CULTUS LAKE ENVIRONMENTAL SERVICES VALUATION

PHASE 1– Revised April 2019

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Executive Summary

Cultus Lake is an important recreational site approximately 100 kilometers east of Vancouver, British Columbia. The local economy is dependent on recreational visitors and is tied to the quality of the water in the lake. Research shows that degradation occurring is being cause by nutrient loading from a variety of sources. If degradation continues, it can negatively affect the quality of recreation, which will lead some people to choose alternative locations for their recreation time. This is the most obvious way that diminishing water quality may harm the Cultus Lake economy. Beyond this direct impact on Cultus Lake businesses, there are indirect impacts from reduced water quality on environmental services that are not often captured in market transactions. Environmental services are those things that environmental assets, such as Cultus Lake, provide on an ongoing basis. Like any other asset, if investments are not made in protecting the state of an environmental asset like Cultus Lake, the value of the services it provides will decrease. Services that the lake currently provides include habitat for salmon and water where people can safely swim. These services are not as easy to measure as the value of lumber provided by a forest, which has lead to a variety of methods to indirectly estimate the value of the environmental services. This report summarizes the work done for Phase I of the Cultus Lake Environmental Services Valuation which consists of three main tasks: review the scientific literature and develop a set of future scenarios, conduct interviews with community members and experts of Cultus Lake, and perform a review of the relevant economic literature.

Future Alternative Scenarios

The first step for this project was to review existing scientific literature on Cultus Lake and develop a set of future scenarios, to understanding the extent of the impacts from eutrophication and to serve as a basis for surveys to be created in Phase II of the project. Nutrient loading in Cultus Lake comes from four primary sources: atmospheric deposition, surface and groundwater runoff, septic system leaching, and deposition of gull guano (Putt, 2014). The yearly amounts of each source are presented in Table 1.

Table 1 Yearly Nitrogen and Phosphorus Loadings (Adapted from Putt 2014, revised))

	Phosphorus (kg/yr)	Percentage	Nitrogen (kg/yr)	Percentage
Atmospheric Deposition	124	4.9%	8,673	17.1%
Surface/Groundwater Runoff	1,459	58.8%	36,854	72.5%
Septic Leaching	523	21.1%	4,557	9%
Gull Guano	355	14.3%	585	1.2%
Sockeye salmon Carcasses	23	0.9%	191	0.04%
Total	**2,484**	**100%**	**50,859**	**99.8%**

The status quo scenario (worst case) assumes that no mitigation techniques will be used to reduce nutrient loading. This loading is expected to increase with population growth and increased gull population (Putt, 2014). This will lead to major problems on the lake such as reduced water quality, and harm to Cultus Lake sockeye salmon, Cultus Lake pygmy sculpin and other fish species. Water quality is reduced in the form of algae blooms, green murky water from cyanoplankton, health risks to humans and animals, and increased Eurasian watermilfoil. All of these make Cultus Lake a less desirable location for water-based recreation.

The habitat of the Cultus Lake sockeye salmon and the Cultus Lake pygmy sculpin is at risk due to hypoxic zones at the bottom of the lake, increasing water temperatures, altered food web from cyanoplankton, and increased E. watermilfoil. All these factors are expected to increase in severity in the future, further harming their habitat (Putt, 2014; Sumka, 2017). Other fish may be affected by eutrophication as well, which may then impact recreational fishing. These effects could affect the local economy from reduced visitation, or the average income of visitors may become lower leading to less money spent in Cultus Lake.

The best-case scenario is assuming that the amount of nutrient loading is reduced from all four major sources at the local level. Agricultural-sourced nutrient will be reduced by an estimated 50% of the status quo level, which contributes to both atmospheric deposition and surface/groundwater runoff. Septic leaching would be reduced by more than 90% of the status quo levels by converting all areas of the lake to 'Class A+' effluent treatment systems. The number of gulls will be reduced by 45% of the status quo amount using non-lethal deterring tactics. Unfortunately, these mitigation techniques will not stop or reverse eutrophication, but it will slow the deterioration and allow more time for improvements to be made outside the local level (Putt, 2014).

Three intermediate scenarios are proposed here, that are combinations of the best and worst-case scenarios.

1. 'Class A+' effluent treatment facility on the northeast side of the lake
2. 'Class A+' effluent treatment facility in the southwest and BC Parks
3. Gull reduction and agricultural practices improved

Of the first two intermediate scenarios, an effluent treatment facility on the northeast side of the lake would be most effective as this area contributes approximately 55% of septic nutrient loading for each of phosphorous and nitrogen inputs (Putt, 2014). Reducing the number of gulls that roost on the lake and improving agricultural practices would reduce loading by a greater amount, but will be more difficult to implement.

Interviews

Interviews were conducted with people who have an interest in the health of Cultus Lake and the surrounding community. The purpose of the interviews was to identify, from the perspective of the interviewees, the most important services provided by Cultus Lake. In total seven people were interviewed including residents, business owners, and experts whose work involves Cultus Lake. Attempts to contact Soowahlie First Nation were incomplete at the time of the writing of this report, so to date a First Nation perspective is lacking. While far from a substitute for their participation, interviewees were asked to describe how they thought Soowahlie First Nation's view might differ from theirs.

The interviews indicate that the most important services are the availability of outdoor recreation, the aesthetics of the lake, and Cultus Lake as a quiet close-knit community with easy access to additional amenities in Chilliwack. One interviewee expressed that improving business development in the community is more important than the health of the lake, so the community can be sustainable through the year. The health of the lake is important to most community members, but some perspectives focus on impacts on recreation as opposed to Cultus Lake sockeye. Thus, they are more worried about the impact of algal blooms and E. watermilfoil. However some participants are primarily concerned with the wellbeing of the Cultus Lake sockeye. They feel a responsibility to protect the salmon's habitat since it is human activity that has threatens the lake. A common theme was the problem of the E. watermilfoil. This plant is highly invasive, is a nuisance to swimmers and boaters, and provides a habitat for the pikeminnow.

With addressing eutrophication on the lake, multiple people expressed that they do not believe there has been enough research to make factually informed decisions. Most interviewed stated that people do not complain about the water quality, but people do complain about 'cedar itch' and E. watermilfoil. Two interviewees mentioned complaints of water quality in Maple Bay. Almost all who were interviewed approved of overhauling the treatment systems to achieve 'Class A+' effluent qualities and would like to see this achieved all around the lake, with a connection to the Chilliwack sewage system. Other concerns that people had about Cultus Lake were mainly lack of communication between jurisdictional groups, congestion on the roads, and congestion on the lake. Another common theme was the culture and the history of the lake pertaining to the Soowahlie First Nation, that it is not often talked about, but respondents hope that their history and their connection to the lake could be pursued to attract visitors.

Overall, the interviews show that respondents have different concerns and priorities, but most are troubled with water quality, even if it may be for different reasons. For the literature review, only the most common themes that could be related to water quality and the health of the lake were used. The services sought were aesthetics, recreation, and the health of the Cultus Lake sockeye salmon. Economic valuation studies related to E. watermilfoil were also considered since all interviewed mentioned it, as it potentially has some effect on all key services.

Literature Review

The goal with the literature review was to find valuation studies that were most relevant to the case of Cultus Lake, and reported values related to the services apparent in the interviews. Additional criteria for the studies were that they related to water quality and eutrophication in lakes, had a recent year of publication, and used data from North America. Unfortunately, environmental services valuation is a relatively new discipline in economics, thus the literature is not very deep. In the end, 17 studies were chosen as the most relevant. These studies reported values for various services all over the world, dating back to 1991, and use a variety of estimation methods.

The study methodologies can be grouped into six different categories: travel cost, choice experiment, contingent valuation method, hedonic pricing, avoided costs, and benefit transfer. The first five are methods that measure the willingness to pay of people in an area directly, while benefit transfer is adapting values from one analysis for use in another. Travel cost models estimate the willingness to pay of consumers for recreational services by surveying them on the costs – vehicle maintenance and fuel, value of time for travel, etc. – they incur to enjoy those services. Choice experiments use surveys to elicit willingness to pay for a good or service by asking respondents to choose between a set of scenarios that contain different levels of the good, with a cost associated with it.

The contingent valuation method is similar to choice experiments, but instead of being asked to choose between alternative scenarios they are asked to report what they would be willing to pay for each scenario directly. Hedonic pricing attempts to estimate the proportion of property prices that can be attributed to a service by regressing the relevant characteristics of the home on the sales price. Avoided costs estimate the value of a good or service based on the cost needed to preserve, replace, or restore that good or service. The benefit transfer method aggregates data and values from previously completed studies and uses those values as a proxy.

Studies gathered can be roughly grouped into three categories: studies pertaining to water quality, salmon and Eurasian watermilfoil. Water quality studies report values for improving water quality, relate water quality to recreation, or relate water quality to property prices. The biggest challenge for the water quality group was that many studies in this did not focus on specific sites, but rather a regional or national effect of water quality. However, these studies do provide evidence of the economic impacts of deteriorating water quality and eutrophication.

In the United States, Dodds et al. (2008) used a travel cost model and found that eutrophication in US lakes and rivers cause a combined cost between $385 million and $1.3 billion per year in lost fishing days, boating days, property values and loss in biodiversity. Similarly, Vesterinen et al. (2010) used a travel cost model to estimate that an increase in water clarity of one meter in lakes in Finland could generate between €74 million and €221 million per year in swimming and fishing benefits, but found no increase in boating benefits. Complementing these two studies is Needelman et al. (1995), which estimates

achieving swimmable water quality in New Hampshire lakes generates up to $18 million per year in swimming benefits. These studies show that eutrophication and degrading water quality cause great economic problems, but improving the conditions can generate significant economic benefits; the discrepancy between Vesterinen and Dodds shows the need for more site-specific studies.

Site-specific studies also show differences in their values. Crase et al. (2008) studied the total recreational value of Lake Hume, Australia using a travel costs model, with some aspects of contingent valuation scenarios to value the loss from algal blooms. Total recreation value was assessed at $3 million per year, and the loss from algal blooms was assessed at $1 million per year. In contrast, Mueller et al. (2016) valued recreation on Lake Rotura, New Zealand and estimated the benefits to be between $52 million and $81.3 million per year.

Other values reported show the benefits and willingness to pay for improving water quality, as reported in Table 2. These values show that there are significant benefits to improving water quality, and people are willing to pay to receive these benefits.

The last study to mention is Robinson (2011), which reports willingness to pay for improving water quality and recreational services in Quamichan Lake in North Cowichan, B.C. This study estimates that residents in North Cowichan are willing to pay between $300,000 to $860,000 per year to improve water quality, and between $110,000 to $350,000 per year to improve recreational facilities. This study may best represent the willingness to pay values in Cultus Lake since it has the highest degree of comparability, but since Quamichan Lake does not receive the same influx of visitors as Cultus Lake, the value for Cultus Lake may be significantly higher.

Regarding salmon, there were several valuation studies that relay the non-use value of salmon and the value of restoring salmon habitat on the west coast of the United States, using choice experiments and the contingent valuation method. Unfortunately, no studies could be found that reported existence values for sockeye salmon. There are other studies that estimate the fishing and commercial value of sockeye salmon, but these are inappropriate for Cultus Lake. A total of seven values were collected that are between $6.25 and $67 per household per year, are overall lower than the willingness to pay values for water quality. However, Helvoigt and Charlton (2007) used the benefit transfer method to calculate the annual non-use marginal value of northwest salmon and found that the marginal value per fish to be $525 per year when the population is 1,500,000, but is $1,595 per year when the population is 500,000 (Table 3, Salmon Valuation Studies). So, it is possible that the value of the Cultus Lake sockeye salmon is higher, but it requires people to differentiate the species from other salmon species.

