresh water resource management policies. In Cochran and Ray (2009), for instance, the inclusion of fairness in grass roots community planning trumped economic profitability for many individuals due primarily to religious and cultural duties that might otherwise seem absurd in a differing community and under different circumstances. In order to assess which equitable policies are also economically feasible, economists have a series of tools at their disposal during infrastructural cost-benefit analyses.

The revealed and stated preference methods are able to adequately capture the preferences of individuals towards their water resources albeit for purposes of improving quality or quantity. Due to the robust methodological testing of scientists such as Whittington (1991; 1996; 1998; 2001; 2002; and 2004) and Anselin (1996; 2007; 2008) economists can say with relative certainty that it is possible to demonstrate how consumers respond to changes in water quality and quantity, and how their respective

WTPs are influenced. Chapter 2 will examine the role of econometrics more specifically, with emphasis on the contingent-valuation method.

Chapter 2: Contingent Valuation Methodology

2.1 Introduction

The economic valuation of natural resources is complex and this complexity is exacerbated when attempting to develop sustainable policy directives for non-market goods and even more so for those regarded as a public good.[4] The classification of fresh water delivery system improvements satisfies the public good criteria in most regions in Canada. When upgrades to water delivery systems are made, an understanding of the attitudes and preference towards the local resource is needed to ensure that developments will be ecologically and financially sustainable. Since there is no established market price for water quality or quantity improvements, resource managers must rely on econometric techniques such as the contingent-valuation (CV) method.

The preferences individuals possess towards fresh water resources are heterogeneous across communities, regions, and cultures. The contingent-valuation method utilizes a survey to adequately capture this variety of consumer opinions to estimate willingness-to-pay and demand for non-market goods. Whittington, et al. (1991) define an individual's demand for a good as "…a function of the price of the good, prices of substitute and complementary goods, the individual's income, and the individual's tastes, usually measured by the individual's socioeconomic characteristics". Within the context of fresh water management, substitute goods are often defined as variations in the quality and or quantity of resources available at a corresponding price. Through highly specialized CV scenarios researchers can estimate WTP for water utility improvements by providing options for substitute and complementary goods.[5] However, this

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[4] Public goods are non-rival and non-excludable, meaning: consumption by one individual does not limit consumption by others; and, no individual can be excluded from using the good. Describing water as an economic good can be unsettling for non-economists. The functions of water as a social and economic good are described further in Rogers, Bhataia, and Huber (1998).

[5] Although CV methods have been improving since the 1980s (Whittington, 1981), criticisms of its robustness as a scientific tool have been questioned (McComb, 2002).

methodology has been criticized in the past as being flawed due to inherent biases that arise in poorly planned studies.

In order to prove empirically the effectiveness of this econometric tool, a number of researchers have been testing the robustness of various approaches to WTP elucidation using a CV survey (Whittington, et al. 1991; McComb 2002; Whitehead 2006; Cochran & Ray 2008; Kanyoka, et al. 2008). The result has been the publication of documents designed to aid CV practitioners in utilizing the most rigorous methodology when assessing the value of non-market goods.[6] Wedgewood and Sansom (2003) (WS) centers on CV methodology as it relates to freshwater resource management and outlines four distinct benefits that the data from a CV study can provide to policy makers. They include: Justify future investment proposals; develop a better understanding of user perceptions and preferences; support the selection of preferred service options; and set the scope of future tariff increases and subsidy reduction plans. To accurately measure the right kinds of information, this document provides a "robust" research methodology that is designed to be used for researchers, government staff, water resource managers, as well as other practitioners in the water and sanitation sector. Numerous studies are available that describe the results of CV studies in developed and undeveloped countries; however, few articles exist that discuss in depth the methodology, making it difficult to carry out world-class CV studies in some regions. Wedgewood and Sansom attempt to provide researchers with an effective methodology in order to encourage a wider use of CV studies. The document produced by Pearce, Atkinson, and Mourato (2006) (PAM) is similar, but constructed on a slightly different premise.

The Organization for Economic Co-operation and Development (OECD) commissioned the document *Cost-Benefit Analysis and the Environment* (Pearce, Atkinson, and Mourato, 2006) to address the plethora of issues which arise during a Cost-Benefit Analysis (CBA) study. The author's of this text make it clear that, unlike Wedgewood and Sansom (2003), their intent is not to provide a manual of CBA or

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[6] Two documents outlining contingent-valuation methods are Pearce, Atkinson and Mourato's *Cost-Benefit Analysis and the Enviornment* (2006) and Wedgewood and Sansom's *Willingness-to-Pay Surveys: A streamline Approach* (2003). Although these documents possess similar objectives, they differ in several ways relating to the depth and format of information presented.

econometric methods contained within the volume, but to combine various considerations for economists with past experience in Cost-Benefit Analysis. Pearce, Atkinson, and Mourato (2006) address the issue of estimating values for non-market goods, the theoretical framework involved, a detailed description of the contingent-valuation process, as well as other stated and revealed preference methods.

Together WS and PAM provide a multidimensional description of the conceptual and practical framework for quantifying the value of non-market environmental resources. The purpose of this chapter is to examine the theory and procedure of robust CV methodology. This includes the design and management of a study, as well as data analysis and resulting policy implications.

2.2 Methodological Framework

2.2.1 Stated Preference Methods

The econometric tool of contingent-valuation (CV) is an example of a stated preference method. This branch of techniques for estimating the value of non-market goods is different from its counterpart of revealed preference tools in that it does not use market information for goods and services, but rather, the explicit stated-preferences of consumers. Through the use of a survey, a population sample is asked to make choices regarding their attitudes and preferences towards a particular good. This idea of using the "choices" of consumers to model their views on the value of goods and services, thus estimating their value in a hypothetical market place, has come to be known as choice modelling (CM). The CV method, in essence, is a form of CM research. By summarizing key chapters of PAM (2006) and WS (2003), this section outlines the theoretical framework of CV research. Section 2 focuses on stated preference methods with emphasis towards choice modeling and the contingent-valuation survey.

2.2.2 Contingent-Valuation Method

The contingent-valuation and choice modelling methods are similar in that both utilize a survey based approach to elicit data relating to consumer preferences towards a specified good, or bundle of goods. Within the context of water resource management, a good suitable for CV analysis typically relates to infrastructure developments that will improve water quality, storage, or delivery. Like the CM technique, this involves designing a scenario that aids in the conceptualization of core economic principles for providing an accurate estimation of ones WTP. Pearce, Atkinson, and Mourato (2006) (PAM) provide a chapter relating specifically to stated preference methods and the contingent-valuation survey.

Chapter 8 of PAM focuses on CV study design and the importance of robust methodology in order to obtain the most accurate WTP estimations. According to the authors, the CV survey can be broken down into three parts: Background attitudinal and behavioural questions concerning the environmental good; a contingent scenario that is used to elicit monetary evaluations by respondents; and finally, questions concerning socioeconomic and demographic attributes of individuals.

The first section of the CV survey helps determine the most important underlying attributes that determine the WTP decisions of the sample. In the case of water resources, the perception of the quality and or quantity available could be assessed. Additionally, the need for improving water utility infrastructure could be weighed against other community services that might be considered a public good. The second section of a CV survey presents a scenario where respondents are asked for a monetary evaluation of the good in question. A specified series of terms and conditions relating to a hypothetical purchase will precede a method of WTP elicitation. Examples of price elicitation methods include bidding game, price card, or dichotomous choice method and will be discussed under the subsequent heading. The final section of the CV survey determines the socio-economic and demographic characteristics of the respondents. This is done in order to verify the representativeness of the sample, as well as how WTP varies according to the respondents' characteristics.

Constructing the hypothetical scenario is the most sensitive component of the contingent-valuation study. According to PAM, specific considerations include providing the right information about the good, the wording, and type of valuation questions. This step is critical to the elucidation of an accurate WTP for a specific context-dependent environmental good. To adequately ascertain reliable responses, a hypothetical scenario will require three elements: A description of the policy change; a description of the market where a transaction takes place; and a description of the payment method. These three elements will be discussed at length under the heading *Questionnaire Design Process – Developing CV Scenarios*.

A number of concerns regarding the validity and reliability of data gathered using the CV method, and other survey based studies, remains controversial. These concerns pertain primarily to inherent biases in individuals that arise due to problems associated with survey design. Table 2.3.1. below outlines these biases. The high and low strategic bid biases, are sometimes referred to as the embedding affect where a respondent feels they will be able to influence a policy decision by providing an intentionally skewed response.

The influence of many of the aforementioned biases can be minimized through the careful and thoughtful construction of CV scenario. Providing adequate background information and presenting the scenario using readily comprehensible language and concepts determined through focus groups and pre-testing will improve the robustness of survey conclusions. To ensure that results are accurate, PAM describes a series of validity tests appropriate for this particular methodology. The first test involves regressing the estimated WTP on the socio-economic and demographic variables to ensure that they are accurate determinants. This accuracy will be demonstrated by significantly high coefficient of determination values for an independent variable such as income. PAM reports that, previous studies (Kahneman and Knetsch (1992) and Descousges, et al. (1993)) discovered that WTP does not change as the quantity, or scope, of a good changes; however, calculating whether WTP increases with the quantity of a good is another way of ensuring valid and accurate results.

Table 2.2.1: Contingent-valuation survey biases

Bias	**Description**
Low Strategic Bid	Respondent lowers bid assuming others will pay more
High Strategic Bid	Respondent bids higher than actual WTP to influence project approval
Hypothetical Bias	Respondent does not believe in the option due to the hypothetical nature of the scenario and has trouble constructing accurate preferences
Poor Sampling	Insufficient non-representative or non-random sample was collected
Starting Point Bias	Starting point in bidding game influences final WTP
Interview and Compliance Bias	Enumerators influence responses
Payment Method Bias	Payment method affects response

Determining correlation coefficients for income and WTP for a good is another validity test described by PAM. If the good being valued assumes a normal elasticity of demand, then a positive coefficient is to be expected. A final validity test is to compare the results with other CV studies for the same good and determine similar trends in WTP.

The CV method has been gaining notoriety amongst academics and policy makers as an effective econometric tool. With the assistance of documents like WS and PAM, the robustness of this tool in its array of applications will increase. There is currently no uniformity in the design and application of CV surveys and, according to PAM, this should not be expected any time soon. Moreover, given the contextual uniqueness between studies, the development of a uniform model may not necessarily be effective. The authors conclude chapter 8 of their text by stating that the merits of robust CV studies validate the reliability of this methodologically sound econometric tool. The guidelines for meeting best practices summarized in this text and are beneficial for the advancement of this method. The next section of this essay outlines a vigorous CV procedure to ensure that best practices are followed (2003).

2.3 Questionnaire Design Process

2.3.2 Introduction to CV preparation

WS (2003) focus on estimating values for water resources specifically and propose a triphasic method for completing CV studies. The first phase is called *preparation* and consists of six independent steps. These range from selecting an interview technique and developing a sampling strategy, to designing the CV scenarios and determining costs and elicitation methods. The second component is known as the *implementation* phase. It has only two steps and focuses on training enumerators and pilot-survey testing, and implementing the final survey. The third phase involves data analysis and resulting policy implications. At this point, WS provide recommendations for data entry and analysis and ensuring that the WTP study data is presented in a way that informs policy decisions.

2.3.3 Survey Preparation

The first step to preparing a survey is selecting the interview technique. For this relatively short step, the researchers must ask, what form should the survey take? A number of options are available and include postal, telephone, internet, or personal interviews. The method selection should be based on the size of the study, literacy of the adult respondents, and access to technology such as telephones and computers.[7]

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[7] The Wedgewood and Sansom text focuses on water utility studies in underdeveloped regions. For this reason, they suggest that the survey be in the form of personal interviews due to mixed literacy levels and a lack of available technology.

The second step involved in survey preparation is to determine a sampling strategy and complete background research. Collecting information on the selected community through existing socioeconomic reports and visits to the location is necessary in order to develop an accurate hypothetical CV scenario with realistic options and costs. This scenario must include viable choices that meet the needs of the various consumer groups in the specific community to prevent the invalidation of responses through information asymmetries. Meeting with management staff to gather relevant data will allow the researcher to develop an understanding of the local water supply situation and provide for better scenario design.

Specific types of data that should be accounted for include census and population statistics, maps, information on other utilities and billing records, employment, and education. Reports already compiled for Savona, BC that will aid in developing this survey include Statistics Canada 2006 *Community Profile*, as well as the Thompson-Nicola Regional Districts 2009 *Annual Report for the Savona Water System*. Additionally, meeting with water utility managers and engineers will aid in the thorough understanding of problems with the water source and delivery system, as well as local cultural and social practices that may influence management options. To better understand the water system during preliminary research and survey preparation, a series of questions are provided:

- What is the relationship between key stakeholders such as consumers, local governments, and water managers?;
- What are the current prices from water sources including vending, kiosks, piped system?;
- How will costs be recovered for development and operation and management?;
- Are there problems with the supply such as power shortages, or a lack of chemicals or filters?; and
- Are any plans being initiated to change the management of services? (Wedgewood and Sansom, 2003).

The next important step in survey preparation involves selecting your sample size and method for ensuring that it is representative of the population. The largest constraints on the sample size are budget and time which often hinder the number of surveys distributed. To decide the number of individuals, researchers must account for: the population of the town and average household size, number of enumerators, number of questionnaires that can be completed each day (should be six to eight per enumerator per day); and the minimum portion of the total population to be surveyed. To complete the study in a timely manner, it is important to account for desired sample size based on the population, budget, and number of enumerators. For example, it would take two enumerators approximately nine days to complete 130 surveys using the personal interview format.

Achieving a random sample can be done using one of several probability sample methods. The *simple random sample* is the most straightforward of these methods. Once you have determined your required sample size based on budget and time constraints, each household must be assigned a number (in Savona this would be 1 to 260). Next, 130 random numbers must be selected using a table of all 260. It is then simply a matter of assigning those 130 numbers to the corresponding household. With this method, there is no opportunity for human bias or selection bias to occur as the sample is drawn purely on statistical theory. Another technique described by the authors is *systematic sampling*. This method involves selecting numbers from a framework of available addresses. If you are sampling 1 in 20 households, a random starting point is selected and then every 20th household after that is chosen for surveying.

Using maps to select a random sample can also be useful when there is inadequate census data or address information. For this method, a map is drafted showing the town borders, streets, housing density, high to low-income areas, key water system locations, and any other significant town details. Once the map is drawn, it can be subdivided further into geographic areas containing similar numbers of households – maybe one area per each enumerator. Next, a sampling strategy is determined based on the size of the subdivided areas, days to complete the survey, and number of enumerators. The strategy should be labelled on the map and include which enumerator will be surveying which area and when.

Stratified sampling is useful in towns where representative sampling may not be effective due to inequalities in income, education, and location. To reduce the risk of an unrepresentative sample being collected, regions are stratified according to a range of criteria. This method, however, is only feasible when there is adequate and up to date household information available. This method is also not well suited for small towns that encompass a small area and lack overall socioeconomic diversity when compared to larger urban areas.

The *multi-stage cluster sampling* technique is more commonly used in larger cities or across a number of cities. Larger regions are broken down into smaller clusters which are then segmented further. Next, addresses are drawn at random, possibly through a lottery process, and assigned to enumerators. In small towns such as Savona, this method is not necessary due to the close proximal nature of houses in the town.

Developing an adequate sampling strategy can sometimes be difficult given the multitude of community characteristics that must be considered. If local governments lack information regarding household locations and sizes, simple maps provide a suitable means of assessing survey distribution. It is important to ensure that an adequate number of surveys are delivered because as your sample size decreases, the sampling error experienced will increase. Once the organizational attributes have been worked out, researchers can begin developing the most critical component of the CV procedure, the hypothetical CV scenario.

2.3.4 Develop the CV Scenario

The third step in the survey preparation phase is to develop a contingent valuation scenario. This phase encompasses four specific steps that are to be considered when designing a realistic set of circumstances for the questionnaire. These steps are: define the options being offered to the respondent; decide which options will be provided to different households; choose a realistic payment method that outlines how the respondent will be asked to pay, and; select the elicitation method which can be detailed and depends on the types of WTP questions and options being offered. The information used to complete these steps will largely be determined by previous background research with community stakeholders and local governments (Wedgewood and Sansom, 2003).

Using information previously collected, a check list of water supply options should be used to determine the feasible choices that exist. A list of this sort may not be applicable for research conducted in Savona due to the strong influence of the TNRD in determining which options are best suited based on cost. The number of scenarios presented should also be reasonably small. This will improve the credibility of the survey and make reviewing data less complicated. The elicitation and review process can also be made more difficult for enumerators if a large number of choices are provided. Finally, it is important that the water supply options presented in the survey are realistic choices for resource management that will be accepted by the various consumer groups.

Market segments in small communities are determined mainly by the location of the property with regards to the core and fringe community areas. Savona, British Columbia seemingly falls into this category of explicit geographical fringe and core bifurcation. Statistics Canada reports the population of the Desert County Electoral Area to be approximately 1,600 individuals whilst more local sources claim the population of Savona to be approximately 650 suggesting that a fringe community exists beyond the town limits. To clarify separate consumer groups the researcher must consider the different house types, tenure of housing, income groups, and location to utility infrastructure. For example, to place a household connection in a home three kilometers from the next nearest connection may be cost prohibitive. Segregating consumer groups ultimately improves the survey design by meeting the demands of the various socioeconomic groups thus improving the financially viability of the utility development project.

Wedgewood and Sansom advise that the CV scenario should be slightly different for homeowners and home renters. A number of complications can arise from questioning the renter: first, the wording of the WTP question should change from utility fee payment to monthly rent increase; secondly, if the renter does not determine the utility connection type then it may be inappropriate to survey them. The author's also state that it is not appropriate to survey a household that already has a private connection (a private well) how much there WTP is to have a public connection installed. It is also stated, however, that if the water supply is unreliable, it may be valuable to question private connection households on preferences for alternative options. These additional options can be simpler and less expensive choices such as water kiosks that sell bottled water for drinking and cooking.

When designing a survey for a multitude of market segments, or consumer groups, it is important to be flexible when considering possible scenarios. In Savona, British Columbia, the respondents will likely be coming from within the core community and consist of one consumer group. Nevertheless, it is important to consider: is the house rented or owned?; Is it located in the core or fringe area?; What types of water supply systems are feasible in each area?, and; what level of service meets the demands of the various groups?.

Describing the water supply improvement in a given scenario is one of the largest challenges to CV researchers. A checklist of illustrative attributes that are normally included in a scenario are:

- The hours of service;
- The water pressure;
- The quality of water (boil water advisory impact);
- Location of water source;
- The regularity, fairness, and predictability of billing;
- How the water will provided through upgraded pipe system;
- Whether a water operator will collect fees and if so when;
- Whether bills will be monthly, quarterly, and flat rate or metered;
- Who manages the system; and
- Who conducts repairs on the system.

Parallel to the attributes of the system, the benefits of the upgraded system should also be described in the CV Scenario. These benefits should encompass the improved reliability of water quality and pressure, location of source to household, and ease of payment scheme. Because the WS document is designed for rural underdeveloped locations some of the options likely do not apply to Savona, BC. Additionally, it may not be valuable to question Savona residents on improved quantity infrastructure because these improvements are already underway via the intake pipe extension.

The ability of a community to reliably manage and maintain the delivery system must be considered. In many cases, this may reduce the technological scope of the improvement options. Moreover, social and cultural factors can play an equally large role in questionnaire construction. In Savona, this may include whether or not respondents favour private or public connections over one another. Preferences may largely be determined by social attitudes so researchers must account for this in survey design to include all groups. To determine if any social conflicts could possibly arise during the CV process it is important to discuss local issues with local resource managers and stakeholders.

The final consideration in scenario design is the institutional setting and payment method of the proposal. The methods presented must be realistic and clearly describe how and when the respondent will be paying for their utility improvements. The detail in the CV survey must be sufficient as to provide individuals the ability to realistically assess their WTP for specific scenarios. The author's note that how respondents will be charged can impact the maximum amount they will pay. Often, one improvement option can be presented with multiple payment methods in the questionnaire.

When designing the survey scenarios, it is critical to describe the capital costs involved in addition to the operation and management fees. If private connections are being provided, only a portion is likely to be covered by government subsidy resulting in additional moneys being required from individuals. These might include the purchase of pipes, water meters, storage tanks, and an initial connection fee. In Savona, it is doubtful that this will be a problem due to the cost-recovery constraint of the TNRD and efficient fee collection system. As a general rule, water managers attempt to limit these costs to prevent creating barriers for some people when entering the market or connecting to the system.

To summarize developing the CV scenario, the author's main point seems to be that adequate detail is crucial in describing the scenarios. This detail provides respondents with realistic options that are clearly understood and meet their multitude of demands. Although some of the considerations do not apply directly to a developed community like Savona that has benefited from years of a readily available water utility connection, many of the scenario design principles still apply.

2.3.5 Elicitation Methods

A well developed question using the right technique is more likely to elicit an accurate measure of an individual's true willingness to pay. The five types of elicitation methods discussed in this section are open-ended questions, bidding games, payment cards, referendum voting, and contingent ranking.

The direct open-ended question method asks the individuals to express their WTP for improvements to services offered in a scenario explicitly. With this method, the respondent is not offered any cues that might influence their response; however, there is no framework to aid in decision making. The idea of placing a price on environmental resources that have not traditionally had market values may be difficult conceptually for some respondents. This method also invites strategic overstatements, or strategic bias, for those who feel they will be able to influence a policy decision by grossly over or understating their true WTP. The bidding game method helps overcome this lack of realism and strategic influence associated with the open-ended question method.

A bidding game method scenario offers the respondent a range, or series, of bids beginning with a starting point. Typically, the bids begin with the lowest WTP option and increase incrementally. The individual is asked if they are willing to pay the bid option, and if yes, they move forward up the bid scale until a negative response is reached thus determining their maximum WTP. A method whereby the highest bid is presented first can also be used. In this scenario, a respondent is asked the maximum bid and then moves down the bid scale until a positive answer is given. This method is beneficial in that respondents have time to develop an opinion about the scenario as they move through the bid process allowing them to develop a more accurate WTP. A negative characteristic of this method is that it invites a starting-point bias. To avoid this, a split bidding method can be used whereby various starting points are presented in different surveys. If there are no major clusters around the lowest starting point then the starting-point bias has been overcome.

The literature provides several names for the referendum voting method including the take it or leave it method, and the dichotomous choice method. This technique provides the respondent with a WTP for a specific improvement to an environmental good. Two choices are then presented: Yes, I accept, or; no, I do not accept – hence dichotomous choice. This method is ideal because there is no reason for the respondent to answer untruthfully – i.e. no biases are introduced via the question format. More advanced statistical techniques are used to determine information such as mean, mode, and median WTPs for the good in question. These techniques include the logit and probit statistical methods which utilize probability theory to estimate values. The payment card method provides a simpler analytical tool.

In the payment card method scenario, an individual is provided with a list of prices for a certain environmental good and asked to select the answer that best represents their maximum WTP; however, this method invites a number of biases. For example, it was discovered that a large proportion of respondents often choose the lowest price offered resulting in starting-point bias. In a study conducted in Uganda, this method was found to possess the most inherent biases and was favoured least by researchers (Wedgewood, Oriono, and Sansom 2001).

The contingent ranking method provides respondents with a series of management options with a price attached and then asks them to rank their preferred strategy. According to Wedgewood and Sansom this method is becoming ever more common in the water sector. The literature uses the example of Participation, Ranking, Experiences, Perceptions and Partnership (PREPP) that has field tested the contingent ranking method with positive results. This method is usually used in focus group discussions instead of personal surveys or interviews. The biases in this method are derived from individuals in the focus group that may be overly vocal of their strong opinions. This may lead to one individual influencing the response of individuals in a large group; however, an experienced focus group chair, or facilitator, is able to reduce this effect.

To decrease the influence of biases in a CV study, it is beneficial to repeat the questions to the respondent and offer a chance to change the WTP that was initially provided. The major hindrance to reviewing and repeating the procedures is time. However, by conducting a review biases can be reduced. Additionally, providing adequate information and time to answer carefully designed and well explained questions limits the influences of prejudicial responses. A description of biases is provided in Table 2.4.1.

Table 2.4.1.: Inherent CV biases

Bias	**Description**
Low Strategic Bid	Lowers bid assuming others will pay more
High Strategic Bid	Bid is higher than WTP to influence project approval
Hypothetical Bias	Respondent does not believe in the option due to the hypothetical nature of the scenario
Poor Sampling	Insufficient non-representative or non-random sample was collected
Starting Point Bias	Starting point in bidding game influences final WTP
Interview and Compliance Bias	Enumerators influence responses
Payment Method Bias	Payment method affects response

The literature describes a study in Bushenyi, Uganda that tested the effect of different elicitation methods on response values. According to the study the least successful of all techniques was the payment card method. This was primarily due to the introduction of strategic bias. By allowing the respondent to see all prices on a card resulted in the selection of the lowest price provided more than 50% of the time. On the other hand, the most successful technique was the bidding games method. In the Bushenyi, Uganda study, enumerators provided ample information and time for respondents to choose their WTP. Those surveyed were then given a chance to review and change their answers. Although approximately 30% did raise or lower their bid, no pattern was observed. This method was preferred because respondents took the survey more seriously and sincerely considered the option they wanted and the amount they were able to pay.

The manner in which the elicitation method is presented to the respondent needs to be carefully designed and revised. Often, multiple elicitation methods are initially offered and then reduced once field testing has determined the most appropriate technique. Factors that result in method selection can include the type of service being offered, location of respondents relative to the core or fringe of a town, as well as different market segments or income groups.

In summary the authors offer a series of considerations for CV practitioners during the elicitation method design phase. Although these have been outlined in previous sections, reiterated they include:

- Developing one or more CV scenarios for different market segments;
- Accounting for social and cultural factors;
- Accounting for institutional and political factors;
- Payment methods and their realism; and
- Which elicitation technique is used and what level of statistical analysis is possible.

By accounting for these factors during the selection of the elicitation method, as well as providing enumerators with the tools to adequately explain survey questions and options, errors and biases in CV studies can be reduced.

2.3.6 Determining Option Costs

This section addresses the issue of assigning realistic costs to goods which are the focal point of CV studies. The goal of a CV survey is to estimate the willingness to pay for a good or service for which a market value does not exist. For this reason, a range of WTP options is often provided using one of the five elicitation processes discussed in the previous section. Once appropriate scenarios have been designed, researchers must estimate as accurately as possible what the costs will be. There are two key factors that must be accounted for when estimating appropriate prices, these include: how the cost of the good or service, in this case an improvement to water supplies, will be paid for; and, whether to use realistic or random prices. Using random test prices improves the precision of statistical analysis and may more accurately reflect the real maximum willingness to pay.

Determining how the initial capital costs of infrastructure upgrades will be paid for is important. If local governments will not cover the construction costs, then this aspect must be included in the real costs of the CV scenario in addition to future tariff schemes. Whether or not these costs will be included will depend on specific situations but ultimately it will be determined in the field during discussions with key stakeholders. Explaining these costs during the survey elicitation process is critical to ensure that respondents understand the policy implications of the survey. The author's provide examples of how some individuals become confused during the survey elicitation process. For example, during a CV study in Mozambique (Whittington, 1997) some individuals believed that the price they selected from the range offered was the actual cost they would pay. This led them to believe that some households would pay less than others if they selected a lower bid which was never the intention of the researchers.