In addition to these studies, two studies were found that valued the economic impact of Eurasian watermilfoil. Eiswerth et al. (2000) estimates the cost of controlling E. watermilfoil for mechanical and chemical harvesting. For mechanical harvesting, it estimates that the cost of removal equipment to be between $30,000 and $100,000, and the

cost of harvesting to be between $750 and $1500 per hectare per year. For chemical harvesting, it estimates the cost to be between $500 and $5000 per hectare per harvest. It also assesses the recreational value of the Truckee River Watershed at $30 million to $45 million annually using the benefit transfer method. It does not estimate the impact that the E. watermilfoil will have on these values. But for example, if E. watermilfoil reduced this value by 10% then that translates into $3 million to $4.5 million per year. Another study Zhang et al. (2010) shows the impact of E. watermilfoil on property values and finds that the marginal impact on property prices is $355 to $17,764.

There are many impacts from eutrophication on Cultus Lake that each affect multiple services. Considering the combined effect of these impacts, the benefit of reducing nutrient loading is significant. Due to lack of studies highly comparable to Cultus Lake, it is difficult to estimate the true economic impact for the future of Cultus Lake. One option to better understand the impacts is to apply the benefit transfer method to the values in this report. However, the appropriate way to obtain the most accurate results would be to administer a combined and revealed preference survey to value the services of Cultus Lake.

Table 2 Water Quality Valuation Studies

Study	Service	Value Type	Method	Minimum	Maximum	$	Year
Abidoye et al. 2012	Recreation	Compensating Variation	Travel Cost	30.08	30.08	US	2012
Ahtiainen et al. 2014	Water Clarity	WTP/household/year	CE	9.50	1103.80	EUR	2009
	Fish Species	WTP/household/year	CE	11.10	1515	EUR	2009
	Blue-green algae	WTP/household/year	CE	41.10	1834	EUR	2009
	Sliming	WTP/household/year	CE	8.80	775.70	EUR	2009
Azevedo et al. 2012	Water Quality	WTP/person/year	CVM	436	1630	US	2012
Crase et al. 2008	Algal Blooms	Loss in Consumer Surplus	Travel Cost	1000000	1000000	AUS	2008
Dodds et al. 2008	Fishing Days	Loss in Consumer Surplus	Travel Cost	189000000	589000000	US	2008
	Boating Days	Loss in Consumer Surplus	Travel Cost	182000000	567000000	US	2008
	Property Value	Loss in Property Value	Hedonic Pricing	14100000	141100000	US	2008
	Biodiversity	Loss in Biodiversity	Avoided Cost	732800	732800	US	2008
Lansford and Lonnie 1995	Recreation and Aesthetic	Marginal Value per foot	Hedonic Pricing	3	1248	US	1995
Mueller et al. 2016	Biodiversity	Existence Value	Benefit Transfer	15100000	15100000	NZD	2012
	Nutrient Sequestration	Removal Spending	Avoided Cost	4100000	13300000	NZD	2012
	Amenity and Aesthetic	Loss in Property Value	Hedonic Pricing	16000000	19100000	NZD	2012
	Recreation	Consumer Surplus	Travel Cost	52000000	81300000	NZD	2012
Needelman et al. 1995	Swimming	Consumer Surplus	Travel Cost	18000000	18000000	US	1995
Robinson 2011	Water Quality	WTP/year for community	CVM	300000	860000	CAN	2011
	Recreation	WTP/year for community	CVM	110000	350000	CAN	2011

Vesterinen et al. 2010	Swimming Days	Consumer Surplus	Travel Cost	31000000	92000000	EUR	2010
	Fishing Days	Consumer Surplus	Travel Cost	43000000	129000000	EUR	2010
	Boating Days	Consumer Surplus	Travel Cost	0	0	EUR	2010

Table 3 Salmon Valuation Studies

Study	Service	Value Type	Method	Minimum	Maximum	$	Year
Garber Yonts et al. 2004	Salmon Existence	WTP/household/year	CE	51	67	US	2004
Helvoigt and Charlton 2009	Salmon Existence	Marginal Value per fish	Benefit Transfer	525	1595	US	2007
	Salmon Habitat Restoration	WTP/household/month	Benefit Transfer	4.42	4.42	US	2008
Payne et al. 2000	Salmon Existence	WTP, one-time payment/household	CVM	13.20	16.40	US	2000
Stevens et al. 1991	Salmon Existence	WTP/person/year	CVM	6.25	7.93	US	1991
Stevens et a. 1997	Salmon Habitat Restoration	WTP/person/year	CVM	21.20	21.20	US	1997
	Salmon Habitat Restoration	Lump Sum	CVM	29	29	US	1997

Table 4 Eurasian Watermilfoil Valuation Studies

Study	Service	Value Type	Method	Minimum	Maximum	$	Year
Eiswerth et al. 2000	Eurasian Watermilfoil	Removal Equipment	Avoided Costs	30,000	100,000	US	2000
	Eurasian Watermilfoil	Mechanical Harvesting ha/harvest	Avoided Costs	750	1,500	US	2000
	Eurasian Watermilfoil	Chemical Harvesting ha/harvest	Avoided Costs	500	5,000	US	2000
	Recreation	Annual net economic values	Benefit transfer	30,000,000	45,000,000	US	2000
Zhang et al. 2010	Eurasian Watermilfoil	Property Value	Hedonic Pricing	355	17,764	US	2010

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Introduction

Cultus Lake is an important recreational site approximately 100 kilometers east of Vancouver, B.C. The local economy is heavily dependent on recreational visitors, and those visits are tied in no small part to the quality of the water in the lake. Ongoing research has documented a gradual degradation of water quality in the lake, caused by nutrient loading from human wastewater, agriculture, birds, and airborne pollution. If this degradation continues, the quality of the experience had by visitors will deteriorate, which in turn may lead these visitors to choose alternative sites or alternative forms of recreation. In this way, a reduction in the quality of the recreational experience can adversely affect the local economy that is dependent on the lake.

In addition to the direct impact on recreation, there are other indirect impacts that water quality can have, which are not always captured in market transactions. The process of estimating the economic impacts of these indirect effects is known as environmental goods and services valuation. Environmental goods and services are the flows of benefits that come from the earth's ecosystems, such as the atmosphere, water, lands, and natural resources (Robinson, 2011). These aspects of the environment are important services that provide inputs into the human economy, and that are able to assimilate waste outputs from the human economy. Often the value contributed by these services is not recognized. Because they are not traditionally perceived in this way, they are often ignored in market transactions, which cause them to be exploited. By treating them as goods and services that contribute economic benefits, we can analyze and estimate their economic value and importance.

This report summarizes the work done for Phase I of the Cultus Lake Environmental Services Valuation Study, which primarily consists of three parts: summarizing the existing scientific literature to develop future scenarios of the lake, identify the services that are most important to the community members and experts of Cultus Lake, and conduct a review of the economics literature relevant to Cultus Lake. Developing future scenarios is used for understanding how the impacts of eutrophication manifest over time and is necessary for the creation of a valuation study survey. Identifying the most important services ensures that the appropriate services are considered when conducting the literature review. Finally, the literature review provides value estimates of the environmental services of Cultus Lake based on research conducted elsewhere in the world, and identifies the most common methods in evaluating these services. These steps combined provide the foundation for Phase II of the project that will estimate the true value of Cultus Lake's environmental goods and services through primary research.

Future Alternative Scenarios

These scenarios were developed using the following papers: "Spatiotemporal nutrient loading to Cultus Lake: Context and implications for integrated watershed-lake management" by Annika Putt, "Cultus Lake User Survey Report" by Marion Robinson, "Climate change on a eutrophying lake: Cultus Lake, British Columbia," and "Cultus Lake Liquid Waste Management Plant Stage 2-3 Report" by Urban Systems.

Status Quo (Business as Usual)

The status quo scenario is the prediction of the future condition of Cultus Lake, given that no further mitigation techniques will be used to reduce the effects of eutrophication (nutrient overload) on the lake. Establishing the status quo requires an account of what the current causes of eutrophication are and what effect those sources have on the lake now and in the future.

In Cultus Lake there are four main sources of nutrient loading: Atmospheric deposition, surface and groundwater runoff, septic systems, and gull guano:

- Atmospheric deposition is the process whereby nutrients are loaded into the lake directly via the air or precipitation. These nutrients are in the atmosphere primarily due to pollution from the Lower Mainland and the Fraser Valley, and aerosol fertilizer use from nearby agricultural properties (Putt, 2014).
- **Surface and groundwater runoff** is water that flows over and through land into a watershed. Runoff water can contain nutrients, and can carry sediment and other materials that contain nutrients as well. These nutrient loads are deposited either directly into Cultus Lake or via tributaries. While some nutrients occur in the runoff naturally, much is from Columbia Valley agricultural run-off, and will include airborne nutrients from the Fraser Valley that is deposited into the Cultus Lake watershed.
- The septic systems in Cultus Lake vary by location, but most septic systems eventually flow effluent into some sort of septic field. The effluent contains high levels of phosphorus that make their way through the ground and are deposited into the lake or tributaries. Septic leaching is especially problematic in the summer due to the increased usage with the seasonal visitors throughout the lake. There is a plan to install a new treatment facility at the northeast end of the lake that will achieve 'Class A+' effluent quality, removing most of the nitrogen and phosphorus from the effluent. This is expected to significantly reduce septic leaching from the north end community into the lake (Urban Systems 2016, 27).
- Gull guano is deposited directly into the lake when the gulls roost on the lake. Each year an estimated 9,500 to 12,500 gulls roost on the lake during the winter months, feeding at nearby agricultural fields and landfills (Putt 2014, 13).

Each source contributes varying amounts of nitrogen and phosphorus, outlined in Table 1.

Table 1 Yearly Nitrogen and Phosphorus Loadings (Adapted from Putt 2014, revised)

	Phosphorus (kg/yr)	Percentage	Nitrogen (kg/yr)	Percentage
Atmospheric Deposition	124	4.9%	8,673	17.1%
Surface/Groundwater Runoff	1,459	58.8%	36,854	72.5%
Septic Leaching	523	21.1%	4,557	9%
Gull Guano	355	14.3%	585	1.2%
Sockeye salmon Carcasses	23	0.9%	191	0.04%
Total	**2,199**	**100%**	**50,859**	**99.8**

The combined loading of these sources over many years is what has led to eutrophication in the lake. These nutrients can stay in the lake for a long time, meaning that every year the problem will progressively get worse (Putt, 2014). It is expected that there will be further development on the lake to accommodate more visitors due to increasing population growth in the Lower Mainland (Putt, 2014). It is also predicted that in approximately 25 years the number of gulls that roost on the lake will increase to 30,800 per year (Putt, 2014). These factors will increase the nutrient loadings by a significant amount, further exasperating the problem leading to major impacts on the lake: reduced water quality, harm to Cultus Lake Sockeye salmon, Cultus Lake Pygmy sculpin and other fish species. These in turn can impact the Cultus Lake community and surrounding communities as well.

Water Quality

Increased nutrients in the lake will cause algae and cyanoplankton to thrive (Putt, 2014). This will negatively affect the aesthetics of the lake by making the water murky and green, and perhaps even produce a smell (Putt, 2014). Certain species of cyanoplankton are toxic to animals and humans, so there is a risk to human health that is present, and if eutrophication continues it may be unsuitable for recreation (Sumka, 2017); there are also health risks due to E. coli and fecal coliform contamination as well as from swimmer's itch, which has been a problem in Cultus Lake for some time (Dan Selbie, personal communication). The nutrients will also increase the amount of E. watermilfoil growing in the lake, which in turn will reduce the desirability to swim in the lake and can be a nuisance to boaters (Putt, 2014). All these effects make Cultus Lake a less desirable location for visitors and can negatively impact the local economy.

Sockeye Salmon and Pygmy Sculpin

Eutrophication combined with climate change has already significantly harmed the habitat of the Sockeye salmon and the Pygmy sculpin. Eutrophication and warmer temperatures have caused hypoxic zones in the lower levels of the lake which is typically where the Sockeye salmon and Pygmy sculpin occupy, because of colder water temperatures (Putt, 2014; Sumka, 2017). The salmon are forced to occupy the upper water columns which increases their risk of predation, but the Cultus Lake Pygmy may not be able to leave the bottom of the lake due to their species lacking a swimming bladder (Sumka, 2017),

additionally the upper water columns are warmer and can be harmful to sockeye salmon (Sumka, 2017). Increased cyanobacteria can cause the food web for the Cultus Lake sockeye and the Cultus Lake pygmy sculpin to degrade and may make the flesh of the fish toxic and unsuitable for consumption (Sumka, 2017). More Eurasian Watermilfoil further depletes the oxygen available in the lake and can provide a habitat for the juvenile Northern Pikeminnow which are a predator of the juvenile Sockeye salmon, and could possibly predate on the Pygmy sculpin (Sumka, 2017). If current conditions of the lake remain the same it is predicted that the lake will become mesotrophic, meaning that the lake will rarely or irregularly stratify, causing even warmer temperatures in the lake and decrease the productivity of the lake putting both the Cultus Lake Sockeye and the Cultus Lake Pygmy sculpin at extreme risk (Putt, 2014; Sumka, 2017).

Recreational Fishing

There are many species other than the Cultus Lake sockeye salmon and the Cultus Lake pygmy sculpin that occupy the lake that are not endangered. Eutrophication will likely affect the abundance of and composition of these species as well (Dan Selbie, email message, October 30 2017). Recreational fishing for species such as the cutthroat trout and the Dolly Varden are a significant attraction that bring people to Cultus lake (Robinson M., 2011). If the number of these species is reduced and/or the composition of these species change recreational fishers may be less inclined to visit Cultus Lake for this purpose. Additionally, the risk to Cultus Lake Sockeye salmon affects the recreational fishing market for Sockeye salmon on the Fraser River, since less Sockeye spawning in Cultus Lake means less sockeye available in the Fraser River.

Impact to Local Economy

Due to the increasing population in the Lower Mainland and in the Fraser Valley, as Cultus Lake deteriorates the number of visitors to Cultus Lake may or may not decrease. There is likely considerable demand for the recreational opportunities offered by Cultus lake, meaning that if some visitors go elsewhere because the water quality deteriorates, there are likely others who will take their place. However, the type of visitors that the lake receives will likely change. People with higher incomes are more likely to be willing to pay more to visit a lake that does not have the water quality issues that are expected to occur in in the future Cultus Lake, even if they are further away. People with lower incomes who are not willing to pay more to visit other lakes will still go to Cultus Lake. These visitors will likely spend less during their visit than those with higher incomes would. This will impact the traffic that local businesses in Cultus Lake receive and may impact people who rent out their property. For the same reasons this can impact businesses in nearby municipalities, mainly Chilliwack. With all the above effects including the impact on local businesses, the price of property on the lake may be impacted as well.

Best Case Scenario

The best-case scenario assumes that programs and policies will be pursued that effectively reduce the amount of nutrient loading from all sources that can be controlled at the local

level. This means reducing nutrient loading from agricultural sources, septic systems and gulls:

- Agriculture contributes both to atmospheric deposition and surface/groundwater runoff in the Cultus lake watershed. In this scenario it is assumed that nutrient loading from agriculture can be reduced by 50% of the status quo amount. Reduction may be achieved by landowners using improved fertilizer and manure management practices (Putt, 2014), promoted via policies, education or other methods (Urban Systems, 2016). Currently it is estimated that agricultural practices contribute 10% of total phosphorus and 73% of total nitrogen loadings (Putt, 2014), but are also expected to double in the next 25 years (Putt, 2014). So, the 50% reduction will keep the nutrient loadings at their current levels.

- Septic leaching will be reduced by more than 90% of status quo levels by connecting BC Parks sites and residential areas on the southwest side of the lake to a 'Class A+' effluent treatment system, along with the new facility on the northeast end of the lake, either by connecting to the north end treatment system or to future treatment systems in the southwest. As stated in the status quo scenario, a 'Class A+' system will reduce septic leaching of nutrients from areas in which it is implemented. With BC Parks and the southwest side also on a 'Class A+' system, it is reasonable to expect to achieve this level of treatment around the lake. Currently septic leaching contributes about 21.0% (523 kg/yr) of the total phosphorus and 9.0% (4,557 kg/yr) of the total nitrogen entering the lake (Putt 2014, revised). Although this amount may seem low, septics contribute disproportionately since most of the effluent loading occurs in the summer, which may cause septic leaching to have a greater impact in promoting eutrophication; also, reducing phosphorus loading is critical when limiting eutrophication (Putt, 2014). Effluent flows are expected to rise with increasing numbers of summer visitors (Putt, 2014; Urban Systems, 2016).

- The number of gulls that roost on the lake is expected to increase every year to 30,800 gulls roosting per year in 25 years (Putt, 2014). It is thought that the number of gulls can be reduced 45% by using non- lethal tactics (Putt, 2014). If successful, the number of gulls roosting on the lake will only increase to 16,940 in 25 years.

Overall, these mitigation techniques will not stop or reverse eutrophication in Cultus Lake. Eutrophication will only start to ameliorate once improvements happen outside the local level by reducing pollution in the Lower Mainland and beyond (Putt, 2014). Mitigating nutrients on the local level will however slow down the deterioration of the lake to a mesotrophic state and will prevent significant reductions in the aesthetics, recreation and fish habitat capabilities of the lake over the next 25 years (Putt, 2014). This will reduce the impact on the local economy, reduce the risk of the Cultus Lake sockeye and Cultus Lake pygmy sculpin from going extinct, and provides more time for improvements on the regional level.

Intermediate Scenarios

The intermediate scenarios proposed here are essentially combinations of the status quo and best-case scenario in which some of the mitigation techniques from the best-case scenario are used and other mitigation techniques are not. Three intermediate scenarios were identified:

1. 'Class A+' effluent treatment facility on the northeast side of the lake
2. 'Class A+' effluent treatment facility on the southwest area and BC Parks
3. Gull reduction and improved agricultural practices

Reducing the amount of nutrient-laden septic effluent from all residential areas around the lake will be further enhanced if BC Parks connects to a septic treatment facility to the southwest or northeast. In any case, while a 'Class A+' treatment is a good way of reducing the phosphorus loading into the lake, it is not major factor in reducing the nitrogen loading as these septic sources contribute a small load relative to agriculture (Putt, 2014). Reducing the number of gulls that roost on the lake and improving agricultural practices will reduce nutrient loading by a significantly greater amount than effluent treatment systems, but these achievements will be more difficult to implement. However, it is important to reduce septic contributions because most septic leaching occurs in the summer, and phosphorus reductions are more important than nitrogen reductions in decreasing the effects of eutrophication (Putt, 2014). Overall, these intermediate scenarios will slow down the eutrophication process relative to the status quo, but may not be effective enough to prevent the lake from entering a mesotrophic state in the next 25 years.

Interviews

A major component of this project was to conduct interviews with people who are likely to be impacted by changes in Cultus Lake water quality, to identify what are perceived to be the key services provided by the lake. The purpose of identifying these key services is to aid in performing a literature review, in which the services are used to find economic valuation studies that are most applicable to Cultus Lake. To conduct the interviews, a document on the current condition of Cultus Lake was created to familiarize the interviewee with what has been shown in the scientific literature when applicable and time permitting (Appendix B). This was followed by a set of 9-10 questions. The questions were designed to be sufficiently broad and to encourage the interviewee to speak as much as possible to gain a surfeit of information from the interviewee. In total, seven people were interviewed including residents, business owners, and experts whose work involves Cultus Lake. Lacking in these interviews is a First Nation perspective. The perspective of the local Soowahlie First Nation will be a valuable addition in future interviews given Indigenous communities' history and heritage in regard to Cultus Lake. It should be noted that approximately 200,000 decisions per year legally require consultation with Indigenous groups (Tomkins, 2008). Tomkins (2008) finds that the Cheam First Nation staff is challenged by the number of referrals that they receive, and it can be inferred that many First Nation communities face similar issues. As a remediation to the lack of an interview, a question was included in the questionnaire regarding how the interviewee thought the Soowahlie community's view might differ than theirs. Although this does not replace the information we will gain from the Soowahlie community, it was the best option at our disposal given the circumstances we had in Phase I.

Conversations with community members indicated that they like Cultus Lake because it is a quiet, close-knit community with low crime that is also vibrant in the summer when thousands of visitors come every day. They suggested that the aesthetics of the lake and the availability of outdoor recreation are the most important services that the lake provides. Residents said the reason they enjoy living on the lake is the ability to go out and participate in various outdoor activities such as swimming, hiking, jogging, biking, kayaking, bird watching and other activities, while having the aesthetic background of the lake and the mountains and being surrounded by nature. Without having these services available to them, they would not have chosen to live on the lake. While Cultus Lake is special to those who have come to the lake for many years, another attracting factor is its proximity to Chilliwack and the Lower Mainland. Chilliwack provides residents with many additional services that Cultus does not, such as major grocery and hardware stores, while being near the Lower Mainland is convenient so residents and their families can easily visit each other.

One participant expressed that they think that improving the local economy and promoting business development should be the most important focus of Cultus Lake and would like to

see more money being spent in Cultus Lake rather than in Chilliwack. While eutrophication and other environmental concerns are a problem that they would like to see addressed, they dislike these issues being used as a tool to stop development that they believe will improve the community, stating: "The people who live here [use] the trees as a catalyst to stop more people from coming here." They want the community to be sustainable throughout the year and not just a purely seasonal location, but believe that currently that is prevented from happening to keep Cultus a quiet place to live during the off season.

The health of the lake is very important to most interviewees, but some of their perspectives differ from that in the scientific literature. The scientific literature gathered thus far focuses on the effect eutrophication has on the Cultus Lake sockeye and the Cultus Lake pygmy sculpin since these species are at risk. Some revealed that they are somewhat worried about the wellbeing of these fish species, but it is not their primary interest regarding the health of the lake. Their main consideration with the health of the lake is that the water quality will degrade to the point that the lake will be unsuitable for recreational activities. Consequently, they are more worried about the algal blooms and E. watermilfoil since they effect the quality of water recreation activities, and they are more troubled with the effect that eutrophication can have on recreational fishing species such as cutthroat and Dolly Varden trout. Some of these respondents indicated the health of Cultus Lake sockeye would be more of a concern to them if it were shown to affect the population of other species such as the bald eagle, since bird watching is important to them. It was also conceded that although the sockeye salmon might not be their priority, other community members such as the Soowahlie First Nation might hold their existence in higher regard.