It is critical that scenarios are presented in such a way that respondents understand the hypothetical nature of the question and that the service in question may or may not be offered. In small towns CV studies are usually commissioned during "live" projects resulting from a privatization program, local council agendas, or centralized management by national governments (Wedgewood and Sansom, 2003). The economic theory of maximizing WTP to assess economic benefits is replaced by a more practical approach of offering accurate pricing for potentially real improvement options. If households are unable to afford operation and maintenance expenditures to ensure cost-recovery and financial viability, then new options must be considered by project planners. However, a CV study attempting to determine how consumers value fresh water resources generally will likely be using hypothetical scenarios with hypothetical pricing that may or may not result in any kind of utility improvements being implemented.

The author's describe three types of costs experienced over the life cycle of a water supply improvement project. These are capital costs, recurrent costs, and replacement costs. Capital costs can be broken down into several main components. This includes hydro geological testing of area resources, drilling and pumping, reservoir construction, piping network, labour, and the cost of other individual components. Operation and maintenance costs can be slightly more complicated to calculate due to various payment and funding schemes that exist in various regions. Components that should be included when costing options are staffing and administration, electricity or fuel for pumping, chemicals for treatment, routine maintenance and repair, as well as meter reading and billing. Replacement costs simply involve the price of replacing expensive components of the water delivery system such as pumps. For example, if a pump lifespan is estimated to be five years, then the replacement cost should be divided over a five year period and accounted for.

The three types of costs previously described should also be adjusted for inflation and changes in interest rates. Stakeholders responsible for ensuring that long term operation and maintenance costs can be met should take expected inflation into account.

If inflation is expected to increase 5% annually a tariff scheme must cover future increases in the costs of staff wages, contracted services, and replacement parts.

In summary, this section explains the importance of considering the multitude of variables impacting the immediate and long-term costs of a water utility improvement project. Depending on the nature of the study, researchers are able to use realistic costs or those that are completely random in order to elicit willingness to pay bids. The step of costing options is critical in ensuring that the appropriate management direction is selected and that it will be financially sustainable in the areas of capital, operation and maintenance, as well as replacement costs.

2.3.7 Completing Survey Questions

The next step of the CV process involves drafting a contingent-valuation (CV) survey. According to the author's, this component of the process is relatively straightforward to carry out. The most important steps are ensuring adequate training of enumerators and including only the most necessary questions, as well as structuring the survey generally.

Using local community members and training them for the specific task of CV survey enumeration is important to best manage the research process. A lack of training may result in poorly explained questions during enumeration which will elicit inaccurate results. Another problem with CV questionnaires is that too many questions are used. Any questions that will likely not be analyzed due to time constraints should also be avoided. Correcting these problems is relatively simple and only briefly explained in this section, however, survey structure is discussed at length. A questionnaire should have three distinct sections:

- Section 1 – Introduction to survey and demographic/socioeconomic data;
- Section 2 – Existing water supply services; and,
- Section 3 – WTP data (Wedgewood and Sansom, 2003).

The introduction provides background information and explains to the respondent why the survey is being conducted so that they understand the context of the questions relating to scenario options and WTP. Without adequate background some respondents may be apprehensive about completing the interview or survey process. The amount of demographic and socioeconomic data that is needed will depend on the nature and scope of the survey. Several key areas to focus on, however, are income, expenditure, household size, employment of household members, and educational attainment. Researchers must consider why a question is being asked and how exactly the data will be utilized to benefit the study results. As a general rule, the authors note that no more than 15 questions should be asked in a single section.

The second section of the questionnaire focuses on the state of the existing water supply and consumption patterns in the community. Questions should focus on water used for drinking, washing, cooking, and seasonal variation in water use. It is standard procedure to determine the water source that is being utilized in each season (well, reservoir, vendor, surface water, rainwater, shared connection, private connection, etc.) and then ask specific questions about each water source. Specific questions may be required that relate to crop irrigation, livestock, or other situations where economic benefits accrue from water consumption. Determining the level of risk to consumer health due to poor water quality is also important. Often queries concerning the regularity of disease episodes or other health problems are used. Ultimately, these questions are most important for the engineers who will design upgrades to the water utility system.

The third section of the questionnaire is designed to elicit the WTP values. This section should build on the contingent valuation scenario and can be broken down into supply options, payment modes, and method of eliciting WTP.

Finally, enumerator feedback can be important when assessing the results of a particular survey. This can result in answers to uncertain questions or explanations in the survey, as well as a questionnaire being discarded if, for example, an obvious bias or unwillingness to participate truthfully is observed. Additionally, respondent feedback can be just as important in determining other factors influencing the decision making process of consumers. In McComb (2002), a CV survey ended with a section titled *retrospective reporting* and was completed by the majority of respondents. References made in the short reports related to factors affecting their WTP bid, such as cost or income, water quality, political issues, and using substitute goods such as water filters.

2.3.8 Managing a Successful Survey

Managing a successful survey extends balancing budgets and formulating scenarios to include adequate enumerator training and pilot testing. Enumerators are typically social science graduate students or individuals with past experience conducting in-depth household surveys. Background knowledge of sampling methods, water and sanitation services in the area, and local customs and language are also beneficial attributes for potential enumerators. The number of enumerators required will be determined by the size and scope of the survey. It is also recommended that project managers hire more enumerators than is necessary in case some drop out or are unable to demonstrate sufficient comprehension of the survey process. A final consideration is required for the cost requirements of paying and potentially feeding or housing enumerators due to travel distances.

Contingent-Valuation survey methodology is a process that is continually reviewed and revised. It is therefore important to ensure that enumerators receive adequate training to provide the most robust methods possible. Classroom training is recommended and should include a well planned curriculum that covers background information relating to the water sector and CV theory, as well as random sampling and questionnaire pilot testing. The enumerators will be required to carry out a wide array of tasks beyond delivering surveys and need to be prepared before data collection occurs. A short test is able to solidify the survey process and further isolate and remedy problems before they occur in the field.

An informal contract is recommend that clearly outlines the roles and obligations of the CV manager’s and the enumerators. These can include work ours, wages, expectations relating to behavior, as well as times for classroom and field training. This ensures a transparent process that reduces the amount of potential survey related conflicts. A “Survey Instruction Sheet” can also be provided to maintain continuity between the survey presentations by enumerators. This should cover basic information relating to filling out the survey as well as presenting background information and the questionnaire to respondents. In the Bushenyi study, a booklet accompanying the instruction sheet provided a household coding sheet, sketch map of the town with sampling zones, work schedule, and copy of the CV scenario script. Once successful training has been completed field sampling can commence.

The first step to sampling is familiarizing the research team with the area to ensure the sampling strategy is clear to everyone. Sub-divided geographic segments can be identified and a systematic route map drawn. The first houses to be sampled in each of the areas are identified and the random sample is then collected beginning with that point. A field supervisor should be present to work these details out with enumerators. The next step occurs during pilot testing.

The rehearsal for the real questionnaire distribution days is conducted through a pilot test. This occurs with real members of the public under the observation of the field supervisor. The supervisor is able to then determine the ability of enumerators through the test interviews. The questionnaire details discussed by supervisors and enumerators should include whether questions were difficult for respondents to understand, were interval ranges missing, and which WTP bids were acceptable. Each enumerator should conduct at least five pilot tests as it is an important part of their training. After several surveys the team should meet to discuss any recurring difficulties with the survey and make adjustments if necessary. Although the pilot tests will be conducted in the enumerators designated area, they will not be part of the sample for the larger study. Mistakes can often be made on the first day of testing and it is thus critical to review enumerator and survey performance and address any inefficiencies.

To improve the survey quality, focus groups can be used to discuss the attitudes and preferences of the target population. Participants can be screened or segmented based on age, gender, or type of water supply used. Different parts of the survey are they presented and feedback is provided by the local population. This helps enumerators develop better CV questionnaires and it also helps the people understand new options and payment methods. Incentives such as food and drinks or cash can be used to encourage people to attend focus group meetings.

In summary, the enumerator training process is a necessary component of robust CV research methodology. Comprehensive training plans and contractual agreements help to solidify the role of the enumerator and ensure that the process they are about to carry out is fully understood. Focus group discussions are also an effective means of testing the survey instrument during WTP studies.

2.4 Data Analysis and Interpretation

Data entry takes place once all of the completed surveys have been returned. One or two enumerators are often capable of creating tables in Excel to save time and money. Raw data must be entered in the same manner using some form of numerical codes for questions. In the data tables, columns should represent questions from the survey and each row should represent one complete questionnaire. Cleaning the data can take place by removing any surveys that are clearly skewed due to strategic biases.

Often CV studies show a strong skew towards lower WTP values. That is to say, a small number of people vote for high WTP options, while the majority of respondents select low WTP values, or even zero. This gives excessive weight to the small minority selecting high WTP choices and does not reflect an acceptable WTP for the majority of individuals. For this reason, selecting the WTP acceptable to the largest number of respondents, or the median WTP, is preferred to using mean WTP. However, both median and mean WTP deserve consideration and should be communicated for policy change decisions.

When conducting econometric analysis of data it is important to ensure that an experienced economist is used to produce reliable results. In developing countries, it is often difficult to acquire such an economist for water system improvements because of the cost and the fact that most specialists of this sort are located in developed countries. Using a professional also allows for more advanced statistical techniques such as multi-variate analysis and random utility models such as the probit and logit methods. The level of sophistication required is typically dependent on the size of the population being surveyed and the scale of the project. Often in large cities it is needed to provide quantifiable reassurance to donors and investors that the development will be financially sustainable. However, in smaller communities CV surveys without advanced econometric analysis is acceptable. These small communities often have smaller budgets for project planning and expenditures so limits are often placed on the amount of data used.

Once the data has been entered into a worksheet the results need to be checked to ensure they are plausible before conclusions are formulated for policy makers. It is important to determine the degree to which the respondent answers are true reflections of willingness-to-pay. Often socio-cultural dynamics can affect decision-making in the household and impact survey results. In understanding this relationship, researchers can improve the credibility of their recommendations. Additionally, respondents' answers should be somewhat consistent with prior expectations or the CV study may have been flawed at some stage. This can result from survey design, as well as enumerator bias. If one enumerator consistently has higher or lower valuation responses then doubts can be raised about the reliability of their survey delivery method. If an enumerator rushes through surveys, results may also be affected. It is therefore important to use enumerator codes and note the survey presentation times for each enumeration.

Socioeconomic data is used to help explain WTP results during analysis. Patterns in WTP and income, age, or education can be used to explain preferences for a particular option. WTP does not depend solely on income, but rather a combination of income, gender, education, and household size. Respondents with five or more years of education have WTP bids 25% higher than those with less education. Third is gender; however, the impact of this was dependent on the specific cultural context of the region. The perception of quality for a new water supply system also plays a large role in determining WTP. Reliability of the water system played the largest role on determining demand for a particular option. These main indicators were derived from summarizations from a World Bank Research Team that carried out 11 CV studies in various countries (Wedgewood and Sansom, 2003).

Simple frequency graphs, or histograms, are able to provide a graphic description of the socioeconomic conditions present in a community. These graphs can represent snapshots of certain aspects of education, employment, income, etc. More in depth social research could be conducted to determine income sources and the state of industrial and commercial diversity to help explain WTP trends. Geographical analysis can also be conducted to compare WTP bids between those living in community centers to rural households. In addition to graphs, refined academic tables can also provide adequate snapshot descriptions of the data. Once data has been verified to be statistically reliable and descriptions in the form of tables and graphs have been completed, any survey management and participation issues that have arisen during the process can be addressed before policy implications are discussed.

To help verify that any biases have been accounted for it is beneficial to include a question that asks respondents their willingness to participate in meetings concerning their water supply. It can also be useful to determine if they think it is reasonable to pay for improved supplies. In some areas, many residents believe it is the states responsibility to provide clean and free drinking water. In these areas, WTP bides are often lower than other regions. These influences can have large implications for the design of a demand responsive sustainable water supply service. It is important to avoid providing just econometric statistics that focus on finance and include other key findings from the CV data. This will help researchers better interpret the demand for a new water system amongst residents.

Often CV surveys can produce a mix of results. For example, the amount of respondents that prefer a private connection and the amount of individuals that prefer water kiosks may be split at around 50% each. A significant contrast between urban and rural preferences may also be observed. It is therefore important that CV researchers work with engineers and water utility planning officials to produce the most utilitarian outcome that will best service the demand present in a community.

In conclusion, this section has covered steps associated with data entry and result interpretation. Ultimately, data interpretation can be made much simpler by following robust survey design methodology. This helps reduce biases in WTP questions and accounts for other socioeconomic variables that may impact WTP. The use of histograms and thematic tables also aid in graphic data interpretation that assist in adequately conveying CV results to policy makers and non-economists.

2.5 Cost-Benefit Analysis and Policy Implications

WTP helps to measure an individual's gain in well-being or utility based on the maximum amount they will spend for a specific quantity of a good or change in services – for example water utility system improvements. Conversely, if a policy change reduces the amount of utility experienced by consuming a good a measure of willingness-to-accept can be used to determine the amount an individual will receive to forego the benefits of consumption. Determining WTA and WTP can help policy officials make pareto optimal choices whereby windfalls are able to adequately compensate wipe outs of environmental policy decisions. This is known as compensating variation and in theory, will recompense an individual to the point that their benefit is the same as it was before the policy change. Accounting for WTA and WTP during cost-benefit analysis produces a more widely accepted policy. If no amount is able to compensate the wipe outs then alternative measures must be considered.

Until recently, economists believe that these two measures of utility would be similar and there were no practical reasons given to choose one over the other. Benefits for a policy change, in a CBA context, could be measured in terms of a gain (WTP) or a loss (WTA) and it was believed they would produce the same results. More contemporary studies have shown, however, that great variation can exist between WTP and WTA. Typically, empirical estimations have proven that WTA is usually greater than WTP and this disparity is greatest for non-market goods (Horowitz, Kenneth, & McConnell, 2002). Additionally, CV researchers have spent less time exploring problems with WTA, or the compensation variation, because of a substantial hypothetical bias that is difficult to avoid. This omnipresent bias in WTA questions reduces the reliability of CV results designed for economic policy analysis (Cao, Ren, & Du 2010).

This short section has covered some basic considerations that researchers can apply when using WTP and WTA as a measure of change in utility. In promoting equitable policy moves, it is important to determine both of these measures to ensure that adequate compensation can be provided to those who will not benefit, or perhaps lose some benefit, from a policy decision.

2.6 Summary

A well constructed survey not only reduces the instances of problems relating to respondent bias, but also simplifies the interpretation and analysis of results. This is important when the ultimate beneficiaries of the research, policy makers and the public, know relatively little about the contingent-valuation method or WTP theory. Documents such as Pearce, Atkinson, and Mourato (2006), and Wedgewood and Sansom (2003), as well as previous work by Whittington, have helped improve the adoptability and reliability of CV study results. In order to be able to fully interpret and appreciate the water quality problems Savona residents' face and the influence environmental factors have on WTP, an understanding of the physical and biological characteristics of the drinking water source is required. Chapter 3 provides an assessment of the Kamloops Lake basin.

Chapter 3: Physical and Biological Assessment of the Kamloops Lake Basin

3.1 Introduction

The community of Savona, BC draws its drinking water Kamloops Lake using a surface water extraction method with chlorination treatment. The quality of water from the extraction location varies throughout the year and impacts drinking water quality in Savona; thus, understanding its characteristics is important for this research.

Assessments of Kamloops Lake that included multiple forms of water quality and ecological tests have been ongoing, albeit sporadically, for over fifty years. Early studies described the lake as oligotrophic which suggests low nutrient levels (Ward 1964). This typically results in high water quality suitable for a variety of human uses[8] due to the reduced instances of algae blooms. Low nutrient levels also increase the presence of dissolved oxygen which is important for the survivability of fish species, an important attribute for recreational services and ecosystem health. According to more recent literature the oligotrophic state of Kamloops Lake has remained unchanged for the past 50 years. However, sediment cores that date back as far as 200 years suggest that a more mesotrophic equilibrium state is maintained over time (Urban Systems 2009). The dimictic lake goes through two mixing periods each year that impact water chemistry and quality, as well as the richness and diversity of aquatic species. These findings highlight the complexity that exists within and amongst the limnological and biological processes of Kamloops Lake. This chapter aims to identify the physical characteristics of Kamloops Lake, surrounding land uses that impact water quality, other limnological information

[8] Clear oligotrophic waters provide a number of values for humans including drinking water, recreation, and landscape aesthetics. A significant amount of work has been completed on human values derived from lake ecosystems and the influence on community health in Canada (Krantzberg 2006)

relating to temperature, trophic levels, and biology, as well as monitoring strategies and resource stakeholders.

3.2 Physical Characteristics

3.2.1 Geography and Bathymetry

Kamloops Lake is located in a glacial relict valley and is effectively a deepening and widening of the Thompson River. It is 25 km long, 2 km wide and 145 m deep (fig 3.2.1) (Carmack et al. 1979). It is situated near Kamloops, BC approximately 10 km west of the confluence of the North and South Thompson Rivers and sits at 336 m.a.s.l. (International Lake Environment Committee 2011). According to an early assessment, of the lake there is a total shoreline length of 62 km and the surface area is roughly 5,584 ha (Ward 1964). The watershed area from the outflow on the west side of Kamloops Lake to Barriere is approximately 7,200 km sq (Fig 3.2.2). The dominant tributary of Kamloops Lake, the Thompson River, enters from the east near Tranquille and Kamloops, and flows out by Savona at the west end. All of the maps presented in this chapter have a North orientation.

Figure 3.2.1: Bathymetry of Kamloops Lake (Carmacks 1974)

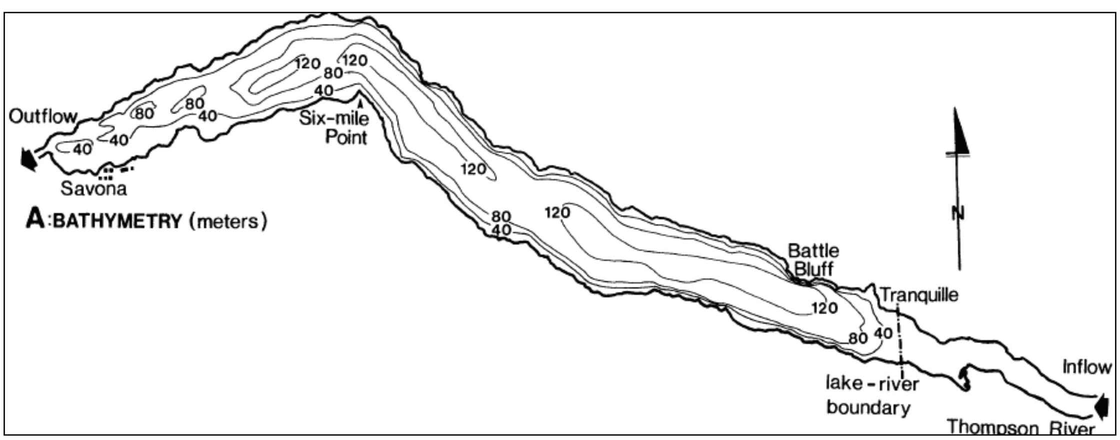
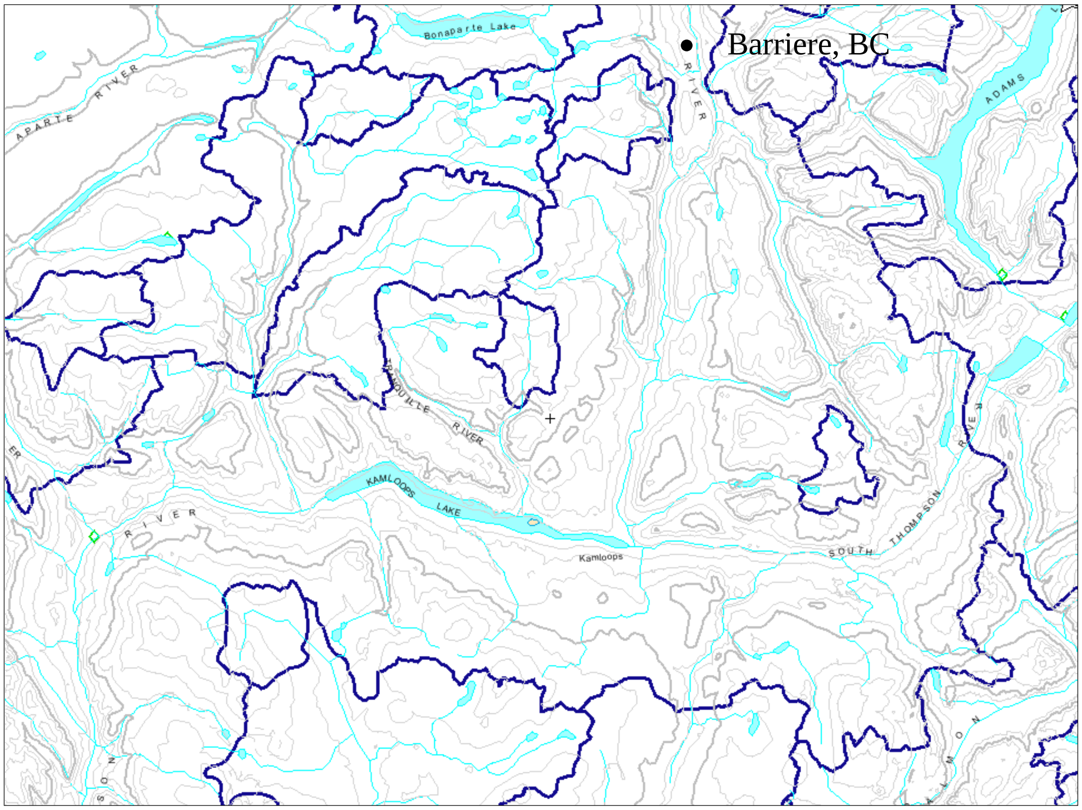


Figure 3.2.2: Watershed boundary of Kamloops Lake to Barriere (BC MoE 2011)



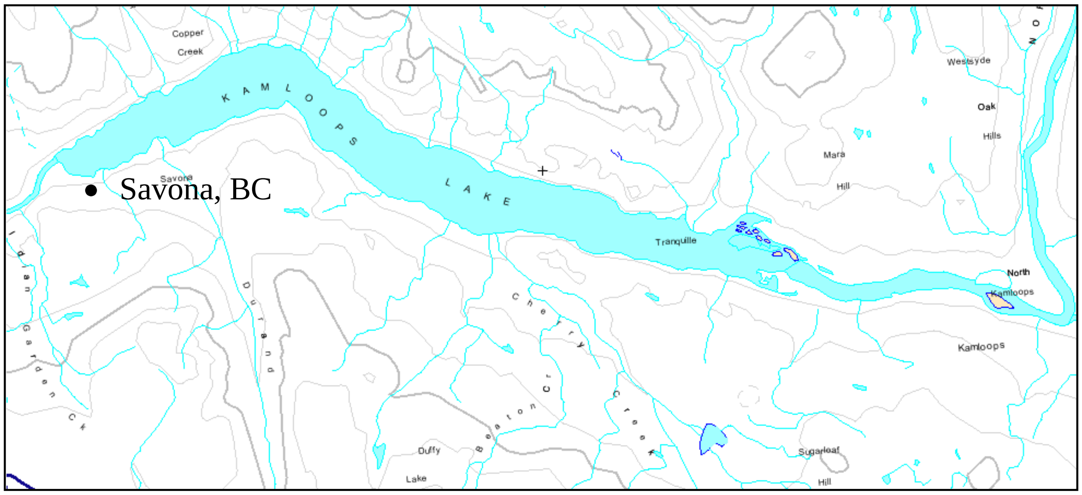
The lake is surrounded by a steep glacial trough that only slopes gently near tributary inlets and outlets. The surrounding landscape is comprised of mostly uninhabited grasslands with some forested areas and is in the Bunchgrass and Ponderosa Pine biogeoclimatic zones (Forest Service of BC 2008). Carved into the steep southern bank are the Trans Canada Highway (Hwy 1) and a rail line managed by the Canadian Pacific Railway. A railway line that is operated by the Canadian National Railway follows the northern shore of the lake. The community of Savona is located on the lake's south-western shore. Frederick is another small community located on the northern shore of Kamloops Lake and has a population of roughly 30 (Urban Systems 2009). Other settlements on or near the lake include the recent Tobiano golf resort development, Copper Creek, and Cherry Creek. Tobiano Resort includes a world class 18-hole golf course, equestrian centre, marina, and when complete, is expected to have 450 hotel rooms, 600 lake-view homes, and 500 multi-family units (Urban Systems 2009). A number of provincial parks can also be found near the lakeshore including Painted Bluffs Provincial Park, Steelhead Provincial Park, and the Tranquille Ecological Reserve (fig 3.2.3.).

Figure 3.2.3: Kamloops Lake with area parks and communities. (Google Earth 2011)

3.2.2 Lake Inputs

The British Columbia Water Resources Atlas (BC MoE 2011) was used to assess the number of streams and rivers flowing into Kamloops Lake. A total of twenty-four tributaries can be accounted for using this software. Tranquille River, Cherry Creek, Sabiston Creek, and Durand Creek are considered to be the lakes major tributaries aside from the Thompson (Fig. 3.2.4). However, the total flow for these four tributaries only contributes 0.2% of the lake's total inflow (BC MoE 2008). Durand Creek flows through Savona but is not in the immediate vicinity of the community utility extraction point. Another smaller tributary, however, does enter the lake near the water system intake pipe and was blamed by one survey respondent as a reason for high turbidity levels in the drinking water. The primary lake tributary is the Thompson River and this waterway is discussed in greater detail under heading 3.3.1.

Figure 3.2.4: Kamloops Lake tributaries



3.2.3 Land Use and Lake Use

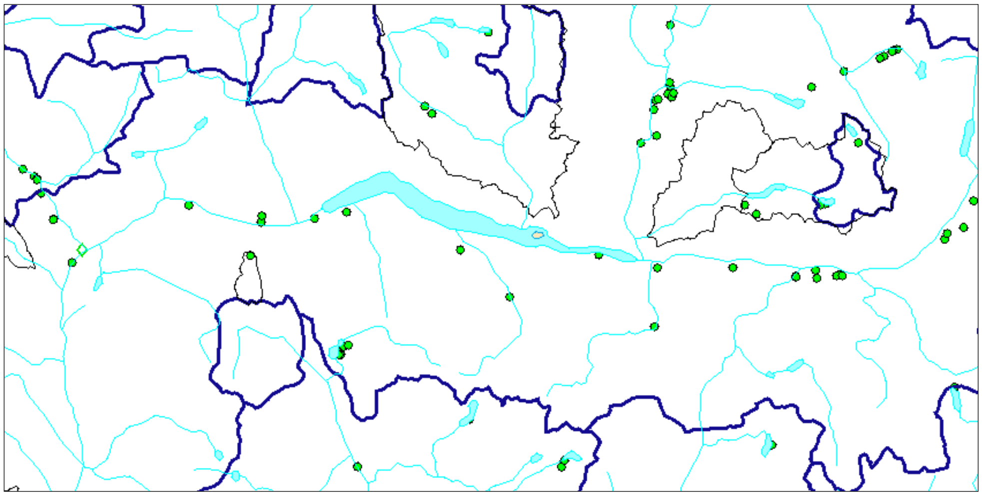
A number of land use activities exist within the Kamloops Lake Basin. They can range from relatively benign activities such as recreation to more intensive uses such as ranching, forestry, and mining. Many of these activities require significant amounts of lake water to operate.