In contrast to above, there were interviewees who care about the health of the lake primarily because of the impact that it is having on the Cultus Lake sockeye population and other wildlife species in Cultus Lake. They feel that there is a responsibility to protect the habitat of this species because of its uniqueness, and because they think it is human activity that has threatened the species. They feel that the impact on recreational activities and the local economy are either equally important or secondary to the natural aspects of the lake. One respondent believes that the changes in water quality will have a marginal effect on the total recreational users that visit Cultus Lake and will mostly translate to a shift in users from water-based to land-based activities. Another respondent believes that the number of visitors will still increase with water quality degradation due to population growth in the Lower Mainland and Fraser Valley, combined with increasing travel costs and the fact that there are few other lakes in the region that are convenient and provide an extensive set of services and amenities. E. milfoil was virtually universally assented to be one of the worst symptoms of eutrophication due to it being extremely invasive, a nuisance to swimmers and boaters, and providing a habitat for the pikeminnow, which preys on pygmy sculpin and young sockeye.

With addressing eutrophication, several people said that they do not believe that there has been enough research done to make factually informed decisions, with one interviewee noting, "I haven't seen, and I am not familiar with enough studies to show me that (the lake

is) in dire straights." Some also had some doubt to the severity of the eutrophication problem, stating that they had observed effects such as green murky water for many years. When asked if visitors have complained about the water quality of Cultus Lake, most participants commented that most people do not complain about the water quality, but some visitors to complain about getting 'cedar itch' and the presence of E. watermilfoil. However, two participants mentioned complaints of the water quality in Maple Bay, with one believing it to be due to inadequate septic systems.

Almost all who were interviewed approved of the overhaul of the septic systems and agreed that it is the best way to tackle eutrophication at the local level. Some stated that they viewed it as the worse source of nutrient loading, but most agreed that it is the most feasible to plan and implement at the local level. Most would like to see the 'Class A+' treatment system at BC parks and Lindell Beach, and generally preferred to connect the Cultus Lake septics to the Chilliwack sewage system to ensure there was no chance of nutrients entering the lake. Additionally, some residents would like to see the gull population reduced since they also drop garbage and other debris onto the boardwalk and other areas of the park. They would also like to see agricultural runoff addressed, but more information is required regarding the kind of farm operations that exist in the Columbia Valley.

Other concerns that interviewees raised about Cultus Lake were mainly lack of communication between jurisdictional groups, congestion on the roads and congestion on the lake. One of the major hurdles that the respondents find with making improvements in the lake is a lack of communication between different jurisdictions. They believe addressing this is key to making progress towards tackling whatever issues the lake and the community faces, through collaboration and cooperation. One participant suggested that an overarching governing body would be necessary to facilitate these improvements. Another issue that most would like to see addressed is traffic congestion, as there is only one main road into the lake. During the peak season it is almost impossible to get in/out of Cultus Lake, making it difficult for emergency vehicles to access the lake. They are also uneasy with the congestion on the lake since there are many different types of users, and expressed concerns about safety issues regarding power boating.

Although the direct First Nation perspective could not be obtained regarding Cultus Lake, some context can be obtained from the 'First Nation Cultural Values and Teachings related to Water' by Darwin Douglas. The author notes the Xwélmexw have a personal relationship with water, "because it sustains all aspects of our life,"and the Xwélmexw ancestors maintained a balanced relationship with the environment (Douglas, n.d.). However, this relationship with water resources has been affected by "increasing urbanization, agriculture, pollution, and development," (Douglas, n.d.). From our interviews, a common theme raised by respondents was the culture and history of the lake, especially in relation to Soowahlie First Nation. They stated that it is an important aspect of Cultus Lake that is not often talked about, with one respondent noting "There is such rich heritage . . . we haven't even turned a dollar on what that heritage means." They hope that one day the

Culture and the history of Soowahlie First Nation and their connection to Cultus Lake will be pursued as an attraction for visitors.

Overall, these interviews have shown that there are many different concerns and priorities regarding Cultus Lake. Most of the participants are troubled with the water quality and health of the lake, but some also believe that there are other issues that should take priority. Even within those who care about the water quality, they care about the water quality for different reasons. For the literature review, only the most common services that were related to water quality and the health of the lake were examined, as the other common themes such as heritage and congestion are beyond the scope of this project. Thus, the main services that are considered in the literature review are recreation, aesthetics, and health of the Cultus Lake sockeye salmon. The focus for recreation studies will be swimming, boating, and fishing since these are the most popular activities and there are not likely studies relating land-based activities to water quality. The main indicators for aesthetics will be water clarity and algal blooms. For the Cultus Lake sockeye salmon, studies pertaining to the existence of salmon will be sought, since there is no recreational or commercial fishing market for the salmon in Cultus Lake. In addition to these, economic valuations related to the Eurasian milfoil will be included, since all those interviewed mentioned it and the milfoil potentially has some effect on the key services we evaluate.

Literature Review

The goal with this literature review was to find the most relevant studies to the case of Cultus Lake, to provide an indication of what the values for the environmental goods and services might be. As stated in the previous section, the primary selection criteria would be valuation studies that report values for the services that were most apparent in the interviews. In addition to this criterion, studies were sought that connected the relevant services to water quality or eutrophication in lakes, had a recent year of publication, and used data from North America. Ideally, the literature review would contain valuation studies that were conducted on single lakes in British Columbia that related the appropriate services to water quality and eutrophication, and were published in the last ten years. However, as environmental goods and services valuation is a relatively new discipline in economics, there is a limited amount directly relevant literature. The degree to which each of these studies meets these criteria varies greatly and is discussed in greater detail below.

A total of 17 studies were chosen as the most relevant. Each of these reported values for various services for locations all around the world that date back to 1991, and use a variety of estimation methods. To properly understand the values that are reported in these studies, an understanding of the methodologies that they employ is required. The studies' methodologies can be grouped into six different categories: travel cost, choice experiment, contingent valuation method, hedonic pricing, avoided costs, and benefit transfer.

Methods

Travel Cost

Travel cost models attempt to estimate the willingness to pay of consumers on recreational goods or services, usually for a specific site. Travel cost models assume that an individual's willingness to pay for recreation can be inferred from the cost incurred to consumers, so estimating the total cost is an estimation of the willingness to pay (*Crase et al., 2008*). For example, a person from Abbotsford chooses to go boating at Cultus Lake this Saturday. This individual incurs the cost of the gas and the wear and tear to their vehicle to get to Cultus Lake, and the value of their time. The value that they gain from this visit must be at least as much as these costs, or they would not come. This is an example of an individual's expenses; there are many individuals who spend varying amounts of money on each trip with many total trips per year. Survey data is collected from individuals in which they report the costs that they have incurred for their trip. This data is then used to estimate a demand curve for the recreational service at a given site (Crase et al., 2008). This demand curve can be used to calculate the consumer surplus generated by the service and can be used to estimate how variables, such as water quality, can affect visitation rates to the site (Vesterinen et al., 2010). An individual's consumer surplus from a choice is the difference between the maximum amount this individual would pay to make the choice, and the amount actually paid. The total benefit received by all the consumers is the sum of each

individual's consumer surplus. Techniques like the travel cost method are used to estimate the maximum willingness to pay for each person in a relevant population, allowing this consumer surplus, the net economic benefit to consumers to be calculated. Travel cost surveys are revealed preference surveys because respondents' willingness to pay are revealed by what they report they spend.

Choice Experiment

Choice experiments are survey instruments that are used to estimate individuals' willingness to pay for a single or set of goods and services. Choice experiment surveys usually contain an explanation of the goods and services that are being valued, questions on the participants' knowledge and opinion regarding the goods and services, and various demographic questions. To elicit a willingness to pay for an individual, choice experiments present a set of scenarios that contain different levels of the good or service in question (Ahtiainen et al., 2014). One scenario is the status quo or current state, which has a cost of $0. The other scenarios contain different levels of the good or service with an assigned cost, and the participant is asked to choose a scenario. A simple example of what might be shown is below.

SCENARIO (IN 20 YEARS)	STATUS QUO	ALTERNATIVE #1	ALTERNATIVE #2
WATER CLARITY	1.0m	2.0m	4.0m
SOCKEYE SALMON	Extinct	Present	Extinct
EURASIAN MILLFOIL	Widespread	Widespread	Limited
COST (PER YEAR)	$ 0	$ 50	$ 200

The cost and combination of attribute levels varies among the scenarios for the different participants. With an effective sample, statistical methods can be used to identify what the average respondent is willing to pay for the changes in each attribute level. The results therefore provide an indication of the priorities of the people who completed the survey, with regards to the offered attributes. Choice experiments fall under the umbrella of stated preference methods, since respondents directly state their willingness to pay by choosing their preferred alternative.

Contingent Valuation Method

The contingent valuation method is another form of a stated preference survey, and similar to choice experiments. Contingent valuation surveys can be thought of as a simple version of a choice experiment, where participants are offered only one alternative relative to the status quo. In the earliest versions, respondents were asked to state their maximum willingness to pay for the alternative. More recent versions use a referendum approach, where each respondent is offered a unique cost to bring about the change, and indicates whether they would vote in favour, given the cost (Robinson, 2011). The statistics can be simpler for this approach. However, with only one response for each participant, a much larger sample must be consulted.

Hedonic Pricing

Hedonic pricing attempts to estimate the proportion of property prices that can be attributed to a good or service. This method assumes that there are a variety of characteristics that homes have that people are willing to pay for, and the proportion that each of these characteristics contribute to the whole price of a house can be uncovered by regressing sales prices on the relevant characteristics. (Zhang et al., 2010; Lansford & Loonie, 1995). For example, a researcher might try to answer the question, "How much more are people willing to pay for a waterfront property?" Using housing sales data and data on how close properties are to a body of water, the researcher can estimate what proportion of the housing price is due to its proximity to the water (Lansford & Loonie, 1995). The statistical analysis from the data creates a virtual house that is identical in all respects except the variable of interest, such as distance from the lakeshore. The difference in the price for these otherwise identical houses indicates the value of being closer to the lakeshore.

Avoided Costs

Avoided costs is the method of estimating the value of a good or service based on the costs that are needed to preserve, replace, or restore a good or service (Mueller et al., 2016). This approach is usually used to generate an estimate of the cost of an undesirable environmental factor such as low water quality, noise pollution, and so on. For example, an individual may install a water filter or buy bottled water if they do not like the taste of their tap water. The value of improving the tap water quality is at least the cost that individuals are paying to avoid the impacts of the poor quality tap water, or they would not make these expenditures. Since the averting actions, filtering the water or buying bottled water, isn't a perfect fix for the problem – the splash of water in the shower still tasted bad – these values typically underestimate the value of improving the environmental quality.

Benefit Transfer

The benefit transfer method is a way to approximate the value of benefits generated from environmental goods and services in one area by adapting values from another area. This approach is attractive, as it is much less costly than conducting primary research. However, the resulting value estimates are only as good as the quality of the reference work done in other areas, and the effectiveness of the 'transfer' process used to adapt the reference values to the new situation.

The next section of the literature review summaries the results of the literature gathered. Detailed summaries for each study are included in Appendix A.

Water Quality, Algae Blooms, Recreation and Aesthetics

In this section, studies that report values for improving water quality, and studies that relate recreation services and property value to water quality are discussed. The biggest challenges faced for finding relevant studies in this group is that many studies did not focus on the impacts of individual lakes, but rather they studied the regional or national effect of impaired water quality. Thus, the values that they report are not always representative what the values in Cultus Lake may be, but they do provide evidence of the economic impacts of deteriorating water quality and eutrophication.