Recreational activities on the lake include primarily swimming, fishing, and boating. There are three marinas on the lake that are located in Savona Park, Steelhead Provincial Park, and Tobiano Resort (Tourism Kamloops 2011). These locations provide direct access to the lake; however, access is also available from Kamloops via the Thompson River. Game fish species that can be caught in the lake include White Sturgeon (*Acipenser transmontanus)*, Chinook Salmon (*Oncorhynchus tshawytscha*), Kokanee and Sockeye Salmon (*O. nerka*), Coho Salmon (*O. Kisutch)*, Sucker (*Catostomus macrochelilus*), Rainbow Trout (*Salmo gairdneri*), Dolly Varden Trout (*Salvelinus malmo*), and Mountain Whitefish (*Prosopium williamsonii*) (International Lake Environment Committee 2011).

Aside from natural vegetation which covers 35,930 km^2 (92%) of the catchment surface area, agriculture is the largest land use. Fields for crops, which are limited to largely forage and silage (alfalfa and grass), corn, commercial vegetables, and tree fruits use 390 km^2 of land. Range land utilized for pastoral uses totals 780 km^2. Together, these two agriculture uses cover 3% of the catchment surface area. Agricultural activities near Savona use 1,710 acre feet of lake water annually for irrigation (International Lake Environment Committee 2011). Mining in the area is growing with the development of New Gold Inc. located near Kamloops Lake. New Gold Inc. has a license to extract 1,531,200 gallons of lake water each day. Afton Operating Corporation also manages a gold and copper mine near Kamloops and possesses a license that allows the extraction of 2,000 gallons per day. To some 1,700,000 gallons a day for two mining operations may seem excessive; however, Tobiano Resort has a license that allows them to extract 197,874,100 gallons per year, or an average of 542,100 gallons per day. Other extraction points and their associated quantity allocation include the TNRD which is licensed for 146,000,000 gallons per year for the Savona utility system, Ainsworth Lumber can extract 8,000 gallons per day, and the Canadian National Railway has a license allowing them to use 20,000 gallons a day (Urban Systems 2009). Figure 3.2.5 illustrates drinking water extraction points within watershed boundaries.

Lake water extraction is clearly important for not only Savona residents, but industrial and recreational users as well. The flipside of extraction involves the inputting of waste water and other effluent into the watershed. While extraction impacts water quantity, the upstream input of storm water, waste water, and other effluent can have negative impacts on lake water quality. Kamloops Lake water quality is discussed in a later section.

Figure 3.2.5: Drinking water extraction points (BC MoE 2011)



3.3 Limnology

3.3.1 Inflows

Hydrometric data for the Thompson River between the North-South confluence and Kamloops Lake is unavailable; however, Environment Canada stations are located on the North Thompson near the community of McLure and on the South Thompson near Chase. Data from these sites has been collected and is dated from 1911 to 2010. The hydrometric station numbers for McLure and Chase are 08LB064 and 08LE031, respectively. By combining the discharge of the Thompson River at these two points, the inflow to Kamloops Lake can be roughly estimated to provide a picture of how flow changes throughout the year. These values do not include water inputs to the channel from below the hydrometric stations, nor do they account for extraction that occurs due to agricultural, industry, and the city of Kamloops. Peak discharge for the river occurs in June with approximately 2,010 m^3/s of flow. The lowest flows of the year occur in February where the combined discharge of the two locations equals a mere 174 m^3/s

(Environment Canada 2010). The combined mean monthly flows of the North and South Thompson at Chase and McLure are summarized in Table 3.3.1, as well as Figure 3.3.1.

The average annual flow into Kamloops Lake from the Thompson River is approximately 668 m^3/s. Like many rivers in North America, peak flows are associated

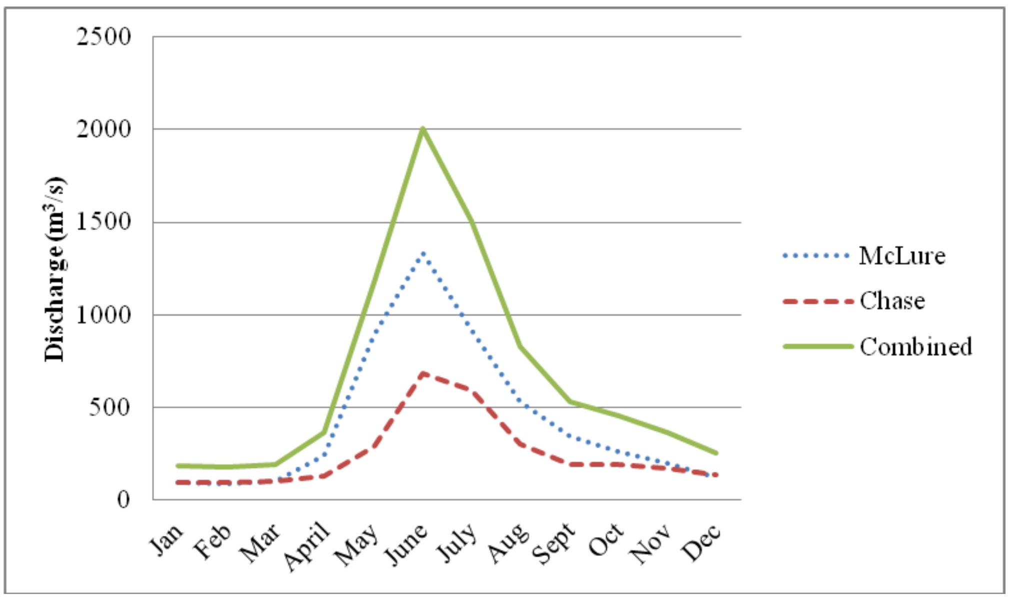
Table 3.3.1: Combined hydrometric data from the North and South Thompson Rivers (Environment Canada 2010)

Month	Flow (m^3/s)
Jan	182
Feb	174
Mar	190
April	363
May	1176
June	2010
July	1506
Aug	824
Sept	529
Oct	449
Nov	364
Dec	250
Average	668

with spring thaw, also known as freshet. This process is gradual and can be observed during the months of May, June, and July. Once the snow storage has been depleted at mid to high elevations, the river discharge rates begin to decrease dramatically. This reduction in flow is observed from August through the winter until snowmelt once again begins to infiltrate the river system in April and May. This relationship of snowmelt and flow volumes is directly linked to the residence time of Kamloops Lake, the mixing of epilimnion and hypolimnion layers, and water quality.

The residence time for Kamloops Lake, or the time that specific water particles remain in the lake system, vary widely across the year. As lake inflows peak during spring and summer freshet the residence time decreases to a mere 7 to 9 days between May and August. However, during the colder months when flows into the lake are diminished, residence time can vary between 100 to 340 days (Urban Systems 2009). On average, lake water is completely flushed from the system in 60 days, or approximately 6 times per year (St. John et al. 1976).

Figure 3.3.1: Average monthly discharge (m^3/s) from the North (McLure) and South (Chase) Thompson Rivers (Env Can 2010)



3.3.2 Temperature and Stratification

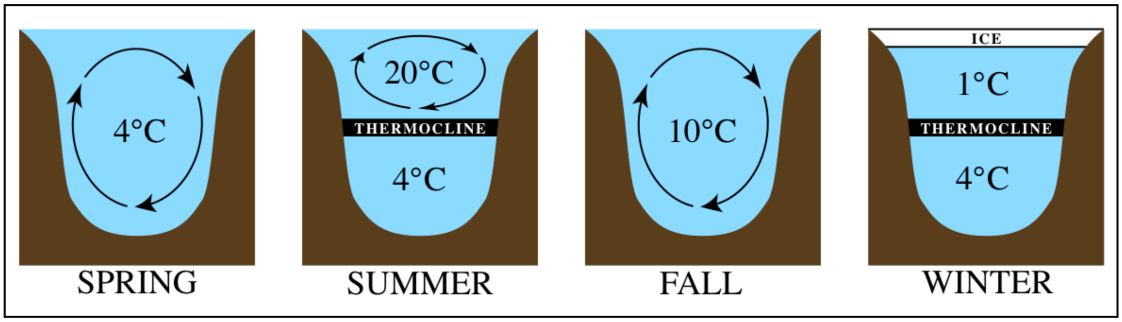
The stratification of lake water occurs due distinct temperature changes in the water column. Water that is colder is also denser and sinks to a greater depth relative to warmer water near the surface. The density of water, however, only increases until water reaches 4°C at which point it becomes less dense until it freezes to a solid state. In bodies of water that undergo significant seasonal temperature variability (i.e. are located in mid-latitude areas with hot summers and cold winters) this 4°C threshold is passed twice annually and adds to the complexity of the lake temperature-stratification relationship (Carmack et al. 1979).

Kamloops Lake can be bifurcated horizontally into two primary stratifications: The epilimnion layer which is located closest to the surface; and, the hypolimnion layer which is comprised of the deepest depths of the lake. These two layers are separated by a thermocline which can be defined as a uniform threshold of drastic temperature change. The extent of the hypolimnion and epilimnion layers change throughout the year in relation to seasonal air temperature changes and Thompson River discharge rates. In the summer months, the epilimnion slowly warms and becomes less dense than the inflowing river water. This causes the river water to sink to an intermediate depth in the lake. The warmer water essentially floats on the denser and much colder hypolimnion and no mixing occurs between the two layers.

In the fall, the river water cools faster than the lake water and sinks to a greater depth. Cooling continues until the epilimnion and hypolimnion are both at around 4°C at which point the lake becomes thermally homogeneous and a strong wind is enough to induce mixing between depths. During the winter, inflow from the Thompson River cools to below 4°C and once again becomes lighter, or less dense, than the lake water. At this point the inflow will once again float along the surface of the lake towards the outlet. Ice will also begin to form at the lake surface. A form of inverse stratification also occurs during the cold winter because the surface water is colder than the hypolimnion. The colder epilimnion remains at the surface because it is less than 4°C and therefore less dense than the deeper water which maintains maximum density at 4°C.

Finally, during the spring, the cycle is complete as the inflowing river water warms to 4°C and the lake once again becomes thermally homogeneous. As air temperatures begin to rise synergistically with increased incoming solar radiation, so does epilimnion layer which floats above the colder hypolimnion which is out of reach of the suns irradiance. At this point the lake becomes clearly stratified once again at a definable thermocline (Urban Systems 2009). This bi-annual mixing regime is a trait of dimictic lakes and common in the interior of British Columbia (Fig. 3.3.2). The thermo stratifications of Kamloops Lake, which fluctuate seasonally, impact water quality and suitability for anthropocentric uses.

Figure 3.3.2: Mixing cycle of a dimictic lake (Wikipedia 2011)



3.3.3 Water Quality

Several reports dating back as far as 1964 provide a glimpse into the state of water quality in Kamloops Lake. Initial studies were undertaken due to industrial developments such as a pulp mill and waste water treatment facility in the city of Kamloops that had the potential to adversely impact the chemical composition of lake water (Ward 1964; St. John 1976). Effluent from the Kamloops Wastewater Treatment Plant and storm water runoff, as well as discharged waste material from a pulp mill managed by Domtar are still reported to impact water quality in the Thompson River in more recent studies (Holmes 2011). Current monitoring of lake water quality assesses dissolved oxygen, phosphorous, nitrogen, specific conductance, fecal bacteria, and pH. The quality of water from the Savona utility system is also routinely tested for bacteria and turbidity (Thompson Nicola Regional District 2009).

Dissolved oxygen is an important indicator of ecosystem health in aquatic environments. Nutrient rich lakes often demonstrate low dissolved oxygen due to the respiration of organisms and consumption by decomposing matter. However, because

Kamloops Lake is classified as oligotrophic, or nutrient poor, significant oxygen deficiencies are not typically experienced. Initial assessments of Kamloops Lake measured a dissolved oxygen content of 8 to 12 mg/L (Ward 1964). St. John et al. (1976) do note, however, that the lowest dissolved oxygen concentrations exist near the lake inlet where nutrient rich sediments from the Thompson River accumulate. More recent assessments of lake water quality have been conducted by provincial ministries and industry (BC MoE 2008; Hatfield Consultants Ltd. 1996; Weyerhaeuser Canada Ltd. 1983). These studies have all verified the earlier findings of Ward (1964) and St.John et al. (1976) and found dissolved oxygen contents ranging from 8 or 9 mg/L to as high as 13 mg/L in Kamloops Lake. According to guidelines established by federal and provincial governments, this level of oxygenation is adequate for aquatic life.

Phosphorous in lakes is also linked to nutrient growth and eutrophication. In Kamloops Lake, total phosphorus concentration samples taken near Savona between 2003 and 2008 from 0 m to 60 m depth range from 2 µg/L to 14 µg/L (Urban Systems 2009). The highest total phosphorus occurred during spring freshet and resulted from increased silt which can contain phosphorus particles. According to the literature, this level of phosphorous is suitable for aquatic life but at certain times may exceed drinking water guidelines (BC MoE 2008). Nitrate levels in Kamloops Lake were also assessed by Ward (1964), St. John et al. (1976), and Nordin and Holmes (1992). These studies suggest that nitrate levels in the lake increase with depth from roughly 30 µg/L to as high as 321 µg/L at a depth of 140 m. Nitrate and nitrite levels fluctuate with location and season; however, the lowest values are observed in the summer and at shallow depths in the epilimnion. Generally, it can be stated that Kamloops lake is phosphorus limited, but not nitrogen limited (Urban Systems 2009).

Electrical conductance tests are used to determine the amount of dissolved solids in water. As the quantity of dissolved solids increases, so does specific conductance (SC) for a volume of water. Testing for SC was also included in the earlier work of Ward (1964) and St. John et al. (1976), as well as by Weyerhaeuser Canada Ltd. (1983) and the BC Ministry of Environment (2008). Evidence from all sources indicates that SC reaches a peak at the end of winter right before freshet. At this point, it is theorized that the inflow dominates the lake and dilutes the dissolved solids thereby reducing SC. After spring freshet, the SC gradually increases through the summer, fall, and winter. SC values have not changed drastically over time (BC MoE 2008).

One aspect of water quality that was not monitored in earlier research was the concentration of fecal bacteria. Recently, the provincial government has been collecting samples at various locations on Kamloops Lake beginning in 2003. Moreover, the Thompson-Nicola Regional District conducts fecal coliform and Escherichia coli tests on water from the Savona water utility (TNRD 2009). Generally all samples collected have been less than 10 CFU/100ml after disinfection from chlorination. However, higher rates are observed during the summer months and are attributed to migrating waterfowl that inhabit locations close to where sample collection occurs (Urban Systems 2009).

pH has remained neutral or close to neutral throughout the decades since testing began with Ward (1964). The most acidic measurement of 6.5 was recorded by Weyerhaeuser Canada Ltd (1983) in April 1980; however, the next most acidic value recorded is 6.9 from May 1978. The most basic lake water sample was collected by Ward (1964) and had a pH of 8.3.

Variations in measurements over space and time are not surprising given the dynamic and complex limnological nature of Kamloops Lake. Compounding the intricate processes of the lake, is coriolis force. This phenomena forces water flowing in from the Thompson toward the right hand shore line and causes the highest turbidity to be observed along the Northern Shoreline (Carmack et al. 1979). The inflowing river also influences circulation in the lake and is in some part responsible for high turbidity values along the northern shore, as well as variation in phosphorus and nitrate, dissolved oxygen, and fecal bacteria (St John et al. 1976). A description of the Savona water quality from the utility system is provided in the Site Description section of Chapter 4.

3.4 Limnobiology

3.4.1 Zooplankton and Phytoplankton

Plankton are an important component of many aquatic ecosystems and can be found in most lakes and oceans. They are typically a food source for larger vertebrate organisms such as fish and thus a key indicator of ecosystem health. Several studies have been undertaken in Kamloops Lake that sought to identify the state of zooplankton and phytoplankton populations (Ward 1964; Kelso and Derksen 1976; Anderson 1981; Hume and Shortreed 2007).

Zooplankton are multicellular invertebrates that are typically too small to see with the human eye. Earlier research on Kamloops Lake was able to show that the most common species were Cladocerans and Copepods (Ward 1964). Unfortunately, the techniques used at this time were unable to capture juvenile individuals during sampling and only a qualitative assessment was therefore feasible. According to the study, zooplankton were most abundant in June at a depth of 0 – 12 m. Kelson and Derksen (1976) studied plankton using finer netting and more robust methodology to assess plankton populations. In addition to Copepods, Rotifera were described as one of the most abundant species while Cladocerans were not found in any great abundance. The findings of Kelson and Derksen (1976) also found that zooplankton were most active from June to September. Further research was conducted in the early 1980s by Anderson (1981) that demonstrated Copepods were the dominant species and once again, they were most active in the warmer months of May to September. The most recent assessment was completed by Hume and Shortheed (2007) with the support of the Department of Fisheries and Oceans. In their assessment Copepods and Cladocerans were the dominant zooplankton species. Based on the limited studies conducted, it can be deduced that zooplankton populations in Kamloops Lake have not changed drastically over the past 50 years.

Phytoplankton, like zooplankton, are common in the open waters of lakes and oceans. They can be unicellular and are sometimes referred to as algae. An assessment of phytoplankton was void from Ward (1964) and did not appear in Kamloops Lake literature until the 1970s (St. John et al. 1976). Diatom were the most common species found with the Tabellaria, Fragillaria, and Melosira genera making up 34% to 64% of the total lake phytoplankton population. The abundance of these species coincides with the growing season and the lowest numbers were observed during the winter months. Relative to other lakes in the area, Kamloops Lake has a low abundance of zooplankton and phytoplankton. This has been attributed to the low residence time, cooler surface water temperatures, and high turbidity during spring freshet (Urban Systems 2009).

3.4.2 Benthic Invertebrates

Assessments of benthic invertebrates in Kamloops Lake are limited, however, studies conducted in the 1970s (Langer et al. 1975) and the 1990s (Hatfield Consultants Ltd. 1996) were able to demonstrate that chironomid larvae were abundant. Nematodes, Tubificid, and Oligochaetes are other common benthic organisms. Currently no monitoring of benthic invertebrate species is being conducted in Kamloops Lake (Urban Systems 2009).

3.4.3 Fish Resources

Kamloops Lake supports a number of fish species that are critical for ecosystem health and anglers alike. Species that are commonly found include White Sturgeon (*Acipenser transmontanus)*, Chinook Salmon (*Oncorhynchus tshawytscha*), Kokanee and Sockeye Salmon (*O. nerka*), Coho Salmon (*O. Kisutch)*, Sucker (*Catostomus macrochelilus*), Rainbow Trout (*Salmo gairdneri*), Dolly Varden Trout (*Salvelinus malmo*), and Mountain Whitefish (*Prosopium williamsonii*) (International Lake Environment Committee 2011). Due to the connection to the Fraser River via the

Thompson, Kamloops Lake is an important gateway for Salmonid species that spawn in interior rivers. However, the steep sides made up primarily of bedrock and high silt and clay content in the alluvial fan sediments near the inflow and outlet mean that the lake itself is not a suitable spawning ground.

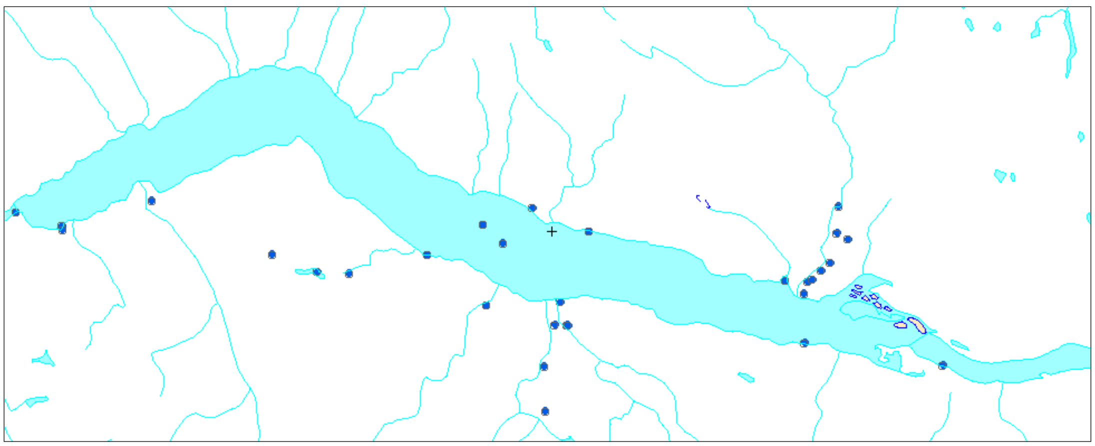
3.5 Lake Monitoring

Soon after the construction of the Kamloops pulp mill in the mid 1960s public complaints regarding water colour, decreasing benthic invertebrate populations, foam, and fish tainting led resource managers to initiate a monitoring strategy and form the Thompson River Task Force (Holmes 2011). This program continued through the 1970s to ‘80s and resulted in the publication of research by St. John et al. (1976). In 2003, a voluntary monitoring program was established and was inclusive of stakeholders along the North and South Thompson as well as Kamloops Lake. Some of these stakeholders include:

- City of Kamloops;
- Village of Ashcroft;
- BC Ministry of Environment;
- Fisheries and Oceans;
- Environment Canada;
- Domtar;
- Tobian Resort;
- Thompso-Nicola Regional District;
- Interior Health Authority;
- Fraser Basin Council;
- Savona Improvement District; and
- Various other native bands and industry partners.

Most lake water samples are collected every two months and tested for temperature, pH, alkalinity, turbidity, fecal coliforms and E. Coli., phytoplankton taxonomy, and raw water quality (Urban Systems 2009). Monitoring sites are located close to populated areas such as Tobiano Resort, Savona, Cooney Bay, and near Frederick. Water quality monitoring sites are illustrated in figure 3.5.1.

Figure 3.5.1: Water quality monitoring stations (BC MoE 2011)



3.6 Summary

Kamloops Lake is an integral part of the Thompson River system and larger Fraser River basin. The 25km long waterway is oligotrophic which is atypical of lakes found in the Interior of British Columbia. Its dimictic nature, however, is relatively common although the dominant influence of one tributary, the Thompson River in this case, is also atypical. Despite its important roles as a drinking water supply, source of recreation, and habitat for aquatic organisms, research on the lake has been sporadic over the years. It seems that more monitoring is completed upstream and downstream of the Lake. This may be due to the complex nature and interaction of lake processes which results in inherent research difficulties, or the accessibility of more accurate data on the confined tributaries. Perhaps a comprehensive and long-term monitoring program is simply not cost effective. Regardless, with the growing Tobiano Resort development and expanding regional mining industry, the limited knowledge available on this resource is cause for concern. The majority of water quality monitoring on the lake is conducted by the Ministry of Environment (Grace 2011). Other quality checks are tracked by the TNRD on the Savona water utility, and by Domtar and the City of Kamloops at associated facilities; however, the scope of these assessments are limited to the defined needs of respective stakeholders (Holmes 2011). The current monitoring strategies have also only been in place since 2003 and there are gaps in the extended history of lake characteristics and how they have morphed over time.

Although changes in the water quality and quantity of Kamloops Lake have been subtle over the past several decades, they are occurring. For example, a decreasing lake level resulted in a need for an intake pipe extension on the Savona Utility during the 2011 Summer (Hughes 2010). Although the lake remains relatively healthy and is not plagued by problems such as eutrophication or high levels of pollution, ongoing land use changes should prompt management officials to scan for potential conflicts that may arise in the future.

Chapter 3 has provided an overview of our study site, the Kamloops Lake Basin and helped elucidate some environmental considerations that impact management decisions. Chapter 4 assesses more closely the community of Savona, the water utility system, and the methods we followed when designing, implementing, and analyzing our contingent-valuation survey.

Chapter 4: Research Methods

4.1 Introduction

The goals of this research were to measure the environmental attitudes and perceptions of Savona, British Columbia residents, in combination with socioeconomic characteristics, to estimate their willingness to pay (WTP) to improve water quality in the community and assess factors that influence WTP. This goal was achieved through the use of a contingent-valuation (CV) dichotomous choice iterative biding scenario and binary logistic regression. It was our initial intention to survey the attitudes and WTP of households in rural communities surrounding Kamloops; however a distinct interest was expressed by the Thompson River Nicola District (TNRD) in a Savona case study. Savona residents face extensive boil water notices and water quality advisories year-round due primarily to high turbidity levels (TNRD 2010). The need to address the issue of water quality was also expressed in strong terms by the Savona Improvement District, a community based organization that helps manage the utility system (Fitzgerald 2011).

4.2 Site Description

Savona is located 32 kilometres west of Kamloops at the south-west end of Kamloops Lake in the Thompson-Okanagan region of Southern British Columbia. The lake provides the surface-water source that supplies 100% of the utility system's needs. After water is extracted from the lake, it undergoes chlorination before being pumped through a pipe network to approximately 265 customers (Hughes 2010). During the 2011 summer, the TNRD installed an extension on the intake pipe because it was on the verge of being exposed at the surface. This pipe has been extended to below 30 meters where water quality is reported to improve dramatically (Grace 2011; Hughes 2011).

The most reliable population data unfortunately includes the entire Thompson-Nicola “J” electoral district otherwise known as Copper Desert Country and is not limited to Savona Residents on the water utility system. The census concluded that the total population in 2006 was 1609 individuals that lived in 905 private dwellings (Statistics Canada 2006). However, the TNRD annual water utility report states that a total of 265 households are currently connected to the distribution system (TNRD 2010). The survey carried out during this research determined that the average number of individuals per household in Savona is 2.5. Using this information, a Savona specific population of 660 men, women, and children was estimated. Socioeconomic data was collected during our enumeration of the population and the results can be found in Chapter 5 of this document. A more detailed description of Kamloops Lake and the surrounding region is presented in Chapter 4.

The water quality of the Savona utility system is monitored by the TNRD. This organization is also responsible for issuing drinking water advisories and boil water notices to the community when certain water quality parameters, such as bacteria and heavy metals, exceed levels outlined by the Canadian Drinking Water Guidelines established by Health Canada. In Savona, the primary water quality issue revolves around turbidity and bacteria such as E.coli that are transported by suspended sediment in the water (Hughes, 2010). Health Canada guidelines stipulate that turbidity must be less than 1 nephelometric units (NTU). According to the TNRD, when turbidity levels exceed 1 NTU then drinking water advisories are issued. When a level of more than 5 NTU is reached then a boil water notice is circulated throughout the community.

Results from community utility system water samples taken in November and May 2010 both indicate that turbidity exceeded 1 NTU by 0.5 and 0.8 NTU respectively (Stewart Group, 2010). These two measurements were taken before the intake pipe was extended, and while water quality tests have been conducted after the intake pipe upgrade, a different laboratory handled the contract and turbidity levels are not mentioned in their report. However, other water quality parameters such as color, dissolved solids, and total metals do not exceed regulated levels. The results that are available indicate that, at least at some points in the year, turbidity levels exceed national guidelines and some form of corrective action is required.