In the United States, Dodds et al. (2008) used a travel cost model and national water quality data to estimate the national impact of eutrophication in U.S. lakes and rivers. They estimate that eutrophication causes economic losses of $189 million to $589 million per year in lost fishing days, from $182 million to $567 million per year in lost boating days, from $14.1 million to $141 million per year in property values and could incur a cost of $732,000 per year to preserve biodiversity, totalling losses of well over a billion dollars per year. Similarly, Vesterinen et al. (2010) used a travel cost model to estimate the water-based recreation benefits associated with improving water quality in Finland lakes. They found that if water clarity were to improve by one meter, it would generate between €31 million and €92 million per year in swimming benefits, and between €43 million and €129 million per year in fishing benefits, but no increase in boating benefits. Complementing these two studies, Needelman et al. (1995) estimates that achieving swimmable water quality in New Hampshire Lakes generates up to $18 million per year in swimming benefits. These studies show that eutrophication and degrading water quality cause great economic problems but improving the conditions can also generate significant benefits. Additionally, the discrepancy between Vesterinen and Dodds shows how values can drastically differ between geographical locations, highlighting the need for more site-specific valuations.

The site-specific studies gathered also show differences among their values. Crase et al. (2008) studied the total recreational value of Lake Hume, Australia, using the travel cost model in conjunction with some aspects of contingent valuation scenarios to determine the value that would be lost from algal blooms. They found that the total recreational value of the lake is $3 million per year, and that algae blooms would reduce it by $1 million per year. In contrast, Mueller et al. (2016) valued recreation on the eutrophic Lake Rotura in New Zealand using a travel cost model, and estimated the benefits to be between $52 million and $81.3 million per year. These studies use similar methods and evaluate the same services but have drastically different results because of site-specific differences.

Other values reported show the direct benefits and willingness to pay to improving water quality and other effects related to eutrophication, all values are reported in Table 2.

Mueller et al. (2016) also estimates the value of biodiversity at $15.1 million per year using benefit transfer method, nutrient sequestration between $4.1 million to $13.3 million per year using avoided cost method for Lake Rotura.

Ahtiainen et al. (2014) surveyed summer house lake owners in Finland using a choice experiment. They found that the mean household willingness to pay is between €76.70 and €126 per year for improving water quality, between €129.40 to €153.50 per year for preserving fish species, between €65 per year to €260.20 per year for removing blue-green algae, and between €65 and €162.40 per year to remove slime from the water surface. Azevedo et al. (2012) used a contingent valuation survey and found people were willing to pay in between $436 and $1,630 per year to improve water quality in Lake Michigan. These values show that there are significant benefits for improving water quality and that people are willing to pay to receive these benefits.

The last study to mention in this section is Robinson (2011). This paper reports willingness to pay for improving water quality and recreational services for Quamichan Lake in North Cowichan, BC. This study estimates that the North Cowichan community is willing to pay between $300,000 to $860,000 per year to improve water quality and between $110,000 to $350,000 per year to improve recreational facilities. This study may best represent what the Cultus Lake community may be willing to pay for improving Cultus Lake, since it reviewed a B.C. recreational lake in eutrophication, and has the highest degree of comparability among the studies in the review. There are differences between the lakes, mainly that swimming is not a very popular activity in Quamichan Lake, and does not receive the influx of summer visitors that Cultus does. As such, this study takes into to account only the values that residents place on the lake. This means that the value of Cultus Lake is probably much higher than Quamichan Lake, but this would be best confirmed with primary research.

Table 2 Water Quality Valuation Studies

Study	Service	Value Type	Method	Minimum	Maximum	$	Year
Abidoye et al. 2012	Recreation	Compensating Variation	Travel Cost	30.08	30.08	US	2012
Ahtiainen et al. 2014	Water Clarity	WTP/household/year	CE	9.50	1,103.80	EUR	2009
	Fish Species	WTP/household/year	CE	11.10	1,515	EUR	2009
	Blue-green algae	WTP/household/year	CE	41.10	1,834	EUR	2009
	Sliming	WTP/household/year	CE	8.80	775.70	EUR	2009
Azevedo et al. 2012	Water Quality	WTP/person/year	CVM	436	1,630	US	2012
Crase et al. 2008	Algal Blooms	Loss in Consumer Surplus	Travel Cost	1,000,000	1,000,000	AUS	2008
Dodds et al. 2008	Fishing Days	Loss in Consumer Surplus	Travel Cost	189,000,000	589,000,000	US	2008
	Boating Days	Loss in Consumer Surplus	Travel Cost	182,000,000	567,000,000	US	2008
	Property Value	Loss in Property Value	Hedonic Pricing	14,100,000	141,100,000	US	2008
	Biodiversity	Loss in Biodiversity	Avoided Cost	732,800	732,800	US	2008
Lansford and Lonnie 1995	Recreation and Aesthetic	Marginal Value per foot	Hedonic Pricing	3	1,248	US	1995
Mueller et al. 2016	Biodiversity	Existence Value	Benefit Transfer	15,100,000	15,100,000	NZD	2012
	Nutrient Sequestration	Removal Spending	Avoided Cost	4,100,000	13,300,000	NZD	2012
	Amenity and Aesthetic	Loss in Property Value	Hedonic Pricing	16,000,000	19,100,000	NZD	2012
	Recreation	Consumer Surplus	Travel Cost	52,000,000	81,300,000	NZD	2012
Needelman et al. 1995	Swimming	Consumer Surplus	Travel Cost	18,000,000	18,000,000	US	1995
Robinson 2011	Water Quality	WTP/year for community	CVM	300,000	860,000	CAN	2011
	Recreation	WTP/year for community	CVM	110,000	350,000	CAN	2011
Vesterinen et al. 2010	Swimming Days	Consumer Surplus	Travel Cost	31,000,000	92,000,000	EUR	2010
	Fishing Days	Consumer Surplus	Travel Cost	43,000,000	129,000,000	EUR	2010
	Boating Days	Consumer Surplus	Travel Cost	0	0	EUR	2010

Salmon

There are several valuation studies that estimate the non-use value of salmon, specifically the existence of salmon and restoring salmon habitat on the West Coast of the United States, and some reporting values for Atlantic salmon. Unfortunately, none of these studies pertain to sockeye salmon species. The studies found focused on the existence and the habitat of Chinook salmon, coho salmon, steelhead, and Atlantic salmon. These studies use the contingent valuation method, choice experiment and benefit transfer method to estimate the value of salmon. It should be noted that there are other studies that value sockeye salmon in terms of their fishing and commercial value. However, these studies are not appropriate in the context of the Cultus Lake sockeye salmon as they are not being used by people in the Cultus Lake habitat.

A total of seven values were collected. Most of the values were reported as willingness to pay per household per year. The willingness to pay estimates varied quite a bit relative to each other, with the lowest estimate being $6.25 per household per year and the highest estimate being $67 per year for the existence of salmon, and are reported in Table 3. These willingness to pay values for salmon are lower than the willingness to pay values found for water quality indicators. However Helvoigt and Charlton (2007) use the benefit transfer method to calculate the annual non-use marginal value of salmon. The results of this study are that when the northwest salmon population is at 1.5 million fish, the marginal value (the incremental value as the population changes) per fish is $525 per year, but when the population decreases to 500,000 fish the marginal value per fish increases to $1,595 per year. Thus, it is possible that the willingness to pay may be higher for the Cultus Lake sockeye salmon population, but it requires that people differentiate the Cultus Lake sockeye from other salmon species and have knowledge of their endangerment. Because of the lack of studies regarding sockeye salmon and the uniqueness of the Cultus Lake sockeye, the true value may be very different than what exists in the literature.

Eurasian Watermilfoil

Eurasian watermilfoil was another focus of the literature review since many respodents reported they were affected by the presence of watermilfoil in the lake, mainly being concerned with the effect watermilfoil has on the aesthetics of the lake and the effect on recreation. The literature on Cultus Lake also indicates that the condition of E. watermilfoil will worsen with eutrophication due to it thriving in high nutrient environments (Sumka, 2017). Additionally, Eiswerth and al. (2000) studied the effect of E. watermilfoil, finding that it can increase nutrient loadings and reduce dissolved oxygen contents that makes controlling the E. watermilfoil population an important part of reducing nutrient loading on Cultus Lake.

Table 3 Salmon Valuation Studies

Study	Service	Value Type	Method	Minimum	Maximum	$	Year
Garber Yonts et al. 2004	Salmon Existence	WTP/household/year	CE	$51	$67	US	2004
Helvoigt and Charlton 2009	Salmon Existence	Marginal Value per fish	Benefit Transfer	525	1,595	US	2007
	Salmon Habitat Restoration	WTP/household/month	Benefit Transfer	4.42	4.42	US	2008
Payne et al. 2000	Salmon Existence	WTP, one-time payment/household	CVM	13.20	16.40	US	2000
Stevens et al. 1991	Salmon Existence	WTP/person/year	CVM	6.25	7.93	US	1991
Stevens et a. 1997	Salmon Habitat Restoration	WTP/person/year	CVM	21.20	21.20	US	1997
	Salmon Habitat Restoration	Lump Sum	CVM	29	29	US	1997

Eiswerth et al. (2000) estimates the impact of leaving E. watermilfoil unchecked using the avoidance cost method by valuing the cost of controlling watermilfoil. For mechanical harvesting, it finds that the cost of removal equipment can be between $30,000 and $100,000, and the cost of harvesting the watermilfoil can be between $750 and $1,500 per hectare per harvest. An alternative method is to use chemical harvesting, which the study estimates to cost between $500 and $5,000 per hectare per harvest. The study estimates the recreational value of the Truckee river watershed at $30 million to $45 million annually using the benefit transfer method. It does not estimate the effect that E. watermilfoil could have on these values, but if it reduces recreation by 10%, then the impact on the watershed recreation would be $3 million to $4.5 million per year. These values show the need for controlling the weed and to increase knowledge on watermilfoil to prevent its spread.

Zhang et al. (2010) also show the impacts E. watermilfoil and overall macrophyte coverage can have on property values. This study looked at a group of lakes in Vermont in which data existed on the extent of watermilfoil coverage on each of the lakes. The study found that the marginal impact that watermilfoil can have on property prices range from $355 to $17,764, corresponding to a 0.3% to 16.4% reduction in property values. This range of values is wide, but the extent of the impact will likely depend on watermilfoil coverage and public perception of the watermilfoil. The Cultus interviews indicate that people are quite concerned with watermilfoil, thus local values may be near the upper end of the range. In any event, even aggregating the low values across properties on Cultus Lake presents a significant economic impact.

Implications

There are many impacts that eutrophication has on Cultus Lake which can each affect multiple services. When considering the aggregation of these impacts on Cultus Lake's services, the economic impacts and the benefits of reducing nutrient loading are significant. However, due to the lack of studies on locations that are highly comparable to Cultus Lake, and the wide array of values from study to study, it is difficult to estimate what the exact impact that eutrophication will have on the lake in the future without further research.

One option to better understand the economic impacts would be to take the values gathered in this literature review and use existing benefit transfer methods to adjust, aggregate, and apply them to Cultus Lake. The advantage of this method is that it is the least expensive and time-consuming method, but although it may show a reasonable estimate of the economic value of Cultus Lake's environmental services, the most accurate results would be obtained by conducting primary research on Cultus Lake. The appropriate way to do this would be to be administer a combined revealed and stated preference survey, by combining the methods of the travel cost and choice experiment surveys to evaluate the multiple services provided by Cultus Lake.