4.3 Econometric Instruments

Economists have a number of tools at their disposal to estimate values for environmental goods that are not bought or sold in a traditional market place. Examples of these goods and services include biodiversity, aesthetic landscapes, as well as air and water quality. The hedonic regression, choice modelling, travel cost, averting expenditure, and CV methods are all useful approaches utilized by environmental economists (See Chapter 2). A CV survey was the principal econometric tool utilized in this study. Although the use of this method in water resource research is limited in Canada (McComb 2002), it has been utilized extensively in underdeveloped regions in Africa and Latin America (Mbata 2006; Rosado et al. 2006; Wedgewood, Oriono, Sansom 2001; Whittington 1997). In an experiment, survey respondents are presented with a carefully designed scenario that aims to garner their most accurate maximum WTP for access to a specific non-market good or service. The use of CV survey was justified for four reasons:

- firstly, it is described in the literature as an "adequate means of assessing human-environment interactions (Whitehead 2006);
- secondly, its framework allows for researchers to estimate a value for a specific environmental service (water quality in this case) versus a range of services which is common in related choice modelling studies;
- thirdly, the literature surrounding CV studies in water resource sectors was sufficiently abundant and aligned with our research goals; and
- finally, there was a need to expand CV studies in the water resource sector in Canada given the limited amount of information that is currently available.

This study also employed the averting expenditure (AE) method to assess the validity of WTP bids derived from the CV survey and to better understand consumer preferences for averting behaviour options. This revealed preference technique determined the amount a household spends to avoid drinking poor quality water by boiling, filtering, or purchasing bottled water (Wu & Huang 2001). Further treatise on the CV and AE methods will demonstrate their functionality in this experiment.

4.5 Constructing and Testing the CV Survey

Several documents in the CV literature discuss the importance of following a robust design process to avoid complications relating to poor sample collection, the occurrence of bias in an individual's response, and data analysis (Wedgewood and Sansom 2003; Whitehead 2006). Using information from a thorough literature review and discussions with TNRD officials, a draft survey was designed. Over many months, this initial survey was revised and edited until all stakeholders were satisfied with the final result. At this point the survey was distributed amongst the thesis advisory committee and additional feedback and edits were incorporated into the overall design and finer question details. To assess the interpretability of the survey by laymen, approximately 20 surveys were distributed amongst members of the public residing in Kamloops that have no association to Savona. It was necessary to test the survey with individuals outside of the Savona community to avoid influencing the opinions of respondents during the official survey enumeration. Additional surveys were tested with economics researchers at TRU, scientists working with Agriculture and Agri-Food Canada, fellow graduate students, and one individual that had extensive experience in survey design and draft proofing. The final survey was inclusive of input from the literature as well as from individuals that volunteered during the testing phase.

4.6 Survey Format

The final survey (APPENDIX A) was designed to be as easy to read and understand as possible given that no enumerator would be present while individuals responded to questions. Technical language was omitted and questions were presented in large font sizes to improve readability. The survey consisted of six sections including the title page and background information notations. This does not include the introductory letter (APPENDIX B) and follow-up (APPENDIX C) letter which were not attached to the survey.

The main document was titled *A Survey on Water Quality in Savona.* A cover page stated that research was being completed as a component of my Master of Science in Environmental Science Degree. Contact information for Dr. Peter Tsigaris and Robert Maciak was also provided on the title page. Background information relating to the Savona water utility was presented on page two of the survey. The details included were designed to inform the respondent of basic utility characteristics such as date of construction, reservoir capacity, and filtration process. A brief description of turbidity is also presented with a note on participation and consent which was stipulated to us during the Thompson Rivers University Ethics Committee approval process (APPENDIX E). Details pertaining directly to water quality, system upgrades, and boil water notices were omitted to avoid influencing choices made by respondents later in the survey which might incur a response bias. The subsequent survey sections contained data collection questions.

As per recommendations by Wedgewood and Sansom (2003) the survey began with broad and general attitudinal questions towards the quality of services provided by Savona and perceptions of water quality and the utility system. This portion was titled *Community and Water Issues* and included questions that would be used for descriptive statistics as well as in WTP modelling scenarios. It begins by assessing how the community ranks the need to improve services such as health care, drinking water quality, education, arts and culture, reducing crime, and improving city streets. These are followed by questions relating to the conservation of other utilities such as fuel for transpiration and electricity. Questions 1.4 through 1.8 evaluate the perception of water quality and the level of treatment and filtration currently being used. Respondents are asked directly how they rank the overall drinking water quality in Savona on a one to five Likert-scale with one being low quality, and five being high quality. If respondents selected three or less, they are then asked to state why they rate the water in Savona so low albeit due to odour, colour, taste, or risk of illness. Once general attitudes towards conservation and water resources are established, individuals are then asked a series of questions designed to determine and validate WTP for improved quality.

The most important question of the entire survey is found in the section titled *Willingness to Pay.* Here a hypothetical CV scenario is presented that asks residents if they are willing to pay more than what is currently being charged if it meant water quality would be improved enough that they would not have to boil or treat water in their homes in the future. The premise of this WTP scenario was derived from Androkovich (2011). The presentation of our WTP is viewable in figure 4.6.1.

Figure 4.6.1: Hypothetical CV Scenario used in Savona

Section 2: Willingness to Pay

The availability of high quality freshwater is important in maintaining a healthy community. Imagine that the local municipality is considering taking additional measures to improve the quality of drinking water in order to consistently meet guidelines mandated by the Interior Health Authority. In order to improve drinking water the local authority would have to raise additional revenue in order to pay the costs associated with increasing the quality. Currently, a dwelling is charged $35 per month for having access to water ($420 per year).

*2.1. If you **could be sure** that the water quality in Savona would be drinkable without any additional household treatment or filtration (including boiling), would you be willing to **accept an increase in your household's water utility bill** to pay for the improved water quality? Remember that accepting an increase in water utility fees requires either spending less on other goods/services or paying less for your current expenditures that improve water quality (e.g. water filter or bottled water)*

☐ *Yes* ☐ *No* → **GO TO QUESTION 2.2**

What is the maximum amount you would be willing to pay for improving water quality per month over and above your current access to water fee of $35 per month?

- ☐ Less than $5 more per month (please specify)________
- ☐ $5 - $6.99 more per month
- ☐ $7 - $8.99 more per month
- ☐ $9 - $10.99 more per month
- ☐ $11 - $12.99 more per month
- ☐ Greater than $13 more per month (please specify)________ → **GO TO QUESTION 2.3**

The dichotomous choice iterative bidding method was used to elicit WTP. Respondents are asked to indicate *Yes,* or *No,* hence the dichotomous choice. If they select yes, they are asked to indicate what the maximum WTP would be above the current $35 per month being charged. A bid price is selected from a list of options that range from $5 per month to more than $13 per month. Individuals read through the increasing bids and select one that they agree with. If respondents select *No*¸ and are not willing to pay more, then they are asked why they are not willing to pay to improve the service provided. A list of answers is provided and relate to a limited income, current fees already being too high for the services provided, and an unwillingness to pay due to individuals improving their water quality through home filtration products. The WTP scenario is followed by a series of questions that inquire about the current amounts homeowners spend to avoid drinking poor water quality. The measures taken are known as averting expenditures and can range from purchasing bottled water and jugs for water dispensers, to expensive home treatment systems such as reverse osmosis purifiers (Um, Kwak, Kim 2002). Costs are also associated with boiling water and relate to inconvenience and time commitments which can be estimated using wage rates.[9]

The risk of illness from consuming contaminated tap water was a concern for 36% of respondents (Chapter 4). In anticipation of this, several questions were included at the end of Section 2 that evaluated the incidence of individuals becoming sick from consuming poor quality water, and the impact this has had on their ability to work. A qualifying question of *Has a member of your household ever become sick from consuming Savona tap water?* is asked. Most respondents answered no and were directed to the next section. Eight respondents answered yes and additional information was gathered relating to the number of times they had been sick and the number of days of work that had been missed due to their illness. During statistical analyses, information from Section 1 and 2 is combined with household background information relating to gender, age, and income.

[9] Wage rates are determined for each household in Section 4 of the survey and estimate the cost of illness from consuming poor quality tap water, as well as the averting behaviour of boiling water.

The penultimate section of the survey assesses socioeconomic characteristics of the household. The placing of this section near the end of the survey and the nature of questions asked are consistent with contingent-valuation literature (Wedgewood and Sansom 2003; McComb 2002; Mbata 2006). The data was used primarily in binary logistic regression tests that estimated causation for changes in WTP. Close-ended definitive questions were presented for gender, age, number of individuals in the household, number of children in the household, employment status, and income. The income question was deliberately left until the end of the section to avoid offending respondents before WTP responses were indicated. The information gathered from the first three survey sections were limited to mostly close ended questions. To expand on our understanding of the attitudes and preferences of Savona residents in a more qualitative way, an opportunity to express personal thoughts was presented.

The fourth and final section of the survey allowed individuals to provide feedback in their own words. Ample space and horizontal lines that accommodated printing of various sizes was provided. Detailed results of this section, as well as all previous sections, are provided in Chapters 5 and 6.

4.7 Survey Enumeration

Once the contingent-valuation survey had been designed, drafted, tested several times, and revised, the enumeration process was initiated. A mail-out survey was used due to the size of the population, assistance offered by the Thompson-Nicola Regional District (TNRD), and time effectiveness. One survey was distributed to each customer connected to the Savona water utility system which equated 265 surveys total. The initial bundle of mail received by residents was mailed on August 11, 2011 and included:

- One 13 page survey;
- One envelope to return completed surveys with postage included; and

- One introductory letter that outlines the nature of the research project and stakeholders involved.

To help boost the overall response rate, a follow-up letter (*APPENDIX C)* was mailed out on August 19, approximately one week after the initial package. The purpose of this letter was to remind residents that the inclusion of their opinions is important and that it would be appreciated if they could return a completed survey as soon as possible. Respondents were given three weeks to complete the survey and return it to an office at T.R.U. courtesy of Robert Maciak. At this point in time data entry and analysis commenced.

4.8 Data Entry and Statistical Tools

The data set was populated by 88 individuals and 7656 observations. Due to the reasonably small nature of this dataset, data points were entered manually into tables using the Microsoft Office 2007 Excel spreadsheet program. The process of entering data involved a simple four step process:

- Firstly, a database structure was designed that would allow for easy data entry and accommodate binary numerical coding;
- Secondly, worksheets were created for each survey section and fields were entered that provided space for each individual and question;
- Thirdly, questions were coded (eg. Q2_9 for section 2, question 9) so that statistical analysis could be conducted using appropriate software; and
- Finally, the database was careful populated one survey at a time and cleaned of incomplete responses.

Some questions from sections one through three used ranges or likert-type scales. These included questions on environmental attitudes, WTP to improve water quality, and background information. To accommodate more complex econometrics, likert scale questions were assigned a column for each possible response. While populating the data set, a binary numerical code was entered for these questions. A zero indicated that a particular box was not checked, while a one indicated that a respondent had checked that particular box. When entire questions or sections of the survey were unanswered, table cells were left blank. Other values from hand written responses, such as monthly expenditures for water treatment or number of bottled waters purchased, were entered using the numerical values given by respondents.

Aggregations typically occurred within income and education classes, as well as perception of water quality and willingness to pay. A more precise explanation of these aggregations is provided in Chapter 5. Due to the mail-out nature of the survey, it was impossible to cleanse the data of mistakes made by untruthful respondents or errors by enumerators which is recommended in the literature (Wedgewood and Sansom 2003). No other anomalies in the data were recorded which is a testament to the survey design.

Statistical experimentation occurred after the dataset was populated with survey results. For the purpose of this research, three different types of analyses were conducted. The first and most basic type of analysis involved conducting descriptive statistical tests and producing tables that highlight means, modes, medians, standard deviations, and variance of the data. The second type of analysis was hypothesis testing. The means of answers were calculated then compared to determine statistical significance of critical WTP questions and identify any meaningful relationships amongst variables in a rudimentary way. Regression estimations were the third type of statistics conducted on the dataset. Ordinary least squares regression tests were conducted and produced some significant results. Binary logistic regression analysis, however, was more robust and was better suited to survey data. Tests were carried out using aggregated values in binary logistic models which were able to produce statistically significant outcomes. Logistic regression is a common tool for analyzing survey data and has been used in previous

WTP studies (Vasquez, et al. 2009; Mbata 2006, Egan et al. 2009). Model verification was conducted using various goodness of fit tests including simple linear regression and correlation. Hypothesis and regression tests were completed by exporting specific columns from Microsoft Excel to Minitab 16.1.1.0 statistical analysis software (Minitab Inc. 2010) which was able to accommodate the dataset and produce readily interpretable and robust results. Detailed descriptions of these tests are provided in Chapter 5.

4.9 Summary

The research techniques employed in this study are in line with methods established by previous contingent-valuation researchers (Whitehead 2006; Whittington, et al. 2007; and Androkovich 2011). The use of a guidebook designed to produce strong CV study results was also followed closely during the survey design process (Wedgewood and Sansom 2003). The result of a long and thorough preparation process, in addition to the inclusion of numerous national and international sources, was a process that was able to produce a concise survey and testable results. These results are explained in both descriptive terms and through empirical models in Chapters 5 and 6, respectively.

Chapter 5: Descriptive Analysis of Survey Results

5.1 Introduction

On August 11, 2011, with assistance from the Thompson-Nicola Regional District (TNRD), contingent-valuation (CV) surveys (APPENDIX A) were mailed to every household in Savona, British Columbia. In total, 265 packages were sent out, one for every customer on the water utility system. Included with the surveys was an introductory letter explaining our research premise (APPENDIX B), as well as a return envelope and associated postage for completed surveys. To boost our response rate from Savona residents, a follow-up letter (APPENDIX C) was mailed out asking individuals to complete and return their survey if they had not already done so. Between the dates of August 12 and September 4 a total of 91 surveys were returned. Of this 91, three were returned due to vacated addresses, and one was unusable due to missing information. In the end, 88 surveys were utilized for analytical purposes. This equated to a 33.2% response rate and adequate sample of meaningful data.

Descriptive statistics were completed for all survey questions. Tables outlining detailed results are provided later in this chapter. Section 2 formed the core of the CV survey and evaluated willingness to pay (WTP). A dichotomous choice bidding game method was used to elicit maximum WTP for improved water quality. Of the 88 respondents 39 (44%) indicated that they would be willing to pay a higher monthly fee for their water utility if quality was improved. The average WTP of the sample was $3.59 per month in addition to the existing $35.00 monthly fee. Of the 39 households willing to pay, the mean was $8.36 per month. Of course, an arguably more important detail is that 56% of respondents said that they were unwilling to pay more. Why exactly individuals were unwilling to pay is discussed later in this chapter.

CV surveys are known to elicit several different types of response biases and have been criticized for not always wielding accurate results (Whittington 2002). Some researchers have attributed the influence of bias in CV scenario questions to a respondent's inability to fully rationalize costs and benefits (McComb 2002). To help verify the accuracy of our findings, a CV scenario asking respondents what they are WTP to improve water quality was coupled with questions designed to identify a respondents averting expenditures (AE). AEs are purchases consumers make to avoid exposing themselves to unnecessary risks. In our case, this means taking in-home water treatment measures in order to reduce the risk of illness or drinking water that is foul smelling or turbid. On average, Savona residents spend $13.60 per month on averting expenditures relating mostly to bottled water and household filtration system purchases.

In addition to the WTP questions, data was gathered on socioeconomic conditions of the household, as well as attitudes towards the water utility and other community services. The survey was developed to accommodate both qualitative and quantitative information. This has helped construct a reliable context for econometric analysis and more robust understanding of WTP. This chapter presents results from our CV survey in the form of descriptive statistics and commentary on the general findings and observable relationships.

5.2 Community and Water Issues Data

5.2.1 Socioeconomic Characteristics

Gathering data on the socioeconomic characteristics of our sample was important for two reasons: first, the information derived helped us develop a broader picture of the community and added context to our arguments; second, data used during econometric analysis allowed us to estimate causation for variation in WTP bids. Contrary to suggestions from Wedgewood and Sansom (2003), the section of our CV survey that gathers socioeconomic data came after the section on WTP, and Community and Water

Issues. This was done to avoid offending respondents early on and causing them to reject the survey before completing the WTP questions which formed the crux of our research. Despite explicitly stating that the survey is completely anonymous and information collected will be used for no other purpose beyond our research, many individuals chose not to respond to inquiries relating to income, employment, and level of education. Missing information did, unfortunately, result in reduced degrees of freedom during statistical testing.

Descriptive statistics for socioeconomic categories have been tabulated (Table 5.2.1 – 5.2.10). Age categories were selected based on the format used by Statistics Canada Community Profiles (2006). Our survey determined that the majority of Savona residents (57%) are aged 40-64 (Table 5.2.1). During the 2006 nation-wide census, Statistics Canada (2006) found that the percent of the population (POP) from the Copper Dessert Country Electoral District within this age category to be 46% (Table 5.2.1). Females were more likely to respond to the survey then males, 60% and 40% respectively (Table 5.2.2).

Developing an understanding of household demographics is important for assessing the microeconomic conditions within the community. Table 5.2.3 illustrates the number of single individuals as well as families living within a household. The majority of homes (53%) in Savona have two residents. Families, or households with 3 or more individuals, comprise 31% of the community.

Table 5.2.1: POP for specific age

Age	Survey (%)	Stats Can (%)
18-24	0	5
25-39	13	14
40-64	57	46
65-80	27	14
80+	3	2

Table 5.2.2: Gender Proportion

Gender	Survey (%)	Stats Can (%)
Male	40	47
Female	60	53

Dwellings with one individual residing in them comprise 11% of the community. There were three individuals that did not answer the question on number of residents per household. In one instance, a business was accidentally mailed a survey and chose to leave this question unanswered. On another occasion, a survey was mailed to a vacation home shared by multiple families. Another survey was missing this information for an unexplained reason.

Table 5.2.3: Number of residents per household

Household Size	No.	Percent
1	11	13
2	47	53
3	7	8
4	14	16
5+	6	7
N/A	3	3

The number of households that were inhabited by retired individuals was also estimated. In Savona, 36 respondents (41%) claimed to be retired. This is higher than the 30% of the population that is aged 65 or older suggesting that at least 11% of community members have retired early. The age and number of individuals per household in Savona is diverse. Equally diverse is the level of education achieved by residents (Table 5.2.4). Many Savona residents have at a minimum completed high school (20%), possess some post secondary training (17%), or are a college/university graduate with some form of degree, diploma, or trade certificate (56%). Only 6% of individuals surveyed stated that they did not complete high school. This finding helps characterize a generally well educated populace. A total of 42% stated that they are a college or trade school graduate which may be typical of a natural resource industry based economy.

Table 5.2.4: Level of education achieved

Education	No.	Percent
Some high school or less	5	6
High school graduate	17	20
Some college or trade school	16	19
College or trade school graduate	35	42
University Graduate (Bachelor's Degree)	6	7
Post graduate studies	6	7

To determine if individuals who rented their home were willing to pay as much as home owners for water quality improvements, we asked respondents if they were owners or renters of their home. In Savona, 97% of respondents said that they were home owners. Two renters were accounted for and three individuals left this question blank. The final question of the Socioeconomic section of the survey was on household income. Ranges covering intervals of $10,000 were provided starting with less than $20,000 and going to more than $110,000. Of the 88 respondents, only 61 (69%) chose to indicate their total annual pre-tax household income. Income classes were also aggregated into categories of low income (under $40,000), middle income ($40,000 to $80,000), and high income (over $80,000) (Tables 5.2.5 and 5.2.6). The mean and median annual household income of our sample was $60,687 and $65,000 respectively (Table 5.2.7). These were determined using mid-point values of income ranges presented in the survey.

Table 5.2.5: Number of individuals in aggregated income brackets

Aggregated Bracket	No.	Percent
Low	18	30
Medium	30	49
High	13	21

Table 5.2.6: Number of individuals in specific income brackets

Income Bracket (x$1000)	No.	Percent
<20	6	10
20-30	3	5
30-40	9	15
40-50	9	15
50-60	5	8
60-70	10	16
70-80	6	10
80-90	2	3
90-100	3	5
100-110	3	5
>110	5	8

Table 5.2.7: Annual household income statistics

Stat.	Income ($)
Mean	60687
Median	65000
Mode	55000
SD	31848

In addition to annual income, we asked respondents to state the highest hourly wage earned by a household member (Table 5.2.8). The open ended question was answered by 38 individuals (44%). A total of 50 respondents (56%) left this question blank because they were offended by the inquiry, retired, did not earn an hourly wage, or were on income assistance. Of the 38 responses, the average hourly wage was $29, the mode was $30, median $27, and standard deviation $9.70. Income data is discussed in section 5.3 of this chapter during the presentation of econometric results as well.

Figure 5.2.1: Distribution of Income

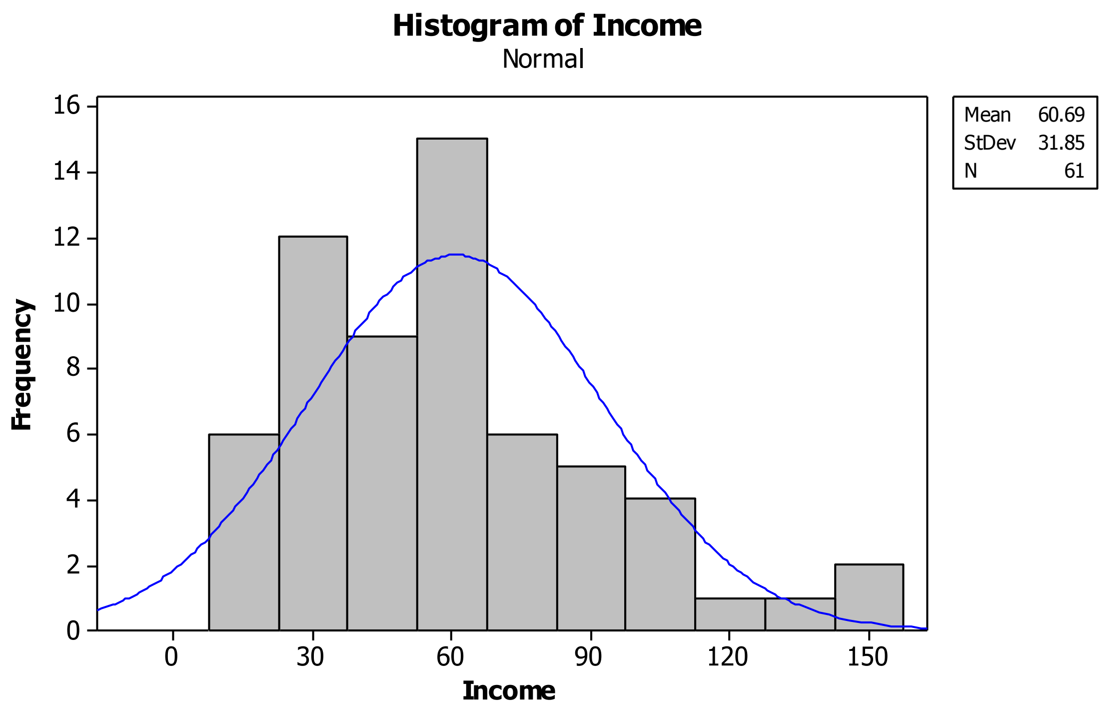


Table 5.2.8: Hourly wage statistics

Stat.	Hourly Wage ($)
Mean	28.98
Mode	30.00
Median	27.00
SD	9.71

5.2.2 Attitudes Towards the Water Utility

To gauge the attitudes of Savona residents towards their water utility, a series of questions relating to community services and perception of water quality were asked. The opening question of the survey inquires about the priority respondents place on certain community services such as:

- Improving city streets;
- Improving the quality of drinking water;

- Reducing crime;
- Improve the quality of health care;
- Improving the quality of education; and,
- Investing in arts and culture.

A total of 46 respondents (56%) stated that *Improving the quality of drinking water* was of the highest importance (Table 5.2.9 and 5.2.10). This was followed by improving community health care (54%), and education services (45%). The lowest ranked community service in need of improving was investments in arts and culture (39%), and improving city streets (25%). Although examining the extreme values provide some insight into the community's perception of services, analyses of means, modes, and medians provides a more accurate depiction.

Table 5.2.9: Number of responses relating to improving community services

	Low 1	2	3	4	High 5
Improving city streets	20	26	19	8	6
Improving quality of drinking water	1	8	15	12	46
Reducing crime	6	10	26	12	23
Improving the quality of health care	1	1	14	20	43
Improving the quality of education	6	12	11	15	36
Investing in arts and culture	30	25	13	4	5

Table 5.2.10: Percentages of responses relating to improving community services

	Low 1	2	3	4	High 5
Improving city streets	25	33	24	10	8
Improving quality of drinking water	1	10	18	15	56
Reducing crime	8	13	34	16	30
Improving the quality of health care	1	1	18	25	54
Improving the quality of education	8	15	14	19	45
Investing in arts and culture	39	32	17	5	6

Descriptive statistics for each of the community services were determined based on responses from a 1 to 5 likert scale (Table 5.2.11). Averages communicate a larger trend of community attitudes. The highest mean value, or the highest priority placed by the residents of Savona on an area most needing improvement, is healthcare at 4.3. This is followed closely by improving drinking water quality which had a mean value of 4.1. The difference is not statistically significant different from zero implying that improving these two community services are top ranked. The mode values for improving the quality of drinking water, improving the quality of healthcare, and improving the quality of education was 5 in all cases. Clearly these three are at the forefront of most people's minds when it comes to improving services. The higher standard deviation of improving education (1.4) suggests that there is less of a consensus within the community on the need to improve this particular service relative to the others. It would be interesting to compare these results to a larger community that had both good quality water and healthcare. Once good quality essential services are provided, I would speculate that a community begins to favour investing in the arts and reducing crime in a more acutely.

Table 5.2.11: Descriptive statistics of community perceptions

	Means	Mode	Median	SD
Improving city streets	2.4	2	2	1.2
Improving quality of drinking water	4.1	5	5	1.2
Reducing crime	3.4	3	3	1.3
Improving the quality of health care	4.3	5	5	1
Improving the quality of education	3.8	5	4	1.4
Investing in arts and culture	2.0	1	2	1.1

We were also keen to learn to what extent households in Savona made an effort to conserve water from their utility system relative to other services. A large majority (69%) of Savona residents make an effort to reduce their water consumption; however, relative to other utility services such as hydro electricity, natural gas for home heating, or fuel for transportation, water conservation lags behind (Table 5.2.12). This question focused on water quantity and is slightly disjunctive from the survey premise of attitudes towards water quality. Some responses in the survey relate to water pressure problems in their home and thus quantity, but it is clear that most individuals find improving water quality to be an important issue.

Table 5.2.12: Community conservation initiatives

	Conserved (%)	Did not conserve (%)
Electricity	80	20
Gas – Heating	75	25
Water	69	31
Transportation Fuel	73	27

After garnering information on the general attitudes of our sample towards community services and natural resource conservation, a series of questions probed more precisely the feelings respondents had towards fresh water and the utility system. The first question asked if Savona residents felt that the water conservation measures imposed in the summer by the TNRD were adequate (Table 5.2.13). A likert scale allowed respondents to indicate if they felt the measures were inadequate, excellent, or somewhere in the middle. Households are polarized on this issue and felt that the measures were either completely inadequate, or excellent. The majority of those that responded (71%), however, felt that the bylaws restricting summer watering were excellent.

Table 5.2.13: Attitudes towards water conservation measures in Savona

	Inadequate				Excellent
	1	2	3	4	5
Total	6	0	0	0	15
Percent	28.6	0.0	0.0	0.0	71.4

The new utility system intake pipe extension was expected to improve water quality to some degree as water in the hypolimnion layer is typically less turbid (Hughes 2011; Grace 2011). To establish if residents had noticed a marked improvement in water quality since the intake pipe was extended, we asked them if they had noticed an improvement since the extension was complete. Once again a likert scale was used with choices ranging from *No Improvement* to *Major Improvement* and also included a *Don't*

Know option (Table 5.2.14). The two most commonly selected answers to this question were *Don't Know* (29%) and *No Improvement* (29%). However, 41.5% of the population was able to state that they noticed mild to major improvements in their household water quality since the system upgrade. Some individuals (11.2%) selected 4 or 5 on the likert scale indicating that some homes are noticing major improvements. Some hand written side notes on surveys indicated that respondents who selected *Don't Know* felt that they required more exposure to the water before making an informed decision.

Table 5.2.14: Improvement to water quality after intake pipe extension

	No Improvement				Major Imp.	Don't Know
	1	2	3	4	5	0
Total	26	14	13	8	2	26
Percent	29.2	15.7	14.6	9.0	2.2	29.2

Savona currently disinfects its water through chlorination. Residents were asked if they felt this level of treatment was adequate. A likert scale was used that allowed respondents to rank the current level of treatment as *Inadequate,* or *Excellent* (Table 5.2.15). A *Don't Know* response option was also provided for this question. The majority of residents (52%) ranked the current level of treatment as 3 or higher. Almost one quarter of those sampled (24%), however, felt unsure about whether or not the current treatment used is adequate. Nearly one-third (30%) selected 3 as their response indicating that the current treatment process is at least adequate. A total of 26% ranked the water treatment process as 2 or less, signifying that they feel it is inadequate.

Table 5.2.15: Adequacy of current water treatment process

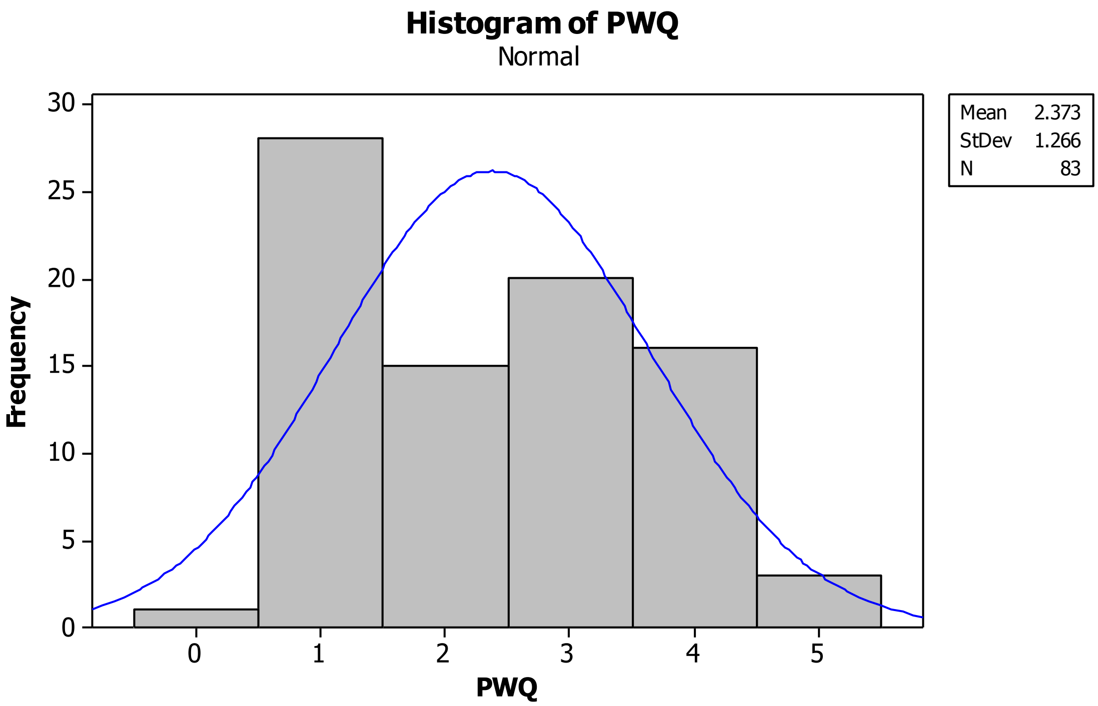
	Inadequate				Excellent	Don't Know
	1	2	3	4	5	0
Total	15	7	27	15	4	21
Percent	16.9	7.9	30.3	16.9	4.5	23.6

The final question on attitudes towards the community water utility and water quality dealt directly with consumer perceptions towards the resource. Respondents were simply asked to rank the overall quality of Savona drinking water. Options on the likert scale ranged from 1 (low quality) to 5 (high quality) (Table 5.2.16). Exactly one-third of respondents (33.3%) ranked their water quality as low quality. A total of 72% of respondents selected 3 or less when ranking their water quality. This number is somewhat shocking and lends credence to statements made by SID officials that many people are "disgusted" with the state of drinking water in Savona (Fitzgerald 2011). Further illustration of this finding is provided via figure 5.2.2. In an associated question, respondents were asked immediately after to state their primary concern with Savona drinking water if they ranked the quality as 3 or less.

Table 5.2.16: Perception of current water quality from the Savona utility system

	Low Quality 1	2	3	4	High Quality 5	Don't Know 0
Total	28	15	20	16	4	1
Percent	33.3	17.9	23.8	19.0	4.8	1.2

Figure 5.2.2: Perception of water quality



Respondents were provided with an open space to answer the question: *If you rank your drinking water quality as 3or less, what is your primary concern?* The responses varied, however, 31% of those surveyed felt that risk of illness, or "fear of sickness" as one respondent put it, due to consuming the poor quality tap water was a primary concern (Table 5.2.17). Colour was the next largest concern for people ranking their water quality as low (24%). In some cases, respondents provided detailed answers and described sediment gathering at the bottom of their bath tub and toilets. Other individuals used phrases like "swampy colour" to describe the water from their taps. To be fair, some households noted an improvement in colour since the intake pipe was installed. The taste and odour of water was also a primary concern for 21% and 15 of households respectively. Many people cited the smell of chlorine bleach as their primary concern. Finally, 9% of responses indicated that pollution was a concern. The term pollution is somewhat vague and encompasses many forms of contaminants. Noted by respondents were industrial and agricultural pollution, Kamloops storm drain outflow, dioxins and furons from pulp mill effluent, contamination from sewers and lagoons, and chemicals from unused medication. Many indicated that multiple poor-water traits concerned them. In total 103 concerns were described by the 88 respondents. Table 5.2.17 displays the percent of responses based on the sample size which is 88.

Table 5.2.17: Primary concerns relating to poor quality drinking water

	Illness	Odour	Colour	Taste	Pollution
Total	32	15	25	22	9
%	36	17	28	25	10

5.2.3 Stakeholder Reactions

There are a number of stakeholders that contribute to the operation and use of the Savona water utility. These include town residents, personnel from the TNRD, as well as staff from the BC Ministry of Environment and the Savona Improvement District. In order to gather an inside perspective on the workings of the water system, several individuals from different organizations were interviewed. Of course, the individuals with the most to win or lose with regards to a well functioning water utility are the Savona residents. It was important for us to also include some of their personal feelings in our analysis. The final section of our contingent-valuation survey provided respondents with an opportunity to provide unfettered feedback. The opinions expressed focused primarily on water quality in Savona, their personal feelings towards the survey costs and motives, as well as other policy dilemmas facing the town. Their criticisms, when combined with comments from water utility managers, provide a level of intimate understanding that is beyond the reach of quantitative econometric tools.

Throughout this research process the TNRD has played an integral role by providing funding and informational support. Peter Hughes (2010) is the Director of Environmental Services at the TNRD and has provided us with a plethora of water utility information relating to annual reports, infrastructure upgrades, as well as general encouragement. Correspondence typically took place via informal emails, however, more formal in-person meetings were also held. Our first physical meeting took place on May 14, 2010 at the TNRD office in Kamloops, BC. At this time we discussed problems facing the Savona water utility system. The primary concern for the TNRD in 2010 was decreasing lake levels caused by climate change that affected the utility intake pipe. It is noted that disruptions to the intake and quantity were being experienced. To remedy this, an intake extension was complete the following summer in 2011. The water utility disaster that took place in Walkerton, Ontario in 2000 was also described as being a catalyst for water management change in BC. This incident resulted in the Drinking Water Protection Act and the role of water utility management falling into the hands of regulatory agencies like the Interior Health Authority, instead of community members.

Economic aspects of the Savona water utility system were also discussed with Hughes (2010). The current system is based on a cost-recovery scheme. In Savona, 66.6% of the system is financed by government grants with the remaining 33.3% paid for by residents. Households are currently charged a $35 per month fee for their connection to the utility. In 2012, this amount will increase to $40 per month, and in 2013 this fee will once again increase to $45 per month. These rate increases are being implemented irrespective of plans to improve water treatment and quality which brings me to why the TNRD was so interested in this research. Without adequate information on consumer WTP, it is difficult for the utility managers and operators to assess their options for improving water quality delivered to residents via upgraded filtration infrastructure. We estimated that those residents that were actually willing to pay to improve water quality were, on average, willing to pay $8.36. When factoring those who were not willing to pay (i.e. willing to pay $0) the mean WTP drops to $3.59. These amounts are less than the rate increase will be over the next two years. The fact that many Savona residents are already upset about increasing fees with no improvement to service does not bode well for the future financial stability of the system.

Bernie Fitzgerald (2011) is a Savona resident and works for the Savona Improvement District (SID) in an administrative support capacity. It is essentially her responsibility to mail out bills and other notices relating to the utility. We discussed general attitudes of the community as she perceives them towards the utility as well as her role with SID over the phone on March 21, 2011. When asked, based on her experience as a community member, what Savona residents thought of the water utility, Fitzgerald stated very bluntly that “people are disgusted”. She described a situation where individual homeowners are forced to purchase expensive water treatment systems only to have them become clogged and unusable within a matter of weeks or months. She regularly receives complaints from people relating to increasing fees with no improvement in water quality. Interest was expressed in the survey and she feels that poor water quality is a major issue in her community. She was aware of the intake pipe extension but not of any initiative to improve water quality.

Meetings with Fitzgerald (2011) and Hughes (2010) took place to better understand the water utility as a system, its operation, and problems. To fully grasp the impact that Kamloops Lake is having on the system, a physical meeting was held with Robert Grace (2011), an Impact Assessment Biologist working with the BC Ministry of Environment on October 4, 2011. It is Grace’s responsibility to assess natural and anthropogenic impacts on water bodies, as well as assess permits for the Domtar Pulp Mill, City of Kamloops, and agricultural producers in the region. Our discussion focused primarily on water quality in the lake including pollution sources, monitoring, and land-use conflicts in the area. The influence of pulp mill effluent and sewage treatment ponds on lake water quality is superficial and related to colour and aesthetics. According to Grace, all discharged waste is non-toxic to humans and the pulp mill has routinely been compliant with regulations since the 1990s. In 1994 components of the pulp mill were also rebuilt which resulted in reduced chlorine bleach usage. Furon and dioxin levels were also reduced to negligible amounts. Other potential pollution sources include Kamloops storm water which enters the river untreated, as well as seepage from landfills and agriculture. Most agricultural impacts are isolated to the North Thompson River given that Shushwap Lake acts as a nutrient sink for the area, filtering nutrients and chemicals that might otherwise flow into Kamloops Lake.

Looking forward, Grace (2011) identified some potential land use conflicts related to water quality that might arise in the future. One is the expansion of mining in the area. Although it is unclear what impact each mine will have, Grace notes Harper Creek Mine which is located on the North Thompson near Vavenby, BC. Ajax mine drains into Peterson Creek and fairly large relative to other sites in the area. As communities along Kamloops Lake grow, the role of lagoons and community septic fields as a pollution source may increase. Finally, an emerging issue noted by Grace is the increasing input of endocrine disrupting compounds and personal care products and pharmaceuticals as problems. It is also the view of Grace that Savona will have problems with turbidity and water quality regardless of City of Kamloops or Domtar inputs.

The stakeholders with the most to win or lose when it comes to an effectively managed water utility are the residents of Savona. To capture their feelings toward the system, its operations, and water quality delivered, a full lined page to accommodated writing was provided on the final page of the survey. Over half (53%) of the respondents took advantage of this section and the opportunity to provide unrestricted feedback. A sample of some of the responses is provided here, however, a complete table with all comments typed verbatim can be found in Appendix H. The subject matter of responses provided was diverse. Some individuals took the opportunity to express their extreme displeasure with their water quality and increasing fees. Comments like “Need higher PSI and volume”, “we desperately need improved water quality”, “it smells awful”, “would you like to drink bleach and pay $400/yr”, and “Walkerton waiting to happen” were numerous. One individual wrote:

> *We used to pay $15 per month for water and garbage (only a few years ago). Now we pay $35 per month, and they are raising it every year. Other than extend our water intake, they have done nothing to improve our water. With raw sewage and pulp mill chemicals being dumped into our water, adding chlorine (another poison) into our water, hardly seems like*

> *a good way to treat the problem. They tell us that the biggest problem is turbidity, but that issue has not been addressed other than telling us we have to boil our newly, high priced, same old crappy water. Many (if not all) of the residents are very unhappy with the whole situation. We were also not told that the water rate would rise every year until after the deal was done.*

There were a few responses, however, that claimed water quality in Savona is fine. Many people felt that money would be better spent providing Savona with a sewer system or health care services. A lack of police presence in the community was also emphasized by some as being a larger problem than poor water quality. Other individuals expressed concern about turbidity during spring freshet, but stated that water quality is fine for ten months of the year. One individual wrote:

> *The present water quality is at an acceptable level for 10+ months of the year. High water each year increases turbidity levels to the point of boil water advisory or the use of alternate water supplies i.e. bottled water. To improve turbidity levels to an acceptable level during high water would cost more than I am willing to pay to offset 4-6 weeks of inconvenience and the use of alternate water sources.*

Other respondents were upset that money was being spent on yet another study instead of on projects that would improve water quality directly. Others were critical of the survey and felt it was a "waste of time", or that money could have been saved had smaller stationary been used. However, several respondents thanked us for taking an interest in their community and wished us luck with our research. The diversity of responses highlights the complexity in understanding the attitudes of Savona residents. I feel that most people appreciated a chance to voice their opinions and believe that this component of the survey was a success. As one practical and eloquent respondent put it:

I find very little wrong with Savona water, but I do have a reverse osmosis unit. Still I find a little discolour since they extended the pipe out into the lake. So I boil my drinking water. How long does it take to boil a kettle of water! Thank you and good luck.

5.3 Willingness to Pay Data

5.3.1 Contingent-Valuation Results

The second section presented in our CV survey was titled Willingness to Pay. Data for the CV scenario and averting expenditures were determined through a series of questions. The first of which used a dichotomous-choice iterative bidding scenario. Respondents were asked if they were willing to pay more to improve their water quality to a level that would not require additional filtration or boiling. If respondents were willing to pay more, they were asked to select from a range of bids. The lowest option was less than $5. Bids increased in intervals of $2 with a maximum of greater than $13. For both the minimum and maximum bid, a space for an open ended response was provided. (Table 5.3.1, 5.3.2 and Figure 5.3.1). A total of 39 out of 88 respondents (44%) were willing to pay to improve water quality delivered by the utility. Within this group of 39, one individual stated they were willing to pay only $1, while another lone individual said they would pay an extra $20 per month. The mean of the group was $8.36 per month on top of the $35 residents already pay. This brings the maximum WTP of respondents to $43.36 per month for a water utility system that provides potable water at a quality within Interior Health Authority guidelines directly from the tap. The confidence interval at the 95% level was $7.26 to $9.46 ($P<0.005$). When factoring in all votes, including the $0 bids that indicate an unwillingness to pay, the mean WTP drops to $3.59 per month.

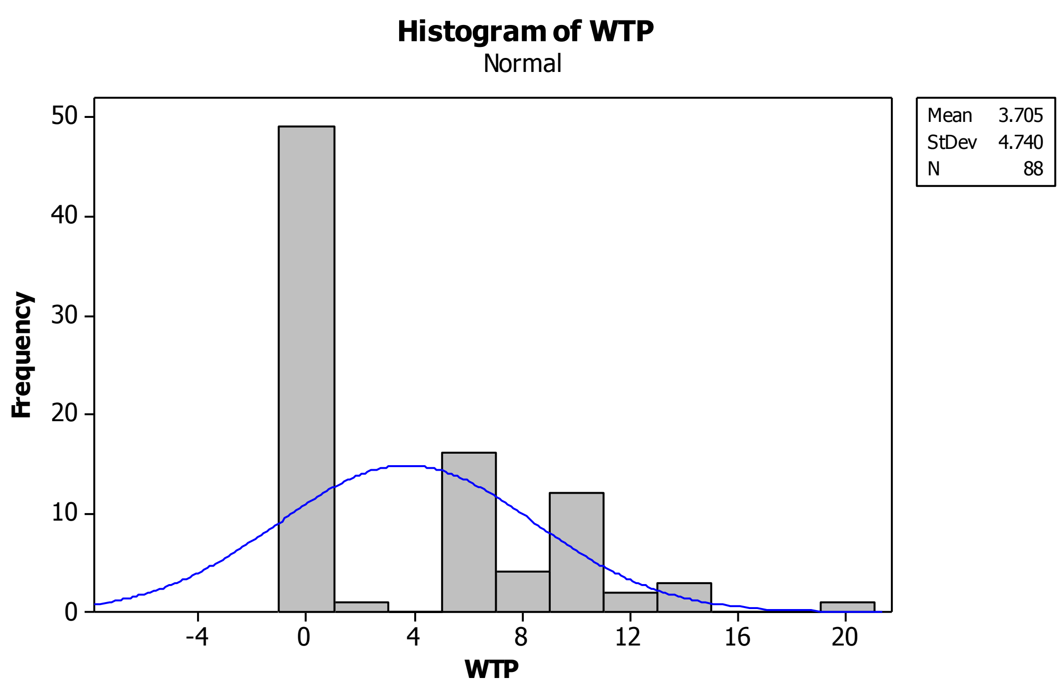
Table 5.3.1: Mid-points of bid prices selected for WTP

Bid Price ($)	No.	Percent
20	1	3
13	3	8
12	2	5
10	12	31
8	4	10
6	10	26
5	6	15
1	1	3

Table 5.3.2: Statistics for WTP scenario results

Stat.	Value ($)
Mean	8.36
Mode	10.00
Median	8.00
SD	3.39

Figure 5.3.1: Distribution of WTP bids



If respondents selected “no” to the dichotomous choice question, they were directed to a series of options stating why they were unwilling to pay to improve services provided.

In the question, it was indicated that individuals were able to select all options that applied. A total of 108 responses were recorded from 56% of households in the sample (Table 5.3.3). The most common response was “Fees are already too high for the service provided” (27%), followed by “I have taken my own necessary measures to improve the quality of water” (22%). Only 13% of respondents said they were unwilling to pay more because they felt that the current level of water quality was acceptable. When individuals selected the “other” option specific water filtration methods were noted. The responses “fees are already to high…” and “increasing fees will not solve the water quality problem” were designed to elicit protest votes, or those that are opposed to paying more for not false reasons. The nature of protest voters is described further in Chapter 6.

Table 5.3.3: Why water users were unwilling to pay more

Statement	No.	Percent
Fees are already too high for the service provided	29	27
Unable to pay more based on my income	15	14
Increasing fees will not solve the water quality problem	21	19
I feel that the water quality is already acceptable	14	13
I have taken my own necessary measures to improve the quality of water	24	22
Other	5	5

5.3.2 Averting Expenditure Results

Answers sought from the AE questions focused on costs to Savona residents associated with purchasing and maintaining filtration devices, bottled water, and time spent boiling water. This approach was consistent with Um, Kwak, and Kim (2002), and Wu and Huang (2001). A large number (38%) of residents claim to spend $0 per month on averting expenditures relating to water purification. The majority (62%), however, claim to procure products that help them avoid risk of illness or displeasure from consuming tap water (Table 5.3.4 and Figure 5.3.2). One respondent claims to spend $75 on expenses related mainly to bottled water purchases. The average amount spent by Savona residents is $13.4 per month. This is $5.04 (38%) more per month than the average willingness to pay without the inclusion of costs associated with boiling (Table 5.3.5). The implications of this observation are discussed at the end of the chapter. Using the average hourly wage and hours spent boiling water, the cost of this behaviour was estimated to be $21.41 per month for the average Savona citizen. This brings the total AE cost per resident to $34.81 per month.

A Pearson correlation coefficient of -0.248 ($P<0.059$) was estimated for AE amounts and perception of water quality. This suggests that individuals who have higher averting expenditure costs have ranked the community water quality as low. This relationship is explained further below in this chapter's discussion section.

Table 5.3.4: Amount spent on averting expenditures (excluding boiling)

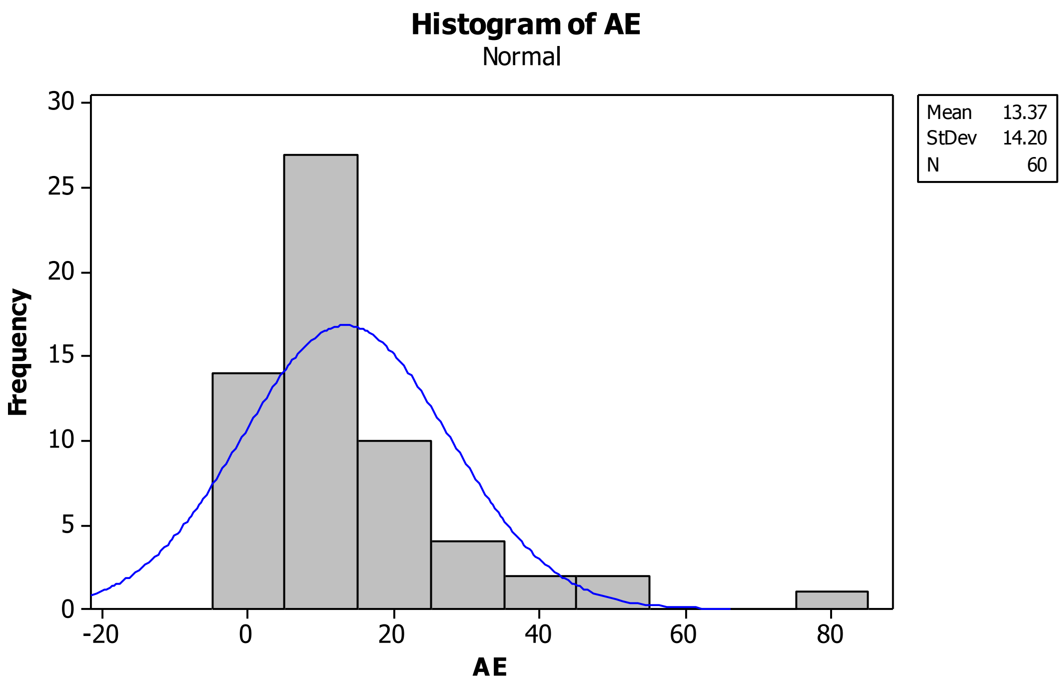
Amount	Frequency	Percent
0	33	37.9
$1 - $10	13	14.9
$11 - $15	16	18.4
$16 - $20	13	14.9
$21 - $25	5	5.7
> $25	7	8.0

Table 5.3.5: Descriptive statistics for AE purchases (excluding boiling)

Stat.	Value ($)
Mean	13.4
Mode	10.0
Median	10.0
SD	14.2
Range	75.0
Minimum	0.0
Maximum	75.0

Figure 5.3.2: Distribution of AE

costs

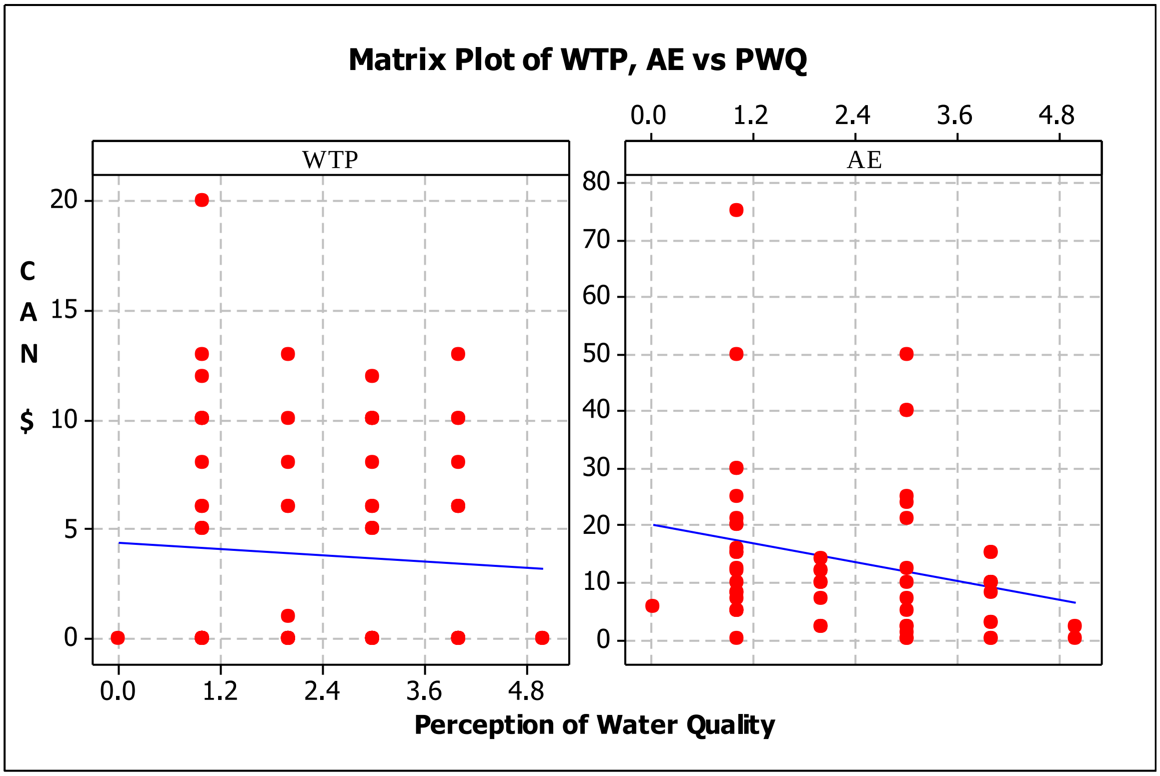


5.4 Discussion

Descriptive statistics were completed for all survey questions. It was determined that the mean WTP to improve the water quality of the Savona utility system is $43.36 per month. This is $3.59 more than the current rate of $35 per month. If all residents paid this increased amount, it would result in an additional $26,584.80 of revenue each year for the utility system. In Savona, 27% of respondents who were not willing to pay justified their decision based on fees already being too high for the service provided. Many individuals have taken measures into their own hands and spend on average $34.81 per month to improve their water quality. This includes the cost of filtration systems, bottled water, and time spent boiling water or traveling to purchase water. Furthermore, the AE estimates are likely more accurate given the inherent biases known to arise in CV studies and the difficulty some individuals have rationalizing the costs and benefits of a hypothetical CV scenario. Taking this into consideration, it can be said that the average Savona resident's maximum WTP, based on AE, CV results and current fees, is $78.17 per month. This cost may be out of reach for some low income individuals; however, one respondent noted spending $75 per month on water treatment in addition to the $35 monthly fee. It was initially suspected that this particular person may have been motivated by a strategic bias to influence policy, but given our WTP findings this amount seems understandable.