Table 4 Eurasian Watermilfoil Valuation Studies

Study	Service	Value Type	Method	Minimum	Maximum	$	Year
Eiswerth et al. 2000	Eurasian Watermilfoil	Removal Equipment	Avoided Costs	30,000	100,000	US	2000
	Eurasian Watermilfoil	Mechanical Harvesting ha/harvest	Avoided Costs	750	1,500	US	2000
	Eurasian Watermilfoil	Chemical Harvesting ha/harvest	Avoided Costs	500	5,000	US	2000
	Recreation	Annual net economic values	Benefit transfer	30,000,000	45,000,000	US	2000
Zhang et al. 2010	Eurasian Watermilfoil	Property Value	Hedonic Pricing	355	17,764	US	2010

Conclusion

The water quality of Cultus Lake is an integral part of the Cultus Lake economy. Deteriorating water quality threatens this economy through direct impacts to recreation and property values, and indirectly through the reduction in the value of the environmental services generated by the lake. To reduce the effect of these impacts, actions must be taken to limit the source of nutrient loading. In developing future scenarios, even in the best-case scenario, eutrophication will still affect the health of the lake, but the progression of the problem can be slowed which will limit the impacts and allow more time for actions to be taken outside of the local level. Interviews indicate that the most important services of the lake are recreation on and around the lake, the aesthetics of the lake, and the habitat of the Cultus Lake sockeye salmon, while being concerned with the invasive Eurasian watermilfoil. Additionally, community members and experts also expressed the desire for continued business development, improving infrastructure, and improving the knowledge of the cultural and historical aspects of Cultus Lake. The literature review yielded few studies that exhibited a high degree of comparability to Cultus Lake, but the studies gathered indicate that water quality, eutrophication and E. watermilfoil can produce large indirect and direct economic impacts. Furthermore, these documented research results show that people are willing to pay significant amounts for improving water quality, and to a lesser extent the existence and habitat of salmon.

In deciding how to best benefit the Cultus Lake community, it will need to be decided where to allocate resources for the greatest benefit to the community. Based on the interviews, they will need to decide whether and/or how to blend the desire of some to strengthen the local economy and of others to protect and/or enhance the state of the Cultus Lake environment. The results of this project suggest that continued degradation of Cultus Lake will have a cost, in terms of the value of the goods and services generated by the lake that locals and visitors currently enjoy. However, since this suggestion is based on a small set of interviews and examples from elsewhere, we do not have a value for this cost that reflects the unique situation of Cultus Lake. Generating values specific to Cultus Lake would ideally be based on primary research that measures the willingness of local residents and visitors to pay to protect the quality of the lake.

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Appendix A: Valuation Study Summaries

Abidoye, B. O., & Herriges, J. A. (2012). Model uncertainty in characterizing recreation demand. *Environmental and Resource Economics*, *53*(2), 251-277.

This article considers an alternative approach of modelling recreational demand. Typically, economic theory provides little guidance in determining what kind of model should be used and what variables are appropriate to be included in the model. To avoid the process of 'fishing,' a Bayesian posterior simulator is used with repeated utility models to compare and average the difference between many different model specifications. In Bayesian selection, researchers select models with maximum posterior probability, and use these probabilities as weights on the results on the models to calculate a weighted average of the results. The study also uses Stochastic search variable selection that sets up the entire range of possible variable set ups, and then uses latent binary variable to indicate whether the data supports the inclusion of the variables or not.

The overall model can be characterized as a random utility maximization model that reflects potential uncertainty of which site attributes impact recreation demand. It assumes that individuals decide to participate in recreational activities over fixed discrete occasions, and only one trip is taken. The data used in the model is from the Iowa Lakes Valuation Project at Iowa State University, which is a four-year panel study eliciting the visitation patterns of Iowan residents to the primary recreational lakes in the state and includes various site characteristics. The results of the model indicate that lake size, the presence of wake restrictions, the inclusion of a lake in a state park, and the availability of handicap facilities all have positive signs. Total phosphorus was the highest-ranking variable in the model and had a posterior mean of -0.16. The authors suggest that this is because phosphorus is a factor in algae growth and is a clearly visible indicator of water quality. Other results are that inorganic suspended solids and chlorophyll have significant positive signs, Secchi transparency is positive but not a significant factor. Cyanobacteria is a largely negative marginal effect. Overall, the main result is that site amenities and water quality are the main determinants in lake usage.

Ahtiainen, H., Pouta E., and Artell J. (2014). Using individual-specific status quo alternatives in choice experiments: heterogeneous preferences for water quality. *5th World Congress of Environmental and Resource Economists.*

This paper presents a choice experiment with individual-specific reference levels that are based on respondents' perceptions of current and future conditions of water quality in Finland, which has many bodies of water that are facing eutrophication problems. The individual specific reference levels in this study replace the status quo scenario, which is the normal approach in discrete choice experiments. This is done to avoid biased welfare estimates and to create a more meaningful scenario for the respondent. The survey used

was addressed to Finnish summer house owners with questions tied to the closest body of water to each summer house, with different sets of alternatives, since bodies of water have differing water quality levels. The survey was administered jointly by mail and via the Internet to new summer house owners, since they are more likely to care about the water quality in the future. The choice experiment focused on eutrophication-related water attributes that were considered visible and important to summer house owners: water clarity, fish species, blue-green algal blooms and sliming. The survey was administered in 2009 and changes in water quality were stated to be visible by 2018 in the survey. Most respondents indicated that they perceived that water quality is good or excellent in its present state, and 34.3% perceived that water quality is satisfactory or worse in its current state. Most respondents believed that water quality would remain unchanged into the future, 20% believed that it will deteriorate, and 10% believed that it would improve. These perceptions of water quality in the present and the future were used to create the individual specific status quo scenarios. For example, if the respondent evaluated a current water quality attribute as satisfactory and expected it to improve in the future, then the status quo scenario would define the water quality attribute as good. Generally, respondents were willing to shift from the present development scenario to one of the alternative programs. However, preference heterogeneity was tested, and it indicated that respondents had significantly different preferences for the cost of the program and most of the water quality attributes. Additionally, respondents who perceive water quality to be in good or excellent condition were less likely to choose an improvement program. The highest willingness to pay measures was for the excellent level of blue-green algae, with good and excellent levels of fish species being similar. The lowest willingness to pay was for the good levels of water clarity and sliming attributes. The study concludes there is evidence that individual specific reference alternatives are a feasible option when there is substantial variation in environmental quality in the study area.

Azevedo, C. D., Crooker, J. R., & Chambers, C.N. (2012)A contingent valuation estimate of the value of remediation of contaminated sediments in Lake Michigan *Environ. Econ*, *3*, 20-5

This study estimates the benefits of Lake Michigan in the United States using the contingent valuation method. The Great Lakes Basin contains 20 percent of the world's surface water, and the lakes are an important natural resource that is used for a variety of reasons. The water quality is deteriorating, and with less than one percent of water outflowing per year, the contaminants remain in the basin for a long time. The governments of Canada and the United States have committed to cleaning up the lakes, but with the cost of restoration projects being upward of $465 million, this means that the governments cannot bear the cost alone. Identifying who is responsible is difficult since there are numerous sources that have contributed to degradation over a long period. To make more informed decisions on restoring the lakes, a better understanding of their benefits is needed. The authors chose the contingent valuation method because they believed it would provide a more comprehensive estimate of the benefits, seeking to gain a value for 10 areas of concern for

Lake Michigan. The contingent valuation survey was sent out to a random sample of 1,800 residents in counties that border Lake Michigan. A standard contingent valuation method was used, with respondents asked if they would agree to pay a given amount to create a Lake Michigan clean up fund. Bid amounts ranged from $100 to $1,000 US, and protest bids were identified using a probing question. The results are a mean willingness to pay of $1,033 per household with a standard deviation of $597. On average, respondents who reported that they are concerned with water quality were willing to pay $845 more than those who did not, and females are willing to pay $397 more than males. Aggregate willingness to pay is estimated to be more than $5 billion US, well above the estimated cost of more than $2 billion.

Crase, L., & Gillespie, R. (2008). The impact of water quality and water level on the recreation values of Lake Hume. *Australasian Journal of Environmental Management*, *15*(1), 21-29.

This study was undertaken to better understand the relationship of water quality and water level with recreation on Lake Hume in Albury, Australia. Lake Hume is not actually a lake: it is the body of water adjacent to a dam. It is an important recreational site that was reported to attract 6.3 million visitors in 2005, with main activities being swimming, boating and fishing. Lake Hume faces two problems: algal blooms due to eutrophication, and low water levels in the summer since water is drawn out for irrigation during late spring. Improving water quality will come as a cost to current users since the major source of nutrients is from agriculture. To improve water quality, certain agricultural practices will need to change. The method of valuation in this study is a zonal travel cost model, which is used to understand changes in visitation rates given different environmental scenarios. Respondents reported where they live and were grouped into eight zones to estimate travel cost. They were asked whether they would have visited the lake given that they knew the condition of water quality and water level before going on the trip. Visitation patterns were extrapolated to 100,000 annual visits, divided by the resident population of each zone, and then the travel cost was estimated based on the return distance to Lake Hume. The model predicts that the estimated demand curve would shift left if environmental conditions were to decline. It is estimated that direct benefits of the lake capacity and water quality are $3 million per year in Australian dollars, with algal blooms estimated to reduce benefits by $1 million per year.

Dodds, W. K., Bouska, W. W., Eitzmann, J. L., Pilger, T. J., Pitts, K. L., Riley, A. J., & Thornbrugh, D. J. (2008). Eutrophication of US freshwaters: analysis of potential economic damages.

This paper estimates the economic losses associated with human-induced eutrophication in lakes and rivers throughout the United States. Total phosphorus and total nitrogen data for the lakes and rivers were collected from the U.S. Environmental Protection Agency (EPA). In absence of lake water quality data, nutrient levels were estimated using linear regression with data from rivers in the same region. Four economic impacts due to

eutrophication were included in this study: Recreation and angling costs, Lake property values, loss of biodiversity and drinking water treatment costs. The first step in estimating the recreation and angling costs was to estimate the area of lake closure due to eutrophication – a lake is assumed closed if the lake is predicted to enter a hypereutrophic state. The value losses were calculated using loss of trip related expenses, and the number of visits to each water body was estimated for the 2001 National Survey of Fishing, Hunting and Wildlife Associated Recreation. Secchi depth was used to proportionally calculate the gains or losses in Lake Property Values. Loss of biodiversity was estimated assuming that human induced eutrophication affects 25% of aquatic species. Drinking water treatment costs were estimated using the amount of money spent on bottled water. Lake and river closures led to 7.1–22.2 million lost fishing days, and 4.8 –15.0 million boating days, which correspond with $189-589 million and $182–567 million losses respectively. Property value lost was estimated to be between $14.1 – $141.1 billion. Loss of biodiversity is estimated to be $732,800 per year. $813 million is estimated to be the cost of treating water.

Eiswerth, M. E., Donaldson, S. G., & Johnson, W. S. (2000). Potential environmental impacts and economic damages of Eurasian watermilfoil (Myriophyllum spicatum) in western Nevada and northeastern California. *Weed Technology*, *14*(3), 511-518.