Another goal of our research was to estimate the influence of an individual's perception of the utility water quality on their maximum WTP. To determine this in a descriptive sense, correlation test were run and a matrix plot was created (Figure 5.4.1). There was no observable correlation between an respondent's perception of water quality and WTP. This test yielded a correlation coefficient of -0.100 ($P<0.550$). A correlation test of water quality perception and amount spent on averting expenditures was slightly more promising. In this test a correlation coefficient of -0.248 ($P<0.059$) was estimated. This suggests that as the perception of water quality drops, averting expenditure costs rise. A matrix plot demonstrates this relationship further in graphic form.

Figure 5.4.1: Relationship of WTP and AE to water quality perception



This first observation one can make is that the bids are fairly uniformly distributed with a small number of high and low bids for each category, with an abundance of responses resting close to the mean. The WTP and AE were both highest in terms of dollar value and most numerous for individuals who ranked water quality as 1 which was the lowest option available. To fully understand these relationships and the variables that influence an individual's decision econometric analysis is needed. The results from binary logistic and multiple linear regression tests are presented in Chapter 6.

Chapter 6: Econometric Analysis

6.1. The Determinants of the Probability of Willingness to Pay

In this section an attempt is made to determine the independent variables which may or may not have a significant influence on the probability that a household in Savona will be willing to accept an increase in water utility fees to improve their water quality. Since the dependent variable which we are trying to explain is dichotomous in nature, taking 1 or 0 values, the linear probability model (linear regression model) is not an appropriate estimation technique for a number of reasons (Gujarati, 2005). First, one cannot do statistical inference if ordinary least squares technique is used because the error term is not normally distributed. Secondly, it can be shown that the variance of the error term is heteroscedastic, finally there is no guarantee that the probability will lie within the 0-1 interval. An alternative method and one we use in this paper is a logistic curve. The logistic curve can be represented as follows:

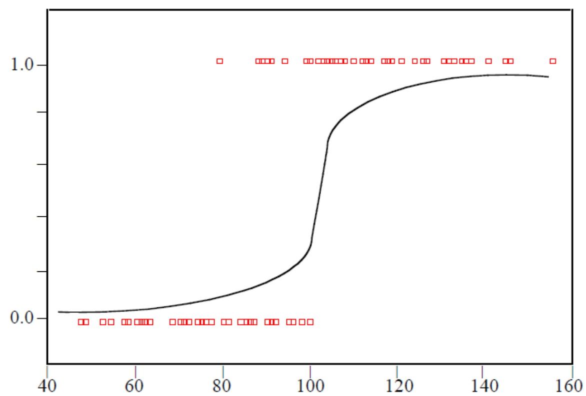
$$\pi_i = E(Y = 1|X_i) = \frac{1}{1 + e^{-\sum \beta_i X_i}}$$

Where, π is the probability that the household will accept an increase in his water utility fees. Hence $1 - \pi$ is the probability that the person will not accept an increase in utility fees to improve the quality of their drinking water. The X_i are the independent variables that have an influence on the dependent variable with β_i measuring the change in the probability that the household will accept an increase given a unit change in the independent variable holding constant the influence of the remaining variables (control variables). Letting $Z_i = \sum \beta_i X_i$ for ease of exposition we can re-write the above equation as follows:

$$\pi_i = E(Y = 1|X_i) = \frac{1}{1 + e^{-Z_i}}$$

This is known as the logistic distribution function and it can be illustrated using a scatter plot. Figure 6.1.1 displays a sigmoidal (s-shaped) curve that is typical of dichotomous choice data. The data takes this shape for two reasons: first, dichotomous data do not follow a linear trend line; and second, the errors are not normally distributed or constant. Logistic regression is able to determine the natural logarithm of the probability of π happening.

Figure 6.1.1: Sigmoidal curve from a logistic regression test



It is easy to show that even though the values of Z_i can range from minus infinity to plus infinity the probability, π_i, ranges between zero and one. Furthermore the relationship between the independent variables and the dependent variable is nonlinear and hence one cannot use ordinary least squares technique to estimate the above relationship. However, one can show that the above logistic regression can be expressed as a logit model:

$$ln\left(\frac{\pi_i}{1-\pi_i}\right) = \sum \beta_i X_i + e_i$$

Where e_i is a random well behaved statistical error term with mean zero, constant variance and uncorrelated error terms between the households. The dependent variable is the natural logarithm of odds ratio and denoted as $\ln\left(\frac{\pi_i}{1-\pi_i}\right)$. Hence, the log of the odds ratio is linear in the independent variables $Z_i = \sum \beta_i X_i$. The odds ratio is the ratio of the probability of accepting an increase in water utility fees to improve quality relative to the probability of not accepting an increase in water utility fees, $\frac{\pi}{1-\pi}$. The odds ratio is greater than unity when the odds are in favour of accepting an increase in utility. If the odds ratio is less than unity then the odds are against favouring an increase in utility fees. It is easy to show that the odds ratio can be calculated as $\frac{\pi}{1-\pi} = e^{\beta_i}$ for the respective influences. Table 6.1.1 summarizes the information for the dependent variable.

Table 6.1.1: Dependent Variables

Variable Acronym	Description	Values
π	Probability to accept increase in utility fees	0 - 1
$1-\pi$	Probability not to accept an increase in water utility fees	0-1
$\pi/(1-\pi)$	The odds ratio	0 and higher
$ln\left(\frac{\pi}{1-\pi}\right)$	The natural logarithm of the odds ratio	Numeric value

The independent variables that are expected to have an influence on the odds ratio are gender, household size, presence of children, household income, perception of water quality and measures taken to improve water quality. Table 6.1.2 describes the main independent variables that were used in the regression as well as the expected influence of the variables on the odds ratio. Prior expectations on the impact of the independent variable on the odds ratio are as follows: Females responding to the survey relative to males is expected to increase the odds in favour of accepting an increase in utility fees; a higher household size will decrease the odds but the presence of a child in the household is expected to increase the odds in favour of accepting an increase in water utility to improve quality; income is expected to have a positive impact but at a decreasing rate due

Table 6.1.2 The Independent variables

Variable Acronym	Symbol	Description	Construction	Effect on the odds ratio
GENDER	X_1	Gender	Dummy, 1 if male, 0 if female	$\beta_1 < 0$ Negative
HSIZE	X_2	# of people in household	Numeric integer greater than 1	$\beta_2 < 0$ Negative
CHILD	X_3	Presence of children in household	Dummy, 1 if a child resides, 0 otherwise	$\beta_3 > 0$ Positive
INC	X_4	Households income	$ mid-income value	$\beta_4 > 0$ Positive
INCSQ	$X_5 = X_4^2$	Household income squared	Square of X_4	$\beta_5 < 0$ Negative
PWQ	X_6	Perception of Water Quality	value of 1 (lowest) through 5 (highest)	$\beta_6 > 0$ Positive
MEASURES	X_7	Already taken own measures to improve water quality	Dummy, 1 if already taken measures, 0 otherwise	$\beta_7 > 0$ Unrelated if understood WTP question, otherwise negative influence
AE		Averting Expenditures	$ per household per month	Not used in regression due to use of the measure variable

to higher income groups already taken measures on their own; finally, the influence of measures already taken to improve water (i.e. averting expenditures) will have a negative impact on the odds ratio.

The binary logistic regression was estimated using Minitab 16.1.1.0 statistical analysis software (Minitab Inc. 2010). More than 40 regression tests were run using various combinations and aggregations of a number of independent variables. Models that produced significant results but were not quite as robust as the one highlighted in this section can be viewed in Appendix I. Establishing model accuracy was completed in three steps: first, specific model variables were examined using z-scores and p-values; second; log-likelihood values, p-values, and g-statistics were used to determine the statistical significance of tests for the complete model; and finally, chi-square values, degrees of freedom, and p-value tests assessed the goodness-of-fit for the model. The result of the estimation is presented below in table 6.1.3 and table 6.1.4.

Table 6.1.3 Response information with protest votes included

Variable	Value	Count
WTP Response	1	28 (Event)
	0	30
Total		58

* NOTE * 58 cases were used
* NOTE * 28 cases contained missing values

Table 6.1.4 Logistic regression table with protest votes included.

Predictor	Coefficient	Standard Error	Z-score	P-value	Odds Ratio

Constant	3.596	1.892	1.90	0.057	
GENDER	-1.813	0.866	-2.09	0.036	0.16
HSIZE	-2.235	0.917	-2.44	0.015	0.11
CHILD	5.845	2.340	2.50	0.012	345.60
PWQ	0.074	0.275	0.27	0.787	
INC	0.029	0.014	2.13	0.033	1.03
MEASURES	-3.371	1.116	-3.02	0.003	0.03

Log-Likelihood = -27.733
Test that all slopes are zero: G = 24.870, DF = 6, P-Value = 0.000

Considering our limited degrees of freedom, slightly small sample size of 33% of the Savona population, and missing observations, the model produced good results. The strongest predictions of factors influencing WTP came from measures undertaken which signify averting expenditures household purchased (P<0.003), household size (P<0.015), presence of children (P<0.012), gender (P<0.036), and income (P<0.033). A coefficient for perception of water quality was not strong (P<0.787). The overall statistical significance of the model, however, was robust as indicated by the G test with six degrees of freedom (P<0.000) and cause us to reject the null hypothesis and accept that at a relationship exists. Goodness-of-fit tests also support this assertion. The ratio of concordant to discordant pairs within the data set is also strong with 85% to 15% respectively. All coefficients have the expected sign. The GENDER coefficient was -1.813 and had an odds ratio of 0.16 indicating that the odds of a male willing to pay to improve water quality is very low. Thus, we can deduce that a female response increased the probability of accepting an increase in utility. In other words, the model predicted that women were more likely to pay to improve water quality than men. This is consistent with environmental economic literature[10] (Stern, et al. 1993). Household size has a negative influence on the dependent variable. An odds ratio of 0.11 was estimated for household size. This value indicates that as household size increases, the odds favour the individual not willing to pay to improve water quality. This indicates that homes with a greater number of residents have already taken measures to improve their water quality and are therefore less likely to be willing to pay increased utility fees.

[10] For more information on the relationship between gender and environmental preferences see Liebe, et al. 2010.

CHILD had a strong positive relationship and shocking odds ratio of 346 which indicates that it is drastically more probable that families with children are willing to pay to improve water quality in their home. The importance this variable played in our model must be emphasized. Income, which logically has a strong and sensible correlation to WTP, also had a strong positive and significant association.

Our model predicted a negative relationship (-3.1844) for individuals who have taken their own measures to improve the quality of water relative to the individuals that have not. Household that purchase products such as filters and bottled water. It was significantly less probably that, if you took measures and if you spend more on averting expenditures, you would also be willing to pay to improve water quality through an increase in utility fees. In our survey, a statement was included in the hypothetical WTP scenario that asked respondents to account for opportunity cost:

> *Remember that accepting an increase in water utility fees requires either spending less on other goods/services or paying less for your current expenditures that improve water quality (e.g. water filters or bottled water).*

Given that most non-economists consider opportunity cost in a subliminal way, many respondents may have failed to account for the reduced AE costs they currently fund when water quality at their tap is improved despite our effort to inform them. If respondents already spend significant amounts to improve water quality themselves, then it seems logical that they would be less willing to pay if they failed to account for the opportunity cost savings of the foregone averting behavior. As was noted in Chapter 5, the average monthly AE costs for Savona residents was $34.81, almost ten times higher than the average willingness to pay of $3.59. The options provided in our iterative bidding list of responses ranged from less than $5 per month, to $13 or more per month. What is interesting is that the average Savona resident who boils water, and purchases filtration products or bottled water is already exceeding the highest bid option with AE costs. It raises the question of what is a better predictor of maximum willingness to pay: The hypothetical CV scenario that presented options using a dichotomous choice iterative bidding method; or the averting expenditure costs? If we exclude the hourly wage aspect included in the estimation of costs associated with time spent boiling or treating water, then the mode AE cost drops to $10 which is reasonably close to our CV result.

The primary findings of our binary logistic model were that: one, women are more likely to pay more to improve water quality while men are less likely to pay; two, households with children residing with them are more likely to pay, a finding likely associated with child welfare and protection; three, that those who take their own measures to improve water quality (spend more on averting expenditures) are less likely to pay more service charges; and four, income plays a positive significant role in determining an individual's willingness to pay to improve water quality in terms of increased municipal fees.

6.2 Factors Influencing Willingness to Pay Amount

In the previous section we estimated the factors that influence the probability that a household is willing to pay to improve water quality. This section estimates the factors that influence the amount people are willing to pay in terms of increased water utility fees in order to improve water quality, WTP. Let the following linear population model describe the relationship:

$$WTP_i = \sum_{i=1}^{n} \beta_i X_i + \varepsilon_i$$

where x is a vector of independent variables that may influence an individual's willingness to pay to for water quality improvements via the water utility bill as indicated by Table 6.2.4, β is a vector of parameters to be estimated, and ε is a normally distributed random error term with mean zero and constant variance. The expected willingness to pay of individual *i* given the independent variables is: $E(WTP_i|x_i) = \beta' x_i$ since $E(\varepsilon_i|x_i) = 0$. The results are shown in the next table and are as follows:

Table 6.2.1 OLS regression results

Predictor	Coefficient	Standard Error	T-score	P-value
Constant	6.34	2.77	2.29	0.026
GENDER	-1.98	1.03	-1.92	0.061
HSIZE	-3.01	0.99	-3.05	0.004
CHILD	7.28	2.31	3.15	0.003
INC	0.1357	0.06	2.27	0.028
INCSQ	-0.000687	0.0004	-1.78	0.082
PWQ	-0.067	0.38	-0.18	0.861
MEAURES	-3.82	1.22	-3.14	0.003

S = 3.43385 R-Sq = 40.5% Adjusted R-Sq = 32.2%

The results in the above ordinary least squares (OLS) regression model provide further evidence that the amount one is WTP is affected by variables such as gender, household size, children residing in household, income, and again measures undertaken by the household to protect themselves from drinking low quality water. As indicated by the respective p-values (P<0.10) all of the variables are significant except for perception of water quality. For example, a male is willing to pay $2 less than a female holding all other factors constant (P<0.061). A household that has three members relative to one that has two members is willing to pay $3 less to improve water quality (P<0.004). Households where children reside are willing to pay $7.30 more than households that do not have children. Income is also significant and positive but willingness to pay increases with income at a decreasing rate as indicated by the significance of income square coefficient. Finally, households who have taken measures to improve their water quality are willing to pay $3.82 less than those who have not again indicating a substitution effect between own measures undertaken versus the public measure undertaken by survey.

To test the significance of our model, the coefficient of determination of 40.5% (adjusted R^2 of 3.2%) was achieved lending further credence to our estimation of WTP determinants.

6. 3 Determinants of Protest Votes

Some respondents of CV surveys reject WTP for the good in question for reasons that are not genuine to their indifference to the good. Often they are protests against a public policy, resource management, or both. To account for these individuals in our study, response options for not willing to pay to improve services were designed to categorize specific protests. Question 2.2 of our CV survey asks respondents to state why they are unwilling to pay. Response options are:

- Fees are already too high for the service provided:
- Unable to pay more based on my income;
- Increasing fees will not solve the water quality problem;
- I feel the water quality is already acceptable; and,
- I have already taken my own necessary measures to improve the quality of water.

If a respondent indicated that “fees are already too high for the service provided” and or “increasing fees will not solve the water quality problem” were selected, we assumed that these selections were made as a “protest” to the policy of increasing fees. Other options, such as “unable to pay more based on my income” are legitimate hindrances to WTP. A protest vote, however, signifies a deeper displeasure with the survey, public policies regarding fee increases, or resource management in general. The most selected response, with 29 individuals making the selection, was “fees are already too high for the service provided”. The other protest vote, “Increasing fees will not solve the water quality problem” was the third most selected answer but highly correlated with “fees are already too high for the service provided”.

A fairly reliable model was produced, for those protesting that fees were already too high for the service provided and for those who selected fees will not solve the water quality problem. Independent variables used in the model were presence of children (CHILD), household size (HOUSE), gender (GENDER), and perception of water quality (PWQ) and income (INC). The results are presented below (Table 6.3.1).

Based on our estimates, the presence of children was once again a strong predictor. The odds ratio is 0 which indicates no protest even. The coefficient of -21.99 (P <0.038) indicates that families are less likely to protest an increase in fees based on existing fees being too high already or that increased fees will not solve the water quality problem. Household size was also a relatively strong indicator with a coefficient of 7.943 (P<0.033) and an odd ratio of 2815 makes size of household favouring protesting than not protesting. This indicates that dwellings with more individuals are more likely to

Table 6.3.1 Logistic regression table for protest

Predictor	Coefficient	Standard Error	Z-score	P-value	Odds Ratio
Constant	-7.52942	3.99366	-1.89	0.059	
GENDER	2.91941	1.85518	1.57	0.116	18.53
HSIZE	7.94286	3.72480	2.13	0.033	2815.33
CHILD	-21.9927	10.5982	-2.08	0.038	0.00
PWQ	-1.06074	0.73780	-1.44	0.151	0.35
INC	-0.066592	0.03497	-1.90	0.057	0.94

Log-Likelihood = -7.580
Test that all slopes are zero: G = 24.491, DF = 5, P-Value = 0.001

protest. Men were marginally more likely to protest than women (P<0.116) and individuals who perceived the water quality to be poor were less likely to protest

(P<0.151). Finally, households with lower income are also less likely to protest (P<0.057). Many of these findings seem logical and fit with other community assessments completed during this research process.

Willingness to pay was then re-estimated without the protest votes. Protest votes were excluded because they may not accurately represent an individual's attitudes towards improving water quality. When protest votes were removed from the sample, 30 observations in total, the remaining households were willing to pay an increase fee except for one household. Thus the probability that a household would be willing to accept an increase in utility fees to improve water quality is almost certain.

The estimated regression without the protest vote is shown in Table 6.3.2. This result is shocking at first as all the independent variables are not significant with the exception of the income variable when protest votes are excluded. The insignificance of gender, household size, children residing, perception and measures in reality influence protest votes. Hence, once protest households are excluded their influence becomes naturally insignificant. When we re-ranthe final regression with only income and income square the following results were obtained (Table 6.3.3).

Table 6.3.2: Regression results with protest votes excluded

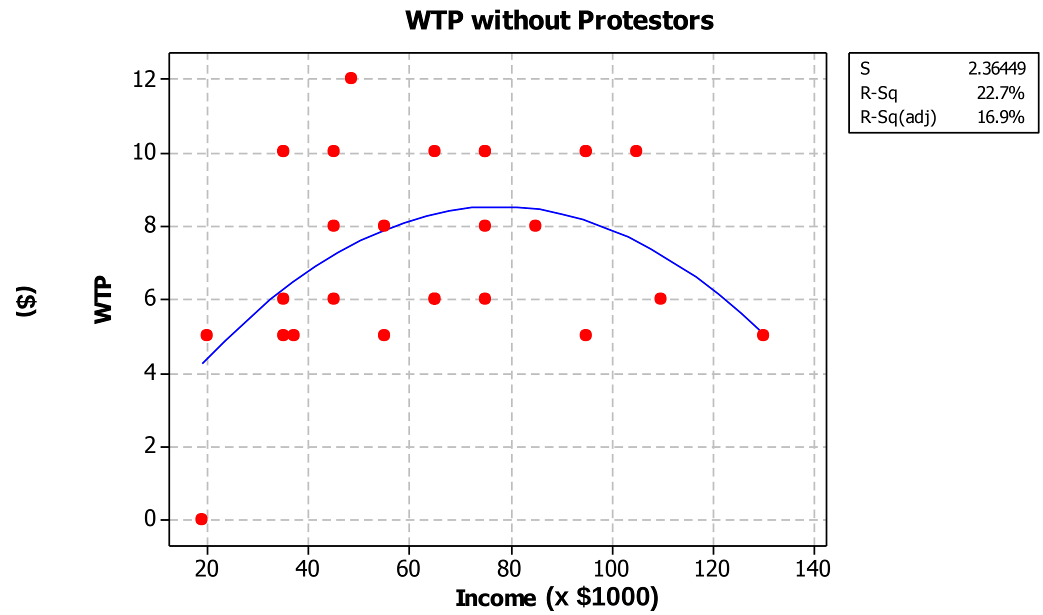
Predictor	Coefficient	Standard Error	T-score	P-value
Constant	2.846	4.795	0.59	0.559
GENDER	-0.283	1.466	-0.19	0.849
HSIZE	-0.646	1.310	-0.49	0.627
CHILD	1.042	3.031	0.34	0.734
INC	0.19523	0.08851	2.21	0.039
INCSQ	-0.00124	0.00059	-2.10	0.048
PWQ	-0.1695	0.5569	-0.30	0.764
MEAURES	-1.671	2.409	-0.69	0.495
S = 2.58325	R-Sq = 27.5%		Adjusted R-Sq = 3.3%	

Table 6.3.3: Regression of WTP and income

Predictor	Coefficient	Standard Error	T-score	P-value
Constant	1.025	2.307	0.44	0.660
INC	0.19369	0.07064	2.74	0.011
INCSQ	-0.001251	0.000495	-2.53	0.018
S = 2.36449	R-Sq = 22.7%		Adjusted R-Sq = 16.9%	

Maximum willingness to pay depends positively on the household's income up to a certain level and then starts declining at very high levels. As income increases improving water quality from increasing water utility is a normal good but beyond a certain income level improving water quality by increasing water utility fees is considered an inferior good. This can be explained by the fact that high income groups have taken their own measures and these measures are trusted more than the public sector involvement to correct the problem. Some higher income respondents also claimed that the Savona home is for summer vacations and place less value on improving water quality than permanent residents. The adjusted R square is a respectable 17 percent and the regression is significant overall (Figure 6.3.1).

Figure 6.3.1: Nonlinear fitted line showing WTP and Income without protest votes



The willingness to pay to improve water quality at different income levels is shown below in Table 6.3.4 and further describes the relationship between income and willingness to pay amounts.

Table 6.3.4: WTP and income levels

Income Levels ($)	Willingness to pay Per month
30000	$5.72
60000	8.16
80000	8.54
150000	1.99

6.4 Discussion

Through many trials and tribulations we were able to produce robust statistical models using both the binary logistic and multiple regression methods. While descriptive statistics presented in Chapter 5 provided an overview of survey results, the models presented in Chapter 6 provide more insight into the causes of WTP variation. This helped us develop a thorough picture of the community and how their socioeconomic characteristics and environmental perceptions influence their decisions.

The single most influential predictor in all of our models with protestors was the presence of children in the household. It was routinely significant and had the highest regression odds ratio of all variables in logistic models. Despite the complex nature of behavior that influences WTP for improved water quality, it can be said that individuals with children value improvements to their utility system more than non-parents. This was admittedly a result that was not anticipated but its inclusion in the survey has proven to be important. Once we remove protestors from the sample the single most influential predictor was income of the household. In particular low and high income households were willing to pay less than the middle income group. Low income household value it less than middle income group because of financial constraints but the high income households because they see this service as an inferior good. They have taken their own measures and do not see the increased fees as necessary for their own interest to improve drinking water quality.

The results from econometric analysis indicate that there are a number of legitimate causes for WTP variation amongst respondents to our CV survey. The removal of protest votes from models improved the statistical relationship of WTP and income. Including income squared revealed another important finding which is that WTP increases at a decreasing rate with income. Therefore, we can deduce that middle income households possess the highest WTP, whilst high income households are willing to pay the least. The role of environmental perception, that is to say the perception of water quality, was not as significant as other socioeconomic variables. It would be interesting to assess WTP of the community in the future to see if improvements to the intake pipe had a significant perceived improvement on water quality and if this improvement translated into lower WTP and AE costs. Some of these key findings, as well as other research conclusions are summarized further in Chapter 7.

Chapter 7: Conclusions

7.1 Purpose and Methods

The purpose of our research was to evaluate the WTP of Savona, British Columbia residents to improve their water utility infrastructure to a level that would provide consumable tap water without the need for additional household treatments. In essence, this meant estimating the value residents placed on community water resources. The value of water as an economic good takes many forms and can be inferred from market and non-market assessments. For example, the quantity and price of bottled water is determined largely by supply and demand theory; thus, water in this instance is a market good and a consumer's preference is revealed through market transactions. However, the preservation of lakes for recreational purposes, or willingness to pay for upgrades to municipal water delivery systems are considered non-market services and require more sophisticated econometric tools to estimate values. The contingent-valuation (CV) approach utilizes a survey whereby the WTP of consumers for a particular service is contingent on the study results.

The CV survey method was selected for this study because it is known to be effective in assessing WTP for improvements to water infrastructure (McComb 2002; Wedgewood and Sansom 2003). Although the use of CV in this field has been largely limited to underdeveloped regions (Whittington, et al. 1990), it was chosen due to its suitability for estimating value for a specific environmental good or service. Our focus was directed towards the specific service of adequate water provision in rural communities. Improvements in CV techniques relating to survey design, administration, and project management have helped to increase the accuracy of results and minimize the impact of bias in respondent answers, a main criticism of older CV studies (Whittington 1990).

To ensure that the most comprehensive and robust survey was produced, the methods of past research and advice of seasoned experts was closely followed (Whitehead 2006; Pearce, Atkinson, and Mourato 2006). The inclusion of averting expenditure costs led to a more complete understanding of community attitudes and helped us test the accuracy of our hypothetical water quality improvement scenario which was consistent with previous studies (Um, Kwak, Kim 2002). Assessing attitudes towards community and environmental services in combination with socioeconomic characteristics of households provided a thorough framework for explaining empirical models as well as descriptive statistics. Our survey yielded a 34% response rate from the community and numerous statistically significant data were produced. Through analysis and extrapolation, several major findings were observed.

7.2 Major Findings

Descriptive statistics were completed for all survey questions. It was determined that the mean WTP to improve water quality of the Savona utility system is $38.59 per month. This is $3.59 more than the current rate of $35 per month. However, when accounting only for those willing to pay, and excluding those not willing to pay, this amount increases to $43.36. If all residents paid this increased amount, it would result in an additional $26,584.80 of revenue each year for the utility system. In Savona, 27% of respondents who were not willing to pay justified their decision based on fees already being too high for the service provided. Many individuals have taken measures into their own hands and spend on average $34.81 per month to improve their water quality. This includes the cost of filtration systems, bottled water, and time spent boiling water or traveling to purchase water.

Another goal of our research was to estimate the influence of an individual's perception of water quality on their maximum WTP. To determine this in a descriptive sense correlation tests were run. A correlation test of water quality perception and amount spent on averting expenditures was conducted. In this test a correlation coefficient of -0.248 ($P<0.059$) was estimated. This suggests that as the perception of water quality drops, averting expenditure costs rise. However, there was no observable correlation between a respondent's perception of water quality and WTP ($P<0.550$). This test was largely influenced by the number of individuals protesting a monthly water fee increase. The question of whether or not a respondent's perception of water quality was accurate was also examined. Water quality and utility system reports provided by the TNRD showed that turbidity levels do exceed guidelines established by Health Canada and that drinking water advisories are warranted. Savona residents are thus also rightly concerned about the poor quality of their drinking water.

It was determined that income and income square do impact WTP at a significant level. This result had major implications for our findings. It demonstrated that both the low and high income groups had the lowest willingness to pay relative to those in the middle income class. The finding is important because it reveals that the valuation of water quality is extremely income sensitive. The high income groups are willing to pay less because financially they are able to cover averting expenditure costs and do not depend on the public provision of an adequate water supply. Even though low income groups depend on the public provision of drinking water, they are simply unable to afford an increase in fees. The middle income group see the provision of improved water quality as a normal good/service. The significance of income also confirms that WTP estimates provided during our hypothetical scenario were accurate and that our presentation of options helped us to avoid response biases.

A hypothetical bias can arise during CV surveys due to a respondent's inability to fully comprehend the hypothetical scenario and actual willingness to pay. By providing statements reminding individuals to consider the existing fee amount and opportunity costs involved with paying a higher fee as it relates to averting expenditures, we hoped to overcome hypothetical bias. Starting point bias occurs when an abnormally large proportion of respondents select the lowest willingness to pay bid. If the presentation of bids is unclear, or the amounts do not reflect an acceptable range of WTP bids, starting point bias can arise. When protest votes are removed, WTP amounts from our survey demonstrate a standard normal distribution. This is evidence that no starting point bias was observed amongst those willing to pay an increased fee.

To fully understand these relationships and the variables that influence an individual's decision econometric analysis was needed. Through many trials and tribulations we were able to produce robust statistical models using both the binary logistic and multiple regression methods. While descriptive statistics presented in Chapter 5 provided an overview of survey results, the models presented in Chapter 6 provide more insight into the causes of WTP variation. This helped us develop a thorough picture of the community and how their socioeconomic characteristics and environmental perceptions influence their decisions. An interesting trend is the role of gender in determining WTP and whether or not an individual is likely to protest fee increases. Whether a respondent was male or female did not play a role in averting expenditure purchases; however, it is clear that women are more willing to pay, and men are more likely to protest against paying.

One of the most influential predictors in our model with protestors was the presence of children in the household. It was routinely significant. Despite the complex nature of behavior that influences WTP for improved water quality, it can be said that individuals with children value improvements to their utility system more than non-parents. This was admittedly a result that was not anticipated but its inclusion in the survey has proven to be important. Once we remove protestors from the sample the single most influential predictor was income of the household.

The results from econometric analysis indicate that there are a number of legitimate causes for WTP variation amongst respondents to our CV survey. The role of environmental perception, that is to say the perception of water quality, was not as important as other socioeconomic variables and routinely produced inconclusive results.

7.3 Weaknesses

Weaknesses in the research were not necessarily a result of a lack of preparation, but rather arise naturally with CV studies. Economic literature describes difficulties in determining the accuracy of willingness to pay measurements (Whittington, et al. 1990). There were no previous studies that provided a case study of a small Canadian community facing problems similar to Savona. Therefore, in order to verify WTP bids we had to employ the averting expenditure method. The average AE amount was significantly higher than values measured through the CV scenario approach. This left us wondering which value was most accurate. Perhaps if the concept of opportunity cost was clearer, and respondents understood that willing to pay to improve water quality meant that the AE costs would decrease, then WTP would have been higher. It is hard to say, however, if this would have made any difference given the high percentage of protest votes.

Generally individuals were displeased with their water quality, management of the system, and the previous and future fee increases that have been both experienced and anticipated. This might have been an accurate reflection of community attitudes more than an explicit attempt to distort survey results which might allow us to rule out a strategic bias. The only way to rectify this problem would have been to conduct in person interviews with each respondent in order to elucidate the meaning of key economic principles associated with WTP. For example, enumerators would note respondent characteristics such as living conditions, household, or demeanor. This method is obviously cost and time prohibitive relative to the mail out process that we used and was not feasible. While it can be said that no starting point bias was observed in the WTP bids, a starting point bias may have been introduced in the list of reasons individuals were not willing to pay. The response that was selected more than any other was our protest vote response (27%). This response was also at the top of the list of options. This statement is somewhat ambiguous, however, given that the next most selected response (22%) related to households already taking personal measures to improve water quality.

Admittedly, a higher response rate would have been preferred, however; the statistical significance of our results suggests that our sample was representative of the overall population. Therefore, no other methodological or empirical weaknesses were observed.

7.4 Future Extensions

It would be interesting to assess the WTP of Savona in the future to see if improvements to the intake pipe had a significant perceived improvement on water quality and if this improvement translated to a change in WTP and AE costs. Conducting a similar survey during spring freshet when water quality is described to be the lowest, instead of during the summer months when water quality is reasonably high, may also produce different WTP and AE bids. Attitudes towards water quality are complex and heterogeneous across regions due to dissimilar environments and parent socioeconomic conditions. Many comparable studies have been conducted in developing countries which make it difficult to draw linkages to our conclusions. One method to test the robustness of our findings would be to conduct a study using similar methodology in a community that is comparable socioeconomically.

7.5 Policy Implications

In May 2000, the community water system in Walkerton, Ontario, which served approximately 5,000 residents at the time, became tainted by *Escherichia coli*, or E. coli. Higher than normal precipitation that year caused manure used as fertilizer on a local farm to infect the drinking water supply. A lack of operator training and government funding cutbacks were blamed for the outbreak that killed seven people and made 2,300 others ill (Dearden and Mitchell 2005). This single event caused water management agencies across all Canadian provinces to re-examine how municipal utility systems are operated. With respect to British Columbia, and more specifically Savona, a change to water management structure occurred. The Interior Health Authority began to scrutinize water quality and developed a provincial drinking water standard. The BC provincial government also removed operational control from local community groups like the Savona Improvement District, and placed it in the hands of local government authorities with expertise in resource management like the Thompson Nicola Regional District (Hughes 2010). The increasing role of integrated water resource management (IWRM)[11] is also a notable departure from past water management strategies.

Developing natural resources for economic production and or simply for the provision of public good have impacts on the stakeholders, landscape, and sustainability of future resources. These impacts vary over the two dimensions of temporal scales such past, present, and future, as well spatial scales relating to local, regional, national, and international contexts. Furthermore, to fully understand the ramifications of resource development, management officials are faced with the monumental task of incorporating a third dimension, stakeholder perspective. While stakeholders themselves come in specific forms, their perspectives incorporate biophysical, economic, social, political, legal, institutional, and technological qualities (Shrubsole and Wilson 2005). Due to the highly interdisciplinary nature of water resource development, IWRM has emerged as an effective way of tackling this complex issue. Our research provided an economic account of the financial sustainability of the Savona water system.

The use of contingent-valuation studies for water resource development projects typically involves applying findings to some form of upgrades to infrastructure in order to improve utility services. Often this information is used to cost the options and determine which developments will be financially sustainable over the long term and what type of investment planning is needed. Economic aspects of the Savona water utility

[11] The concept of IWRM was first discussed in 1992 during the International Conference on Water and the Environment in Dublin. For more information see Mitchell (2005).

system were also discussed with Hughes (2010). The current system is based on a cost-recovery scheme. In Savona, 67% of the system is financed by government grants with the remaining 33% paid for by residents. Households are currently charged a $35 per month fee for their connection to the utility. In 2012, this amount will increase to $40 per month, and in 2013 this fee will once again increase to $45 per month. These rate increases are being implemented irrespective of plans to improve water treatment and quality which brings me to why the TNRD was so interested in this research. Without adequate information on consumer WTP, it is difficult for the utility managers and operators to assess their options for improving water quality delivered to residents via upgraded filtration infrastructure. The contingent-valuation findings in this study may also help the TNRD assess the fee levels that will both fund necessary improvements and be accepted by the community. We estimated that those residents that were actually willing to pay to improve water quality were, on average, willing to pay $8.36. When factoring those who were not willing to pay (i.e. willing to pay $0) the influence of protest votes transcends into a reduced mean WTP of $3.59. These amounts are less than the rate increase will be over the next two years.

The fact that many Savona residents are already upset about increasing fees with no improvement to service does not bode well for the future financial stability of the system. Based on our findings, it is fair to say that the majority of residents will likely be willing to adopt an $8 increase in their monthly utility fees. Whether or not this amount is sufficient to not only fund future infrastructure improvements but also provide operation and maintenance costs in the future is uncertain. A certain level of fee increases is to be expected over time, however, the general attitudes of Savona residents suggests that the majority are agitated about upcoming annual fee increases while water quality remains poor. It is evident that water management can be a complex and costly service to provide. Moreover, the ramifications of a poorly managed system can be dire if inadequacies exist in the system.

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THOMPSON RIVERS UNIVERSITY

Thompson Rivers University Ethics Committee
For Research and Other Studies Involving Human Subjects

Certificate of Approval

PRINCIPAL INVESTIGATOR	DEPARTMENT	NUMBER
Robert Maciak	*Environ. Science*	**10-11-41**

INSTITUTION(S) WHERE RESEARCH WILL BE CARRIED OUT
TRU

CO RESEARCHER(S)
Peter Tsigaris

SPONSORING AGENCIES

TITLE
Freshwater resource perception and willingness to pay for utilities in Savona, British Columbia

APPROVAL DATE	TERM (YEARS)	AMENDED
June 7, 2011	**1**	

SUBSEQUENT CERTIFICATE(S) ISSUED

CERTIFICATION

The protocol describing the above-named project has been reviewed by the Committee and the experimental procedures were found to be acceptable on ethical grounds for research involving human subjects.

Chair, Research Ethics Committee – Human Subjects

This Certificate of Approval is valid for the above term provided there is no change in the experimental procedures.

Appendix B: Examples of Interview Questions

Interview Questions:

1. Please describe your past experiences using the water utility in Savona.
   a. What issues have arisen due to poor quality?
   b. What issues have arisen due to poor quantity?

2. Would you consider boil water advisories to be a significant problem in Savona?
   a. Explain and expand on the frequency of advisories and inconvenience.

3. How long have you lived in the community?
   a. How long have boil water advisories been occurring?
   b. Do you think they have been getting more or less frequent?

4. Are you satisfied with the way that your utility is being managed?
   a. Expand on answer.

5. How do you feel about the amount charged for your water utility?
   a. Too expensive for service?
   b. Willing to pay to improve services?
   c. Expand on answers.

6. Are you forced to purchase expensive filtration systems to further purify your water?

7. Are you aware of the upgrades the TNRD is making to your system

8. Are you aware of water conservation bylaws in Savona?
   a. Do you feel that residents generally respect these bylaws?

9. Do you have any more comments that you feel would be relevant to this discussion?

10. Do you have any questions for me?

Appendix C – Additional Regression Test Results

Binary Logistic Regression: WTP versus MI, HI, Gender, Age, VWQ

Link Function: Logit

Response Information

Variable	Value	Count	
WTP	1	30	(Event)
	0	30	
	Total	60	

* NOTE * 60 cases were used
* NOTE * 28 cases contained missing values

Logistic Regression Table

Predictor	Coef	SE Coef	Z	P	Odds Ratio	95% CI Lower	Upper
Constant	-2.71729	2.02732	-1.34	0.180			
MI	0.673955	0.700376	0.96	0.336	1.96	0.50	7.74
HI	1.62421	1.03847	1.56	0.118	5.07	0.66	38.85
Gender	-1.70470	0.698845	-2.44	0.015	0.18	0.05	0.72
Age	0.0089648	0.0242769	0.37	0.712	1.01	0.96	1.06
VWQ	0.555071	0.260469	2.13	0.033	1.74	1.05	2.90

Log-Likelihood = -35.232
Test that all slopes are zero: G = 12.713, DF = 5, P-Value = 0.026

Goodness-of-Fit Tests

Method	Chi-Square	DF	P
Pearson	29.9058	26	0.272
Deviance	37.8154	26	0.063
Hosmer-Lemeshow	4.2612	7	0.749

Measures of Association:
(Between the Response Variable and Predicted Probabilities)

Pairs	Number	Percent	Summary Measures	
Concordant	666	74.0	Somers' D	0.50
Discordant	212	23.6	Goodman-Kruskal Gamma	0.52
Ties	22	2.4	Kendall's Tau-a	0.26
Total	900	100.0		

Binary Logistic Regression: WTP versus MI, HI, Gender, VWQ

Link Function: Logit

Response Information

Variable	Value	Count	
WTP	1	30	(Event)
	0	30	
	Total	60	

* NOTE * 60 cases were used
* NOTE * 28 cases contained missing values

Logistic Regression Table

					Odds	95% CI	
Predictor	Coef	SE Coef	Z	P	Ratio	Lower	Upper
Constant	-2.10439	1.15441	-1.82	0.068			
MI	0.580659	0.651327	0.89	0.373	1.79	0.50	6.41
HI	1.48120	0.953335	1.55	0.120	4.40	0.68	28.50
Gender	-1.67355	0.689280	-2.43	0.015	0.19	0.05	0.72
VWQ	0.538496	0.256651	2.10	0.036	1.71	1.04	2.83

Log-Likelihood = -35.301
Test that all slopes are zero: G = 12.576, DF = 4, P-Value = 0.014

Goodness-of-Fit Tests

Method	Chi-Square	DF	P
Pearson	20.2152	14	0.124
Deviance	24.8587	14	0.036
Hosmer-Lemeshow	2.2196	6	0.898

Measures of Association:
(Between the Response Variable and Predicted Probabilities)

Pairs	Number	Percent	Summary Measures	
Concordant	656	72.9	Somers' D	0.52
Discordant	190	21.1	Goodman-Kruskal Gamma	0.55
Ties	54	6.0	Kendall's Tau-a	0.26
Total	900	100.0		

Binary Logistic Regression: WTP versus Q3_11, Gender, VWQ

Link Function: Logit

Response Information

Variable	Value	Count	
WTP	1	30	(Event)
	0	30	
	Total	60	

* NOTE * 60 cases were used

* NOTE * 28 cases contained missing values

Logistic Regression Table

Predictor	Coef	SE Coef	Z	P	Odds Ratio	95% CI Lower	Upper
Constant	-2.35753	1.18014	-2.00	0.046			
Q3_11	0.0000145	0.0000099	1.47	0.142	1.00	1.00	1.00
Gender	-1.60136	0.651293	-2.46	0.014	0.20	0.06	0.72
VWQ	0.512596	0.256431	2.00	0.046	1.67	1.01	2.76

Log-Likelihood = -35.491
Test that all slopes are zero: G = 12.195, DF = 3, P-Value = 0.007

Goodness-of-Fit Tests

Method	Chi-Square	DF	P
Pearson	49.8246	41	0.162
Deviance	61.6179	41	0.020
Hosmer-Lemeshow	5.6681	8	0.684

Measures of Association:
(Between the Response Variable and Predicted Probabilities)

Pairs	Number	Percent	Summary Measures	
Concordant	667	74.1	Somers' D	0.50
Discordant	220	24.4	Goodman-Kruskal Gamma	0.50
Ties	13	1.4	Kendall's Tau-a	0.25
Total	900	100.0		

Binary Logistic Regression: WTP versus MI, HI, Gender, VWQ

Link Function: Normit

Response Information

Variable	Value	Count	
WTP	1	30	(Event)
	0	31	
	Total	61	

* NOTE * 61 cases were used
* NOTE * 27 cases contained missing values

Logistic Regression Table

Predictor	Coef	SE Coef	Z	P
Constant	-1.23645	0.668705	-1.85	0.064
MI	0.601532	0.374578	1.61	0.108
HI	0.489016	0.595288	0.82	0.411
Gender	-0.854770	0.386998	-2.21	0.027
VWQ	0.298158	0.151892	1.96	0.050

Log-Likelihood = -36.532
Test that all slopes are zero: G = 11.483, DF = 4, P-Value = 0.022

Goodness-of-Fit Tests

Method	Chi-Square	DF	P
Pearson	13.3982	14	0.495
Deviance	17.2614	14	0.243
Hosmer-Lemeshow	3.7050	5	0.593

Measures of Association:
(Between the Response Variable and Predicted Probabilities)

Pairs	Number	Percent	Summary Measures	
Concordant	636	68.4	Somers' D	0.44
Discordant	224	24.1	Goodman-Kruskal Gamma	0.48
Ties	70	7.5	Kendall's Tau-a	0.23
Total	930	100.0		

Binary Logistic Regression: WTP versus MI, Gender, VWQ, parents

Link Function: Logit

Response Information

Variable	Value	Count	
WTP	1	30	(Event)
	0	31	
	Total	61	

* NOTE * 61 cases were used
* NOTE * 27 cases contained missing values

Logistic Regression Table

					Odds	95% CI	
Predictor	Coef	SE Coef	Z	P	Ratio	Lower	Upper
Constant	-1.83735	1.10840	-1.66	0.097			
MI	0.724693	0.584407	1.24	0.215	2.06	0.66	6.49
Gender	-1.16757	0.581999	-2.01	0.045	0.31	0.10	0.97
VWQ	0.450713	0.257134	1.75	0.080	1.57	0.95	2.60
parents	0.375232	0.702972	0.53	0.593	1.46	0.37	5.77

Log-Likelihood = -36.749
Test that all slopes are zero: G = 11.049, DF = 4, P-Value = 0.026

Goodness-of-Fit Tests

Method	Chi-Square	DF	P
Pearson	19.9127	17	0.279
Deviance	25.5147	17	0.084
Hosmer-Lemeshow	5.8750	6	0.437

Table of Observed and Expected Frequencies:
(See Hosmer-Lemeshow Test for the Pearson Chi-Square Statistic)

		Group								
Value		1	2	3	4	5	6	7	8	Total
1										
	Obs	1	2	2	4	2	6	10	3	30
	Exp	0.9	1.9	2.2	2.3	2.9	8.3	8.2	3.3	
0										
	Obs	5	5	5	2	4	8	1	1	31
	Exp	5.1	5.1	4.8	3.7	3.1	5.7	2.8	0.7	
Total		6	7	7	6	6	14	11	4	61

Measures of Association:
(Between the Response Variable and Predicted Probabilities)

Pairs	Number	Percent	Summary Measures	
Concordant	656	70.5	Somers' D	0.47
Discordant	218	23.4	Goodman-Kruskal Gamma	0.50
Ties	56	6.0	Kendall's Tau-a	0.24
Total	930	100.0		

Binary Logistic Regression: WTP versus MI, HI, Gender, VWQ, retired

Link Function: Logit

Response Information

Variable	Value	Count	
WTP	1	30	(Event)
	0	30	
	Total	60	

* NOTE * 60 cases were used
* NOTE * 28 cases contained missing values

Logistic Regression Table

					Odds	95% CI	
Predictor	Coef	SE Coef	Z	P	Ratio	Lower	Upper
Constant	-2.22075	1.23046	-1.80	0.071			
MI	0.979595	0.703714	1.39	0.164	2.66	0.67	10.58
HI	0.880289	1.10560	0.80	0.426	2.41	0.28	21.06
Gender	-1.42376	0.652824	-2.18	0.029	0.24	0.07	0.87
VWQ	0.520069	0.257856	2.02	0.044	1.68	1.01	2.79
retired	0.271037	0.692882	0.39	0.696	1.31	0.34	5.10

Log-Likelihood = -35.550
Test that all slopes are zero: G = 12.078, DF = 5, P-Value = 0.034

Goodness-of-Fit Tests

Method	Chi-Square	DF	P
Pearson	15.3682	20	0.755
Deviance	20.5714	20	0.423
Hosmer-Lemeshow	3.4100	7	0.845

Measures of Association:
(Between the Response Variable and Predicted Probabilities)

Pairs	Number	Percent	Summary Measures	
Concordant	652	72.4	Somers' D	0.49
Discordant	209	23.2	Goodman-Kruskal Gamma	0.51
Ties	39	4.3	Kendall's Tau-a	0.25
Total	900	100.0		

Binary Logistic Regression: WTP versus MI, HI, Gender, VWQ, fulltime

Link Function: Logit

Response Information

Variable	Value	Count	
WTP	1	30	(Event)
	0	31	
	Total	61	

* NOTE * 61 cases were used
* NOTE * 27 cases contained missing values

Logistic Regression Table

Predictor	Coef	SE Coef	Z	P	Odds Ratio	95% CI Lower	Upper
Constant	-1.57999	1.15425	-1.37	0.171			
MI	1.57281	0.833192	1.89	0.059	4.82	0.94	24.68
HI	1.49820	1.19193	1.26	0.209	4.47	0.43	46.26
Gender	-1.45869	0.661046	-2.21	0.027	0.23	0.06	0.85
VWQ	0.458277	0.254246	1.80	0.071	1.58	0.96	2.60
fulltime	-0.976236	0.822884	-1.19	0.235	0.38	0.08	1.89

Log-Likelihood = -35.845
Test that all slopes are zero: G = 12.857, DF = 5, P-Value = 0.025

Goodness-of-Fit Tests

Method	Chi-Square	DF	P
Pearson	15.7999	19	0.671
Deviance	20.0399	19	0.392
Hosmer-Lemeshow	1.5578	6	0.956

Measures of Association:
(Between the Response Variable and Predicted Probabilities)

Pairs	Number	Percent	Summary Measures	
Concordant	669	71.9	Somers' D	0.49
Discordant	215	23.1	Goodman-Kruskal Gamma	0.51
Ties	46	4.9	Kendall's Tau-a	0.25
Total	930	100.0		

Regression Analysis: WTPAm versus MI, HI, Gender, VWQ, Grads, fulltime

```
The regression equation is
WTPAm = - 0.05 + 2.21 MI + 2.04 HI - 2.50 Gender + 0.909 VWQ + 0.83 Grads
        - 1.22 fulltime


60 cases used, 28 cases contain missing values


Predictor     Coef  SE Coef      T      P
Constant    -0.046    2.113  -0.02  0.983
MI           2.207    1.332   1.66  0.103
HI           2.041    1.951   1.05  0.300
Gender      -2.498    1.128  -2.21  0.031
VWQ         0.9087   0.4345   2.09  0.041
Grads        0.830    1.195   0.69  0.490
fulltime    -1.224    1.365  -0.90  0.374


S = 3.88981   R-Sq = 20.6%   R-Sq(adj) = 11.6%


Analysis of Variance

Source          DF       SS     MS     F      P
Regression       6   208.26  34.71  2.29  0.048
Residual Error  53   801.92  15.13
Total           59  1010.18


Source    DF  Seq SS
MI         1   50.83
HI         1    0.86
Gender     1   64.87
VWQ        1   75.02
Grads      1    4.52
fulltime   1   12.16
```

Binary Logistic Regression: WTP versus MI, HI, ...

```
Link Function: Logit


Response Information

Variable  Value  Count
WTP       1         23  (Event)
          0         22
          Total     45

* NOTE * 45 cases were used
* NOTE * 43 cases contained missing values


Logistic Regression Table

                                                Odds     95% CI
Predictor        Coef    SE Coef      Z      P  Ratio  Lower  Upper
```

Constant	-0.563885	1.98149	-0.28	0.776			
MI	1.41873	0.986373	1.44	0.150	4.13	0.60	28.56
HI	1.41822	1.62317	0.87	0.382	4.13	0.17	99.45
Gender	-0.741125	0.889113	-0.83	0.405	0.48	0.08	2.72
VWQ	0.424465	0.383904	1.11	0.269	1.53	0.72	3.24
fulltime	-1.68110	1.08316	-1.55	0.121	0.19	0.02	1.56
Grads	0.687675	0.915031	0.75	0.452	1.99	0.33	11.95
defense	-0.0412970	0.0266224	-1.55	0.121	0.96	0.91	1.01
NWTP_D	-2.22375	1.22310	-1.82	0.069	0.11	0.01	1.19

Log-Likelihood = -22.086
Test that all slopes are zero: G = 18.190, DF = 8, P-Value = 0.020

Goodness-of-Fit Tests

Method	Chi-Square	DF	P
Pearson	42.4277	36	0.214
Deviance	44.1715	36	0.165
Hosmer-Lemeshow	7.7782	8	0.455

Measures of Association:
(Between the Response Variable and Predicted Probabilities)

Pairs	Number	Percent	Summary Measures	
Concordant	416	82.2	Somers' D	0.65
Discordant	88	17.4	Goodman-Kruskal Gamma	0.65
Ties	2	0.4	Kendall's Tau-a	0.33
Total	506	100.0		

Binary Logistic Regression: WTP versus Grads

Link Function: Logit

Response Information

Variable	Value	Count	
WTP	1	30	(Event)
	0	32	
	Total	62	

* NOTE * 62 cases were used
* NOTE * 26 cases contained missing values

Logistic Regression Table

					Odds	95% CI	
Predictor	Coef	SE Coef	Z	P	Ratio	Lower	Upper
Constant	-0.510826	0.516397	-0.99	0.323			
Grads	0.597837	0.594800	1.01	0.315	1.82	0.57	5.83

Log-Likelihood = -42.426
Test that all slopes are zero: G = 1.033, DF = 1, P-Value = 0.309

* NOTE * No goodness of fit test performed.

* NOTE * The model uses all degrees of freedom.

Measures of Association:
(Between the Response Variable and Predicted Probabilities)

Pairs	Number	Percent	Summary Measures	
Concordant	240	25.0	Somers' D	0.11
Discordant	132	13.8	Goodman-Kruskal Gamma	0.29
Ties	588	61.3	Kendall's Tau-a	0.06
Total	960	100.0		

Binary Logistic Regression: WTP versus VWQ, MI, Gender

Link Function: Logit

Response Information

Variable	Value	Count	
WTP	1	30	(Event)
	0	31	
	Total	61	

* NOTE * 61 cases were used
* NOTE * 27 cases contained missing values

Logistic Regression Table

					Odds	95% CI	
Predictor	Coef	SE Coef	Z	P	Ratio	Lower	Upper
Constant	-1.88236	1.10863	-1.70	0.090			
VWQ	0.475884	0.253657	1.88	0.061	1.61	0.98	2.65
MI	0.790642	0.570873	1.38	0.166	2.20	0.72	6.75
Gender	-1.17674	0.580332	-2.03	0.043	0.31	0.10	0.96

Log-Likelihood = -36.893
Test that all slopes are zero: G = 10.762, DF = 3, P-Value = 0.013

Goodness-of-Fit Tests

Method	Chi-Square	DF	P
Pearson	12.7079	12	0.391
Deviance	16.5125	12	0.169
Hosmer-Lemeshow	3.9372	5	0.558

Measures of Association:
(Between the Response Variable and Predicted Probabilities)

Pairs	Number	Percent	Summary Measures	
Concordant	644	69.2	Somers' D	0.47
Discordant	211	22.7	Goodman-Kruskal Gamma	0.51
Ties	75	8.1	Kendall's Tau-a	0.24
Total	930	100.0		

Binary Logistic Regression: WTP versus VWQ, HI, Gender

Link Function: Logit

Response Information

Variable	Value	Count	
WTP	1	30	(Event)
	0	31	
	Total	61	

* NOTE * 61 cases were used
* NOTE * 27 cases contained missing values

Logistic Regression Table

Predictor	Coef	SE Coef	Z	P	Odds Ratio	95% CI Lower	Upper
Constant	-1.72558	1.07102	-1.61	0.107			
VWQ	0.515886	0.246996	2.09	0.037	1.68	1.03	2.72
HI	0.210064	0.912976	0.23	0.818	1.23	0.21	7.39
Gender	-1.20695	0.618193	-1.95	0.051	0.30	0.09	1.00

Log-Likelihood = -37.843
Test that all slopes are zero: G = 8.862, DF = 3, P-Value = 0.031

Goodness-of-Fit Tests

Method	Chi-Square	DF	P
Pearson	7.8167	9	0.553
Deviance	10.0010	9	0.350
Hosmer-Lemeshow	3.9627	5	0.555

Measures of Association:
(Between the Response Variable and Predicted Probabilities)

Pairs	Number	Percent	Summary Measures	
Concordant	587	63.1	Somers' D	0.41
Discordant	206	22.2	Goodman-Kruskal Gamma	0.48
Ties	137	14.7	Kendall's Tau-a	0.21
Total	930	100.0		

Binary Logistic Regression: WTP versus Illness, VWQ, ...