This paper summarizes the potential negative environmental impacts and economic damages of Eurasian watermilfoil on Lake Tahoe, and uses the benefit transfer method to value natural resource service flows in the Truckee River watershed below Lake Tahoe. The study is not a comprehensive valuation, and the authors' objective is to increase public knowledge of the potential adverse effects of Eurasian watermilfoil. The paper describes Eurasian watermilfoil as an invasive species that can yield adverse changes in water quality such as increased nutrient loadings, reduce dissolved oxygen, and can change water temperature. It can also lead to substantially reduced native plants, increase the prevalence of undesirable species, and have a negative effect on fish and other animals. In terms of economic effects, it can decrease the quantity and quality of recreational activities such as angling, boating, swimming, water skiing and near shore recreation; it decreases agriculture profitability by clogging ditches, canals, farm ponds, and irrigation equipment; and it increases the cost of electricity generation and provision of municipal water by clogging power plant intakes and infesting municipal source waters. Additionally, some people place value on resources they do not themselves use, known as passive use values, and some people place a value on an environmental resource being in pristine condition, known as an existence value. There are two ways that the economic damages of Eurasian watermilfoil can be measured: the value of the lost benefits due to the presence of the weed, which is the preferred method, but is also time consuming and expensive; the second method is the avoided cost approach, which measures the cost of controlling or eradicating the weed, but this method is an undervaluation. Control costs range from $30,000 to $100,000 for removal equipment and $750 to $1,500/ha/harvest, while chemical harvesting costs $500 to $5,000/ha/harvest. To estimate baseline recreation benefits for

the Truckee River Watershed, only a subset of areas in which visitation data could be estimated was used. Even then, estimates for these areas varied by source, so minimum and maximum estimated visits were used for each area. Overall, the annual net economic values of recreation at these sites are estimated to have a conservative baseline between $30 million and $45 million per year. It is likely that the value for the watershed would be much higher, but also if E. watermilfoil were to invade these areas, the decrease in recreational values would only be a fraction of the baseline estimates. The study also recommends that to control E. milfoil, it must be located early and it is necessary to target boat transport as a means of spread.

Garber-Yonts, B., Kerkvliet, J., & Johnson, R. (2004). Public values for biodiversity conservation policies in the Oregon Coast Range. *Forest Science*, *50*(5), 589-602.

This study elicits willingness to pay from people living in Oregon for various environmental conservation programs on the Oregon coast. Respondents were asked to evaluate four different proposed programs: salmon and aquatic habitat conservation, forest age-class management, endangered species protection, and large-scale conservation reserves. Respondents were presented with detailed descriptions of each of the environmental good or services and then presented with a ballot with three choices: no change, Alternative A and Alternative B. Each option stated how the levels of each environmental good and service would change, and the costs associated with it. To be clear, each alternative was a change in all four of the environmental goods, but different levels in each alternative. Willingness to pay was estimated using multiple logit models, and mean estimates and total willingness to pay was calculated using a linear combination of variables and coefficients in the regression model. Respondents' willingness to pay were quite substantial amounts to pay for conservation policies, but at the same time, they were unwilling to support policy changes that would help these conservation programs. The study estimates that residents of the Oregon coast are willing to pay $67 per household per year, and residents from East Oregon are willing to pay $51 per household per year.

Helvoigt, T. L., & Charlton, D. (2009). The Economic Value of Rogue River Salmon, *ECONorthwest, Eugene, OR*, 31.

This report was conducted to estimate the economic values of the Rogue River salmon and steelhead species in Oregon. It attempts to estimate the value to the commercial fishing industry, to sport anglers, and the intrinsic value to residents of the Oregon and the west coast, but does not attempt to estimate the cultural value to northwest Indigenous peoples and the biological benefits to the ecosystem. Conserving healthy salmon populations also reinforces recreational, aesthetic and other economically significant amenities in the Pacific Northwest; however, previous studies have found that, on a per acre basis, the economic value of fishing exceeds all other recreational activities. The study primarily focuses on the

wild and scenic portion of the Rogue River since it provides an important habitat for Chinook, steelhead and coho salmon, and water quality and water temperature in this section is affecting the health of these species. It is also an important section of the river since it has colder water temperatures that provide refuge from the warmer summer temperatures and permits higher concentrations of oxygen for the coming years.

Studies have indicated that Washington and Oregon households are willing to pay $30 - $130 per year to finance salmon recovery efforts, which can in turn create jobs in the commercial fishing market and create benefits for recreational anglers. The benefit transfer method was used with two studies to calculate a lower bound estimate of $1.36 million per year for commercial fishing benefits. The same method was used to calculate the recreational angling value of salmon and steelhead, but using a number of different locations around North America. This yielded an estimated $245 average value for a fish in 2007 dollars. Surveys indicate that people in the Pacific Northwest and California have a higher non-use value on salmon than a use value, since only a relatively small number of residents participate in angling. A previous study by John Loomis estimated a marginal value of salmon and steelhead in the Lower Snake River to residents in Oregon, Washington and California. The results show marginal values go down as the salmon population increases. It is estimated that the marginal value of each salmon is $1,595 when the population of is 500,000 but decreases to $525 when the population is 1.5 million fish. The last estimate reported is willingness to pay for salmon habitat restoration and improved water quality, using the Biennial Oregon population survey. It estimated that each Oregonian household is willing to pay $4.42 per month in 2008 dollars. Overall the estimated aggregated values are $1.36 million annually for the commercial fishing industry, $16 million per year for the recreation fishing industry, $1.5 billion per year in non-use values, and $70 million per year for salmon population preservation.

Lansford, N. H., & Jones, L. L. (1995). Marginal price of lake recreation and aesthetics: an hedonic approach. *Journal of Agricultural and Applied Economics*, *27*(1), 212-223.

The purpose of this study is to take steps towards filling the dearth of information on recreational and aesthetic value. It employs a hedonic pricing approach to examine components of the recreational and aesthetic value of lakes in central Texas chain called the Highland Lakes. The authors hypothesize residential property values around the lakes and attempt to isolate this value. The three objectives of this study are to estimate the marginal value of proximity to the lakes via hedonic pricing, identify those factors influencing the variation of property value among the lakefront properties, and estimate the total non-market, implicit price of recreational and aesthetics to residential properties near the lakes. The implicit price of each characteristic is embedded in the price of the composite good, so to estimate the total recreation and aesthetic values, other components must be added. Thus, a proper hedonic model includes all the characteristics of the housing market.

Variables were selected based on conversations with realtors, real estate appraisers, *ad valorem* tax inspectors and an inspection of the area. Data on the sales of single-family homes was retrieved from the central appraisal district, and water quality of the lake at the time of sale was obtained from the Lower Colorado River Authority. In total, 609 viable sales with 20 different variables were included. Of the 20 variables used, 12 were significant at the 0.05 level, and the signs were as expected for all variables. Variable included: homes on the waterfront, with a view, without obsolescence, with more square feet, higher construction quality, and larger lots sell at higher prices. For a hypothetical average house in the area, the premium paid for a waterfront property is $59,826. Recreational value is shown to decline at an average rate of $4.21 per foot from a lake, but starts at $1,248 at the waterfront and declines to $3.17 per foot at 3,000 feet. Aggregating properties that are within 2,000 feet of the lake, it is estimated that lakefront properties make up 87% of the recreational and aesthetic value, and more than 20% of the total market price of housing.

Mueller, H., Hamilton, D. P., & Doole, G. J. (2016). Evaluating services and damage costs of degradation of a major lake ecosystem. *Ecosystem Services*, *22*, 370-380.

The objective of this study is to address a critical gap in the valuation of freshwater ecosystem services. The hypothesis of this study is that allowing degradation to occur may incur costs that are not currently given consideration in economic assessments. To answer this question, it uses Lake Rotura, New Zealand as a case study because although environmental service evaluations have been becoming more commonly practiced, rarely are they applied to particular lakes. Although Lake Rotura has become eutrophic, it is considered an iconic lake in New Zealand and is culturally important to the Maori people. Point source pollution has largely been removed in the lake, but is still plagued by diffuse pollution that have contributed to invasive aquatic weeds, algal blooms and continued high rates of external nutrient loading impacting of the health of the lake. The study lays the three major steps that were undertaken to develop the evaluation: identifying ecosystem services, valuation and damage costs. The authors identified a total of six ecosystem services: food, biodiversity, nutrient sequestration, amenity and aesthetics, and recreation. The values used for these different services can be summarized as follows. Biodiversity was priced as an existence value and the indicator is a passive value of biodiversity, the low and high estimate is $15.1 million per year. Nutrient sequestration was priced as a replacement cost and the indicator was nutrient removal spending, the low estimate is $4.1 million and the high estimate is $13.3 million per year. Amenity and aesthetics were priced using hedonic pricing and the indicator was property values, with a the low estimate of $16 million and a high estimate of $19.1 million per year. Food was priced using market prices and the indicator is median consumption rates per person, the estimate of people consuming wild food, the low estimate at $6.3 million and the high estimate at $9.4 million per year. Recreation was priced using income/production, and the indicator was angling usage expenditure and tourism spending based on economic impact survey, with a low

estimate of $52 million and a high estimate of $81.3 million per year. Damage cost estimates were based on an existing modelled water quality scenario for Lake Rotura that simulated water quality levels into 2032, which were used to estimate reduction factors for each ecosystem service. When applied to the previous low and high estimates, the value losses are estimated to be $0 – 2.3 million per year for biodiversity, $0.3 – 1.4 million per year for food provision, $1.1 – 3.8 million per year for amenity and aesthetic, and $12 – 40.6 million per year for recreation.

Needelman, M. S., & Kealy, M. J. (1995). Recreational swimming benefits of New Hampshire lake water quality policies: An application of a repeated discrete choice model. *Agricultural and Resource Economics Review*, *24*(1), 78-87.

This study estimates the recreational swimming benefits of lakes in New Hampshire as a function of eutrophication, level of bacteria, and presence of oil and grease. The model used is a repeated discrete choice model in which an individual is faced with choosing from a given number of sites. This is then repeated over the number of days in the swimming season. Data for New Hampshire residents and their swimming trips are taken from a survey conducted in 1989 to gauge support for the National Acid Precipitation Program, which provides demographics and freshwater recreation characteristics of 5,724 individuals. Data on the lake characteristics were obtained from three sources: the first dataset is primary water quality data from the biology bureau of the New Hampshire's Department of Environmental Services (NHDES), the second is a database of lake amenities constructed from an inventory of outdoor recreation facilities published by the New Hampshire office of state planning, and the third was the Nonpoint Sources Pollution Assessment Report which was released in 1989 by NHDES.

To measure the travel cost, a matrix of road distance between individual's hometowns and New Hampshire lakes was created with the price being measured by multiplying distance by $0.25/ mile and travel time by one quarter of a household's hourly income. Traffic patterns were also considered so that travel time is not linearly related to distance. Only swimming day trips were included in the model, since generally overnight trips have more purposes than just swimming, and were assumed to not travel to lakes more than 2 hours away, leaving 500 lakes in the model. Nineteen lakes were randomly assigned to everyone's choice set with random draws done without replacement. The results of the model indicate that people tend to swim at closer, larger lakes with a swimming beach and better water quality. People who enjoy boating while swimming tend to visit sites with boating availability, and people tend to avoid lakes at high elevations, indicating that they prefer lakes that are easily accessible and have higher water and air temperatures. The probability of an individual taking a swimming trip increases with children's ages, up to the age of 28 where it decreases. People who do not work outside the home are more likely to take a trip, and people who were not educated beyond high school are less likely to take a trip. The model was run under five scenarios: eliminate eutrophication, eliminate bacteria,

eliminate oil and grease, eliminate eutrophication and bacteria problems, and eliminate all pollution problems. To aggregate benefits, swimming days are summed for the swimming season to get per season benefits for each individual, then per season means are calculated for each scenario and aggregated by multiplying the mean by the number of people who live in New Hampshire and are 18 years and older. Most of the benefits come from eliminating non-point source pollution, but the benefits of eliminating bacteria problems are more than 30 percent higher than eliminating eutrophication problems. Achieving swimmable water quality in all New Hampshire lakes, a *Clean Water Act* goal, generates $18 million in swimming benefits.