Link Function: Logit

Response Information

Variable	Value	Count	
WTP	1	30	(Event)
	0	31	
	Total	61	

* NOTE * 61 cases were used
* NOTE * 27 cases contained missing values

Logistic Regression Table

Predictor	Coef	SE Coef	Z	P	Odds Ratio	95% CI Lower	Upper
Constant	-1.16496	1.19317	-0.98	0.329			
Illness	-0.633254	0.604606	-1.05	0.295	0.53	0.16	1.74
VWQ	0.421472	0.252532	1.67	0.095	1.52	0.93	2.50
MI	1.11498	0.674916	1.65	0.099	3.05	0.81	11.45
Gender	-1.25229	0.614454	-2.04	0.042	0.29	0.09	0.95
fulltime	-0.527861	0.676681	-0.78	0.435	0.59	0.16	2.22

Log-Likelihood = -36.099
Test that all slopes are zero: G = 12.350, DF = 5, P-Value = 0.030

Goodness-of-Fit Tests

Method	Chi-Square	DF	P
Pearson	25.5542	26	0.488
Deviance	31.2887	26	0.218
Hosmer-Lemeshow	9.4056	8	0.309

Measures of Association:
(Between the Response Variable and Predicted Probabilities)

Pairs	Number	Percent	Summary Measures	
Concordant	683	73.4	Somers' D	0.50
Discordant	221	23.8	Goodman-Kruskal Gamma	0.51
Ties	26	2.8	Kendall's Tau-a	0.25
Total	930	100.0		

Appendix D: Respondent Comments

Respondent Comments
I believe that the water quality is more than satisfactory for household use and it is much simpler to purchase purified water for human consumption. I think it's best to leave the water system as it is and instead concentrate on sewage treatment to eventually replace all septic systems.
Saw and lived on lake since 1959. Watched lake's fast decline after 1964 and Weyerhaeuser pulp mill built and Kamloops quadrupled. Lake shaped like bathtub allowing for accumulation of toxins at east end - top of lake. Run off lake, and a lot of calculations done pre-accelerated global warming and the basins streams and lakes have seen record lows. Recently (4-5 years ago) a large bloom of bluish, foul smelling algae, reportedly an escape from Shushwap Lakes - Savona Lake front properties are almost water side sewer fields and tanks. Severe hazard from both major railways - e.g. 1985 (?) CNR derailed 12 cars of E.D.C. ruptured on rocks just south of blue river which ended up on the bottom of Kamloops lake.
I have found the only issue before the extension of the line was sediment in the water. Since the pipe has been extended, we've been able to enjoy swimming at the previously closed-down park facilities.
This survey comes at a time that a small amount of time has passed since the water pump inlet improvement was done to compare the quality of water from past years. This spring the water was the worst we have ever seen it in over 20 years living here. Even though the turbidity was extremely high we were never notified of a boil water notice. We feel that the TNRD was trying to cover their ass by not issuing a notice to boil the water as it would make them look bad after assuring us the water would be "significantly better" after spending god knows how much money. Hopefully this problem was caused by the new intake sitting in silt until enough water was used to clear out the lake bed near the intake. A better solution to the turbidity problem would have been to move the intake out of the "back eddy" it is in to another spot along the lakeshore where the quality wouldn't be affected by the creek that comes down from Tunkwa Lake and the natural drainage of water and all the septic tanks draining down from "Watson" subdivision right past the pump house into the intake area!
We live in a wonderful country in 2011 and still our water is equal to a third world country we pay for the service but not getting we could do a lot better.
We have reverse osmosis in our home and have had it for 21 years we want the water to be a better pressure and not fluctuate. Sorry for not getting this back to you as I was away and just return on Sunday Aug 28/11. Hope you get this in time.
Who paid for this survey? Tax payers? TRU (Tuition + taxpayers)? From your pockets? TNRD (tax payers)? It could have been done for half the cost by reducing the size of paper/envelope (sizes)

The water which we are receiving is fine. It tastes fine, it is clear with no odour. We are more concerned with the number of septic tanks which are all around the lake here in the town site. Many are old and outdated, and one wonders if the sewage is leeching into the lake. We feel there is a need for TNRD to consider constructing a sewer system and small treatment plant. We use a water dispenser, but fill it with tap water to keep it cold. We have never had problems with the water here in Savona. Thank-you for the opportunity to speak on this issue.
Questions pertaining to my income are really none of your business and I find it insulting to be asked. As previously stated I think natural filtration by using a deep well should have been considered. To filter water taken from Kamloops lake is going to be expensive. Also no one is commenting on the fact that the pulp mill is still dumping into the river feeding Kamloops lake. The city of Kamloops is nightly dumping effluent from their holding ponds into the river feeding Kamloops lake. Anybody with a boat can see raw sewage where river and lake meet. Nobody wants to comment on that. If the city of Kamloops took their water intake to this spot (head end of Kamloops Lake) all hell would break out. The residents of Savona cannot afford spending any money on water systems or on million dollar fire hall for a community so small.
Need higher PSI and volume!!! Cleaner drinking water and compensation for booster pump.
I don’t want to pay more for water usage, as I use very little of Savona's water and every time (nearly) I open the mail boy there is a bill for something from the village of Savona.
Hope you are successful in getting Savona a water purification system that does not include chlorine disinfection! (Possibly ultra violet light!) Or the straw type filters that Kamloops uses.
Not only do we worry about getting sick with our water it smells awful. My laundry is dirtier when I take it out of the washer then when we put it in! When we have company from the coast, they cannot believe how dirty our water is. We absolutely "never" let our grand kids consume this tap water in Savona. The poor water we have is the only thing I totally dislike about living here! We would be willing to pay more for good water if we could afford it, but we cannot. Water is so important to us, to all of us.
We used to pay $15 per month for water and garbage (only a few years ago). Now we pay $35 per month, and they are raising it every year. Other than extend our water intake, they have done nothing to improve our water. With raw sewage and pulp mill chemicals being dumped into our water, adding chlorine (another poison) into our water, hardly seems like a good way to treat the problem. They tell us that the biggest problem is turbidity, but that issue has not been addressed other than telling us we have to boil our newly, high priced, same old crappy water. Many (if not all) of the residents are very unhappy with the whole situation. We were also not told that the water rate would rise every year until after the deal was done.
I think now that the water improvement has been completed some work needs to be done to the small park where the pipe was extended. It should be cleaned up and bathrooms put back in as people are still using it and without bathrooms the shoreline is being used as a restroom. It was the first thing you see when you drive into Savona and for many years was a beautiful little park used by many. This is our water intake and should be kept cleaner.

Make sewer a priority in Savona, not water filtration or well.
TNRD needs to spend grant money on the specified projects and stop doing repetitive studies which cost tax payers extra and give similar results re: project in question. Co-operate and trust in the abilities of your local personnel! He's been working with this system a lot longer than your TNRD "educated" reps and does a terrific job keeping this system functioning to benefit residents. Give him more support for repairs, equipment upgrades on aging equipment and with enforcement issues.
The water is going downhill all the time and all you want to do is put more bleach in. Double the bill and what did we get - boil water from year to year. Would you like to drink bleach and pay $400/yr.
Even if the water was proved excellent we would purchase bottled water due to a chronic illness in the family.
Spend more on crime related issues less on traffic related issues. The region makes money with every traffic ticket. It costs money to apprehend criminals so that is not a priority. It should be. We can pay now or pay later. Read the newspapers. Your worried about water quality give us a break.
Improve the water system with the money they already have.
I think people will still purchase drinking water. The elderly and people with weakened immune systems will be skeptical on its quality!
We pay higher and higher taxes and seem to wait years to see any benefits come back to our community. We paid taxes for a water treatment and waited and paid for over 5 years before it was started. Finally the fire hall. We only see police when there is an incident. I have lived here for 30 years and our taxes keep going up and our home appraisals goes up, but we suffer in the community when it comes to TNRD services. Finally a better garbage collection and that as well took years of paying the taxes and no upgrades till lately. Like every time - I feel this is a complete waste of my time.
Something needs to be done in regards to the water. It tastes like chlorine and is undrinkable. Sometimes when I fill the bath tub it is SO brown I won't go in.
After the Improvement District/TNRD extended the main water intake at the old Provincial Day Park, they have left it as a real eye sore. Before any other projects are brought forward, I would definitely like to see it brought back to a more matured state with some simple landscape done. They have left an unused, half scorched shed, huge water pipes and old pieces of steel. Most communities that have water front, have a more desirable appeal to them.
Walkerton waiting to happen!
Considering the businesses in Savona and the taxes collected from those local businesses, Savona is a have not community. If only a little more of that amount of tax money collected was spent in the community it would make a big difference. If you took all the tax money collected from CN and CP Rail (for section running through town), Spectra Energy, Savona Equipment, Nelson Machinery, Savona Specialty Plywood, just to list a few of the larger companies, it would add up to a huge amount. The quality of life here is going down because we are being robbed, hardly anyone from the businesses live here. Small town BC is drying. Change the tax structure!!!

As a Savona resident not voting for the TNRD to take care of our water system I was not surprised by the results of the operation of the newly installed system. Nor was I surprised that the TNRD held the community grant money from the provincial government for approximately 3 years and increasing resident's taxes with only a shiny new B.S. sign to look at for that same period of time. Nor was I surprised to receive no answers to questions regarding the aforementioned. Also, not surprised to hear that the TNRD representative gave herself a wage increase due to I'm sure in her mind, all the hard and laborious work she had done. I personally have yet to see value for money spent.

We use the water dispenser for drinking only. Tap water is used for cooking. We purchase individual bottles mainly for taking to work and travelling. I trust Savona water but am spoiled with the water dispenser that cools and keeps my fridge space free for other items.

As this is a business, not a residence - the survey questions were not always applicable. We do however, provide filtered water for employee consumption.

The present water quality is at an acceptable level for 10+ months of the year. High water each year increases turbidity levels to the point of boiling water advisory or the use of alternate water supplies i.e. bottled water. To improve turbidity levels to an acceptable level during high water would cost more than I am willing to pay to offset 4-6 weeks of inconvenience and the use of alternate water sources. I consider our water quality as only acceptable due to concerns about possible harmful chemicals entering our drinking water from the City of Kamloops and Domtar effluents. Chlorination takes care of the biological concern but no effect on any chemicals present. I have lived in Savona 30+ years and this has always been an uneasy concern.

We would have to be sure the water is safe before we would consider drinking it. $35.00 per month for poor water is too high. The water seems to be cleaner, better in the winter. Since the TNRD has taken over everything costs more money. Good Luck.

Our home is used primarily April to October and we bring water from Vancouver for drinking and cooking because of the constant boil-water advisories. We are reluctant to drink the water from the tap because of this. Although it is not pertinent to water quality, we have noticed that watering restrictions are not observed by all residents of Savona, especially those on access road where watering is seen at all hours of the day.

I feel that if there is any money to be allotted to our community it should be spent to improve our school and update ambulance service. I feel our water quality is satisfactory and that any additional moneys spent would not necessarily add to a major improvement.

I moved to Savona five years ago. I have an auto immune disease and I inquired with the health department if the water was safe to drink. It was suggested to me that, to ensure safety, the water for drinking should be boiled. At that time I purchased a water dispenser which I use for drinking water. To my knowledge, the boil water advisory has not been lifted by TNRD.

Up to 2 years ago, I was frequently unwell even though we boiled the water. This has not been an issue this past year although we no longer boil water for extended periods of time as previous to this year.

I have little faith that this survey will in any way help our quality of water. We desperately need improved water quality - a vote was held on whether or not we need a new fire hall - it failed - that's not the desired answer - we held another vote - it passed hands down 0 even though I and others I know voted against it. We got a one million dollar fire hall for 265 households - we basically drink Kamloops sewage - I have one 250 micron filter and one big fiber filter - the 250- micron lasts about a month the big fiber filter about 4 months and the reverse osmosis - first filter 3 months carbon filters yearly - the osmosis cost 4900 in 2001 the osmosis filter alone cost about $120 a year - the regional district is very dictatorial - they do what they want including giving themselves a $5,000 raise.
I believe that the Savona residents would not be at such a risk for illness from water borne problems if the City of Kamloops, the Pulp Mills and various other sources of contamination were forced to bring their waste treatment facilities up to today's standards. Instead they keep applying to put more contamination into Kamloops Lake! Have you ever taken a ride in a boat to where the Thompson River flows into Kamloops lake? Please do...it is disgusting! The sludge actually sticks to the side of the boat! That is what the Savona and communities downstream get to consume! In that area there is the contamination that can be seen, what about all the chemicals and bacteria, that is so harmful, that cannot be seen? Interesting that the City of Kamloops draws their water upstream. I also believe above named contaminators should be subsidizing the Savona water treatment costs.
Thank you for taking an interest in our community. Have a great day.
Our perception of the state of water quality in Savona is that it is just fine. We have no problem with the taste or smell. We wish you success with this endeavor and your future studies.
We pay too much and get too little. I would be happy to pay the same as Kamloops. To receive the same services. Like police service, ambulance, fire, sidewalks, and sewer. Regular bus service, not to mention "top of the line" water filtration system! Got the message? Please explain where our money goes from the land taxes. Yes, I know some goes for school tax, hospital, etc. and regional district. What: more money into the TNRD. Then if there is more money shouldn't it be paying for the services and infrastructure?
TNRD increased our utility rates from $15 to $15/month a couple of years ago and nothing was done, except this summer the water intake pipe was extended. That increase was large - over 100% - isn't that crazy!!? In Kamloops, $72/month gets you sidewalks, more policing, great water, some bus service (I know more people). The difference does not compare - perhaps the TNRD is taking for much profit?? We can't have anything for nothing. Something has to lose. I don't mind boiling my drinking water, not necessary to have filtered or boiled bath water.
What would we do without government (Provincial, local, and regional). Just fine in my estimation. Individual responsibility is an issue that needs to be addressed in this province. Taxes are too high and we are heading down a slippery slope.

Undrinkable - even the dog won’t drink it. They drink bottled water. Terrible water! We had to install a filter system so that we could have a bath. The water in Savona is totally unacceptable. The fees are exorbant. There was a 1 inch deposit of dirt in the toilet tanks and the water in the tub was brown, with jets on brown foam on top of water. After purchasing a filter system for the complete water system to the residence, we can now brush our teeth and cook our veggies. WE pay for water on our taxes and per month. The TNRD is double dipping us with fees and we still can’t drink the water. Even our two Rottweilers will not drink tap water except right after the filters have been changed. Not impressed with TNRD.
I find very little wrong with Savona water. But I do have a reverse osmosis unit. Still find a little discolour since they extended the pipe out into the lake. So I boil my drinking water. How long does it take to boil a kettle of water! Thank you and good luck.
At present we are only there for 3-4 weeks per year. The property is shared between me and my four siblings (with families). The water is turned on in the spring - for the lawns and shut off again in the fall. No one stays at the place in the winter, so far.
We would like the TNRD to solve the turbidity problem we seem to have in the spring.

Letter to the Respondent

Dear Sir or Madam,

This survey is being conducted as a requirement of my Master of Science in Environmental Science Degree in conjunction with the Thompson Nicola Regional District Office in Kamloops, BC. We invite you to participate in this survey that will help determine appropriate management strategies for water utility developments in your community. This study assesses your willingness to pay for access to water utilities based on your perception of the state of water resources in Savona. The TNRD may use this information to gauge the public's perception of water quality in Savona as part of an effort to improve drinking water quality to meet Interior Health Authority requirements.

The following pages consist of a series of questions designed to determine your attitudes towards environmental resources and should take no longer than fifteen minutes to complete. If you choose to complete this survey, please mail it back in the prepaid return envelope enclosed in this package.

You have the right to refuse to participate or withdraw from this study at any time. If you complete the survey, it will be assumed that your consent to participate has been given. Please do not put your name or other personal information that is not specifically requested on this survey as it is designed to be completely anonymous. If you are interested in the results, please feel free to contact me via email after September 2011 at r_maciak@hotmail.com. Thank you for your participation in this research project.

Warmest regards,

Robert Maciak

Contacts:

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Dear Sir or Madam,

Last week you received a survey in your mail regarding Savona's water utility system and your perception of water quality in the community. This letter is just to remind you that we will begin reviewing the completed surveys on August 29. We ask that if you have not yet mailed back the completed survey, to please do so as soon as you are able.

The package sent last week with the survey contained a prepaid envelope for you to return the finished survey in. If you are having trouble completing the survey or have misplaced your prepaid envelope, please contact Robert by email or one of the telephone numbers listed below. Your opinion is very important to us and we are grateful for your participation in this research project.

Sincerely,

Robert A. Maciak

CONTACT INFORMATION

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A Survey on Water Quality in Savona

This survey supports research being conducted as a component of a Master of Science in Environmental Science Degree

By Robert Maciak

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Background Information

The freshwater delivery system in the community of Savona has faced problems with quality and quantity in recent years. As a result, the Thompson Nicola Regional District (TNRD) is exploring options associated with improving drinking water quality in order to consistently meet guidelines mandated by the Interior Health Authority. The information gathered by this survey may help the TNRD assess the public's perception of water quality as they attempt to determine appropriate options for future improvements.

Savona Community Water System Facts

- Originally constructed in the late 1970s
- Reservoir capacity is 664m^3 or 146,000gallons
- Serves approximately 265 customers
- Lake water is disinfected through chlorination
- Residents are charged $420 a year per dwelling for access to the water utility

Source: TNRD 2009 Annual Report: Savona Community Water System

Savona Turbidity and Water Quality Monitoring is conducted partially by the Savona Improvement District Committee Members and a hired contractor who conducts daily chlorine tests and system monitoring as well as a minimum of one system inspection per week with more frequent visits when required.

Turbidity is the primary cause of poor water quality in Savona. Turbidity is a water quality term that refers to the relative clarity of water. It occurs when fine suspended particles of clay, silt, organic and inorganic matter, plankton, and other microscopic organisms are picked up by water as it passes through a watershed. Turbidity levels are typically much higher in water from surface water sources such as streams, rivers, and lakes than from groundwater sources. Some surface water sources exhibit high turbidity levels during periods of high rainfall or snow melt (e.g. spring runoff). Measured in nephelometric turbidity units (NTU), turbidity ranges from less than 1 NTU to more than 1,000 NTU. When turbidity levels are above 1 NTU but below 5 NTU the TNRD issues a water quality advisory. When turbidity levels exceed 5 NTU a boil water notice is issued to the community. **In Savona,** boil water notices typically come into effect around the time of Spring runoff. These notices and advisories can persist for months before turbidity reaches an acceptable level.

Consent, Privacy and Right to Refuse

By participating in this survey, you the participant are providing your consent. You have the right to refuse or cease participation at any time within the experiment. The survey is designed to be completely anonymous and no identifying information (name, address, etc.) will be collected.

Time: You will need approximately 15 minutes to complete the survey.

Section 1: Community and Water Issues

1.1 What level of priority does your household assign to the following issues? (Check one box only for each issue)

	Low 1	2	3	4	High 5
Improving city streets	☐	☐	☐	☐	☐
Improving the quality of drinking water	☐	☐	☐	☐	☐
Reducing crime	☐	☐	☐	☐	☐
Improving the quality of health care	☐	☐	☐	☐	☐
Improving the quality of education	☐	☐	☐	☐	☐
Investing in arts and culture	☐	☐	☐	☐	☐

1.2 If your household were to select only one issue as having the highest priority, which of the above issues would you select?

____

1.3 In the past year, has your household taken extra measures to reduce consumption of:

	Yes	No
Electricity	☐	☐
Gas - Heating	☐	☐
Water	☐	☐
Transportation Fuel	☐	☐

1.4 Savona residents face water conservation measures during the summer months such as garden watering restrictions. Do you think Savona's current water conservation measures are:

Inadequate 1	2	3	4	Excellent 5	Don't Know
☐	☐	☐	☐	☐	☐

1.5 The pipe that extracts water from Kamloops Lake for the community utility system has recently been extended. Have you noticed an improvement in drinking water quality over the past several months relative to the same period last year?

No Improvement 1	2	3	4	Major Improvement 5	Don't Know
☐	☐	☐	☐	☐	☐

1.6 The current utility system disinfects lake water through chlorination. Do you think this level of water treatment is:

Inadequate 1	2	3	4	Excellent 5	Don't Know
☐	☐	☐	☐	☐	☐

1.7 How do you rate the overall drinking water quality in Savona?

Low Quality 1	2	3	4	High Quality 5
☐	☐	☐	☐	☐

1.8 If you rank your drinking water quality as 3 or less, what is your primary concern? (e.g. poor taste, odour, colour, risk of illness, etc.)

1.9 How often did you engage in the following water treatments during the past year:

	Not at all 1	2	Occasionally 3	4	Very Often 5	
Boiled Water Only	☐	☐	☐	☐	☐	
Filtered Water Only	☐	☐	☐	☐	☐	
Boiled and Filtered	☐	☐	☐	☐	☐	
Purchased Bottled Water	☐	☐	☐	☐	☐	**Bottled water includes 20L water dispenser refills*
Other (describe): ______________________	☐	☐	☐	☐	☐	

Section 2: Willingness to Pay

The availability of high quality freshwater is important in maintaining a healthy community. Imagine that the local municipality is considering taking additional measures to improve the quality of drinking water in order to consistently meet guidelines mandated by the Interior Health Authority. In order to improve drinking water the local authority would have to raise additional revenue in order to pay the costs associated with increasing the quality. Currently, a dwelling is charged $35 per month for having access to water ($420 per year).

*2.1. If you **could be sure** that the water quality in Savona would be drinkable without any additional household treatment or filtration (including boiling), would you be willing to **accept an increase in your household's water utility bill** to pay for the improved water quality? Remember that accepting an increase in water utility fees requires either spending less on other goods/services or paying less for your current expenditures that improve water quality (e.g. water filter or bottled water)*

☐ *Yes* ☐ *No* → **GO TO QUESTION 2.2**

What is the maximum amount you would be willing to pay for improving water quality per month over and above your current access to water fee of $35 per month?

☐ Less than $5 more per month (please specify)__________
☐ $5 - $6.99 more per month
☐ $7 - $8.99 more per month
☐ $9 - $10.99 more per month
☐ $11 - $12.99 more per month
☐ Greater than $13 more per month (please specify)__________ → **GO TO QUESTION 2.3**

2.2. Listed below are some possible reasons why you are not willing to pay to accept an increase in your household's water utility fees to improve the quality of the drinking water? Please check all that apply to you.

- ☐ Fees are already too high for the service provided
- ☐ Unable to pay more based on my income
- ☐ Increasing fees will not solve the water quality problem
- ☐ I feel that the water quality is already acceptable
- ☐ I have taken my own necessary measures to improve the quality of water
- ☐ Other *(Please Specify)*____________________________

Household Water Dispenser

2.3 Do you currently purchase products that improve the quality of drinking water? (e.g. bottled water, water dispensers, and home filtration systems)

☐ *Yes* ☐ *No* → GO TO SECTION 3

2.4 Do you have a household water dispenser?

☐ *Yes* ☐ *No* → GO TO QUESTION 2.6

2.5 How much do you spend on the dispenser per month?

Water refill for dispenser $ __________ */ month*

Other (e.g. dispenser rent) $ __________ */month (Please Specify)*____________________________

2.6 Do you have a household water filtration system?

☐ *Yes* ☐ *No* **GO TO QUESTION 2.8**

Examples of Home Filtration Products

2.7 How much do you spend on maintenance per month on average?

Maintenance (e.g, replacement filters) $__________ / month

2.8 What is the average number of hours ***per week*** *that your household allocates towards the treatment of water? (e.g. travelling to the store to purchase water, boiling water, filtration system maintenance, etc.)*

0	1	2	3	4	5 or more
☐	☐	☐	☐	☐	☐

If your answer is 5 or more please specify number of hours:______________ / week

2.9 How many bottles of spring water or filtered water (between 250ml and 4L) do you purchase each month?

Number of bottles 250ml (8.5 oz) __________ / Month
Number of bottles 600ml (20 oz) __________ / Month
Number of bottles 1 L (34 oz) __________ / Month
Number of bottles 2 L (68 oz) __________ / Month
Number of bottles 4 L (136 oz) __________ / Month

2.10 Considering your answers from the previous questions in this section, what is the average cost to your household of improving drinking water due to additional filtration each month? $______________/ Month

2.11 Has a member of your household ever become ill due to consuming tap water in Savona?

☐ Yes ☐ No → **GO TO SECTION 3**

2.12 How many times has a member of your household become ill in the past two years?

1	2	3	4	5 or more
☐	☐	☐	☐	☐

** If you selected 5 or more, please specify:___________________*

2.13 Have you or a member of your household lost work days because of illness caused by Savona drinking water?

☐ Yes ☐ No → **GO TO SECTION 3**

2.14 How many work days on average have been lost because of water illness within the past year?

1	2	3	4	5 or more
☐	☐	☐	☐	☐

** If selected 5 or more please specify the number of days lost per year: ________________________*

Section 3: Background Information

The information in this section will remain completely anonymous and be used for no other purpose than this particular study. Please **do not** include your name or address anywhere in this section.

3.0 What is your gender?

☐ Male ☐ Female

3.1 Please indicate your age:

18-24	25-39	40-64	65-80	80 or older
☐	☐	☐	☐	☐

3.2 Please indicate the total number of individuals in your household

1	2	3	4	5 or more
☐	☐	☐	☐	☐

* *If you selected 5 or more, please specify*______________________

3.3 Do you have children below the age of 18 residing at your household?

☐ *Yes* ☐ *No* → **GO TO QUESTION 3.5**

3.4 Please indicate the total number of children in your household

0	1	2	3	4 or more
☐	☐	☐	☐	☐

* *If you selected 4 or more, please specify*______________________

3.5 Are you or another member of your household employed full time?

☐ *Yes* ☐ *No* **GO TO QUESTION 3.7**

3.6 What is the highest hourly gross (pre-tax) wage rate currently being earned by a full-time employee in your household?

$ ____________ / hr

3.7 Are you or another member of your household retired?

☐ *Yes* ☐ *No*

3.8 What is the highest level of education attained by a member of your household?

☐ Some high school or less
☐ High school graduate
☐ Some college or trade school
☐ College or trade school graduate
☐ University graduate (bachelor's degree)
☐ Post graduate studies

3.9 Do you own or rent your home?

☐ *Rent* ☐ *Own* → **GO TO QUESTION 3.11**

3.10 If you rent your home, do you currently pay the water utility bill?

☐ *Yes* ☐ *No*

3.11 Please indicate your total annual pre-tax ***household income***

- ☐ Less than $20,000 *Please specify approximate amount: $*____________
- ☐ $20,001 to $30,000
- ☐ $30,001 to $40,000
- ☐ $40,001 to $50,000
- ☐ $50,001 to $60,000
- ☐ $60,001 to $70,000
- ☐ $70,001 to $80,000
- ☐ $80,001 to $90,000
- ☐ $90,001 to $100,000
- ☐ $100,001 to $110,000
- ☐ More than $110,000 *Please specify approximate amount: $*____________

Section 4: Please provide your feedback or comments in this section

(If more space is required, you may continue writing on the backside of this page)

THANK YOU FOR YOUR PARTICIPATION