Payne, J. W., Schkade, D. A., Desvousges, W. H., & Aultman, C. (2000). Valuation of multiple environmental programs. *Journal of Risk and Uncertainty*, *21*(1), 95-115.

This paper uses the contingent valuation method to elicit willingness to pay from respondents, for multiple different environmental goods and services. The goal of this paper was to study if willingness to pay was affected by the order that the goods and services were presented to the respondent. Each respondent was asked to evaluate five different environmental restoration programs, where the programs were introduced in a random order for each participant. Every respondent participated in two separate sessions with a two-week interval in between; one half was asked to state a willingness to pay the first session, and then asked to evaluate the same programs using an attitude scale during the second session. The opposite order was used for the other half. Respondents stated higher willingness to pay for the first good that was presented to them, and the means for each good given that they were presented first was significantly higher than the means for the goods across all responses. This suggests that the order that the goods are presented to respondents matters, since it can influence their willingness to pay responses. The minimum mean estimate is $13.20, and the maximum is $16.40 per household for a one-time payment.

Robinson, J. (2011). Valuing natural capital in the Quamichan Lake watershed.

This paper focuses on the ecosystem services of phosphorus retention, and the ability of wetlands and riparian areas to purify water and reduce occurrences of eutrophication in downstream watercourses, using Quamichan Lake in North Cowichan, British Columbia, as a case study. The lake is suffering high levels of phosphorus and nitrogen entering the lake from nearby residential and agricultural lands that threatens the ecosystem and recreational opportunities, primarily manifested in the presence of blue-green algae. Quamichan Lake is primarily a recreational lake, used for boating, fishing, wildlife viewing, swimming and walking. Land use patterns in the watershed play a major role in eutrophication at this lake, since lands in the Agricultural Land Reserve are not subject to environmental assessment. Testing shows phosphorous concentration is consistently

higher in creeks draining agricultural areas, which are responsible for about 70% of surface runoff. One method of dealing with surface runoff is by restoring wetlands. Wetlands can naturally purify waters in streams and are a cost-effective method for water treatment shown by several studies, such as in New York City where the city paid $1.8 billion to land owners to protect 80,000 acres of watershed as opposed to paying $8 billion for a new water filtration system.

This study considered four different options for methods to reduce the amount of phosphorus loading in Quamichan Lake: in-lake measures, land zoning, land acquisition, and conservation covenants. In-lake measures consisted of dredging in the lake to reduce the internal loading of phosphorus; land zoning entails changing land zoning classifications to conserve wetlands and riparian areas, and areas responsible for the highest nutrient loadings; land acquisition is done by the municipality buying land responsible for the highest nutrient loadings directly for agricultural users; conservation covenants is a voluntary legal tool that restricts certain uses of land while retaining private ownership. These different methods of reducing the nutrient loadings were used as a basis for different scenarios in a contingent valuation survey, which was used to gauge public assent for the different policy/program options and to show that the community values the lake and environmental goods and services. Three different scenarios, each with different payment methods were presented to the survey respondents. The first scenario was an increase in property taxes in which the funds would be used for dredging at the bottom of the lake; the second was donations to a registered land trust to purchase conservation covenants; and the third was paring fees or annual access fees that would be used to improve recreational facilities in Quamichan Lake. From this survey, it is estimated the community is willing to pay $300,000 – $860,000 per year to protect the watershed and enhance water quality, and is willing to pay approximately $110,000 – $350,000 to improve recreational facilities in Quamichan Lake. Overall, the author recommends both short-term in-lake measures and long-term voluntary conservation methods, and for the province to review permitted land use on the ALR to allow the conservation of natural capital.

Stevens, T. H., Echeverria, J., Glass, R. J., Hager, T., & More, T. A. (1991). Measuring the existence value of wildlife: what do CVM estimates really show? *Land Economics*, *67*(4), 390-400.

This study seeks to evaluate the existence value of multiple species of wildlife by eliciting willingness to pay using the contingent valuation method. The authors asked respondents to evaluate the existence of bald eagles, wild turkeys, coyote control, coyote preservation and salmon. Two separate surveys were used, one for an Atlantic salmon restoration program mailed to Massachusetts residents and another survey for the rest of the wildlife species to residents in New England. The survey method was used was a dichotomous choice method, so econometric treatment was necessary to estimate willingness to pay. The authors caution the interpretation of the results, since when a respondent indicates

that they would be willing to pay, it may be expressing that they want that species to be preserved even though the dollar amount presented to them does not represent their true willingness to pay. Results were analyzed using two different models, a logit model and a tobit model. Overall, willingness to pay was fairly low for most species except for the bald eagle, but this may be due to the fact that the majority of participants did not have any interactions with the presented species. Using the logit model, the willingness to pay was estimated at $6.25 per person per year, and the raw mean willingness to pay to be $7.93 per person per year.

Stevens, T. H., DeCoteau, N. E., & Willis, C. E. (1997). Sensitivity of contingent valuation to alternative payment schedules. *Land Economics*, 140-148.

This study attempts to address the issue that willingness to pays from contingent valuation studies are insensitive to the scope or size of the item being valued, and the issue of temporal embedding that occurs when respondents do not differentiate between one-time payments and a series of payments. To test these problems respondents were asked to evaluate two different types of goods: a familiar one (movie passes) and an unfamiliar one (restoration of Atlantic salmon). Previous studies have shown that respondents are insensitive to the scope or size of the good being valued. One study found that willingness to pay for an entire package of environmental goods and services was almost the same for a subset of the goods and services in the package, and another study on migratory waterfowl found that respondents were insensitive to whether 2,000, 20,000 or 200,000 were being protected. The embedding can be caused by number of sources, from inappropriate statistical analysis, questionnaire design, or an incomplete definition of the commodity being valued, but some authors have argued that respondents react to amenities symbolic meaning rather than the levels of provision. Other studies have found that respondents do not differentiate between one-time payment and series of payment schedules, but there are some studies that contradict these claims as well. To explore these problems, a contingent valuation survey was conducted with 88 undergraduate students in the spring of 1994. Each participant was asked to value a movie pass and a salmon restoration program. The sample was split up into several groups that had questions with different levels of information, payment schedules and question orders. There were also two types of movies passes and two types of salmon restoration projects: a movie pass that could be used at one theater or a movie pass that could be used at any movie theater, and a salmon restoration project along half of a river system and a restoration project that included the entire river system. The results of the survey indicate that willingness to pay varied by payments schedule. For example, willingness to pay per year for the less inclusive salmon restoration program yielded a mean of $21.20, while the lump sum payment mean willingness to pay yielded $29. The Man-Whittey test and a Tobit regression were done to test if the difference between the lump sum and series of payments were statistically significant. Although the test found that differences were statistically significant, implicit discount rates were calculated at 50% to 270% annually when the real discount rate is around two

per cent. The authors think that this may be due to the sample being composed of undergraduate students who have weekly budgets.

Vesterinen, J., Pouta, E., Huhtala, A., & Neuvonen, M. (2010). Impacts of changes in water quality on recreation behavior and benefits in Finland. *Journal of Environmental Management*, *91*(4), 984-994.

This study uses Finland's national recreation inventory dataset along with water quality on Finland's lakes to estimate the recreational benefit of water quality. The authors sought to analyze the relationship between three water activities: swimming, fishing and boating, with water clarity as a water quality indicator. The method used in this study had two stages. The first stage modelled water recreation participation frequency for each activity using a hurdle model. The hurdle model simultaneously estimated a logit model for the participation decision and a count data model for the number of times that an individual participates in the recreational activity, assuming a negative binomial distribution. The second stage estimates the value of water recreation activities pooled together using a travel cost model, and estimates the demand curve using zero-truncated negative binomial regression. The recreation demand model was modelled for a representative site instead of a specific site since the data used was on a national scale. The effect of water quality on recreation demand was estimated by decreasing/increasing the water clarity depth by one meter. Results from the first stage model indicate that water quality in the respondent's home municipality did not restrict annual participation in swimming or boating, but has a positive effect on the probability of participation in fishing. Water quality in the home municipality had a positive effect on the frequency of fishing and swimming but not boating. The results of the travel cost model estimate that a one-meter improvement in water clarity increases the probability of fishing by 2.7% and adds 2.1 days of fishing annually; swimming participation was unaffected, but increased number of fishing days by 1.6 days; boating participation and days were unaffected. A one-meter reduction in water clarity is estimated to lead to a loss of €29–€87 million annually, a loss in fishing benefits would range between €38 and €113 million euros per year, and no loss in boating benefits. If water quality were to improve by one meter, then consumer surplus for swimming is estimated to increase by €31–€92 million euros per year, increase fishing consumer surplus by €43–€129 million per year, and there would be no increase in boating consumer surplus.

Zhang, C., & Boyle, K. J. (2010). The effect of an aquatic invasive species (Eurasian watermilfoil) on lakefront property values. *Ecological Economics*, *70*(2), 394-404.

This study investigates if Eurasian watermilfoil affects property values on selected lakes in Vermont. The authors use two measures of milfoil, the cover of watermilfoil and the cover of all aquatic macrophytes, since native plant species are at times mistaken as E.

watermilfoil. The introduction of E. watermilfoil is an issue because it may outcompete or eliminate native plant species, and it forms dense mats on the surface of the water that interferes with recreation and reduces aesthetics. The region of study is four lakes and one pond in Rutland County, Vermont. This study area was chosen because the Vermont Department of Environmental Conservation (VDEC) could provide data on the extent of milfoil coverage in front of each property sold, which allows the creation of a hedonic (property value) model that can estimate the marginal benefit of preventing or reducing infestations. The authors summarize the result of four previous economic studies on invasive species, two of which are about milfoil. Although the results of the studies vary they all indicate that invasive species reduce near shore property values.

Under the assumptions of the hedonic price model, the marginal values consumers place on individual characteristics of the good can be uncovered by regressing the sale prices on the characteristics of the good. Hedonic pricing must occur in the same housing market, the authors observe that five-year price trends of each lake are generally the same, therefore they are likely in the same market. Data on housing prices were collected from transfer tax records from 1990 to 1995. Only single family residential or vacation homes and unimproved land were used for a total of 65 records.

Data on water clarity, lake area, and aquatic macrophyte coverage were obtained from the VDEC. Water clarity was measured with a Secchi disk, and minimum clarity levels from the summer were used. Aquatic macrophyte growth is measured using a percentage rating on a 1 to 6 scale for total growth and Eurasian Watermilfoil. Data indicates that milfoil as a percentage of total aquatic plant growth ranges from 14% to 100% for an average of 71% and of the 65 observations, 44 have milfoil ratings equal to the total plant ratings. Estimations were done for five different models: first was all explanatory variables, second and third models were with quadratic and exponential functions of milfoil, and the fourth and fifth models were the respective total plant coverage models. Living area, lot size and distance to the nearest business district are significant and positive in all five equations, and unimproved land is significant and positive in all equations containing milfoil, while no lake specific variables were significant. Milfoil does not significantly affect property values, but total aquatic plant cover is significant and indicates that it diminishes property value. Marginal prices for increases in macrophyte coverage range from $355 to $17,764, which corresponds to a 0.3% to 16.4% decrease in property value. This indicates that E. watermilfoil does affect property prices and therefore efforts should be made to control and to prevent the spread of milfoil.

Appendix B: Interview Backgrounder

Interview, Summary of the Current Condition of Cultus Lake

Cultus Lake has an overload of nutrients (nitrogen and phosphorous) that is causing the water quality to deteriorate, in a process called eutrophication, which will have significant impacts on Cultus Lake if left unchecked. There are four major sources of nutrient loading in Cultus Lake:

- **Atmospheric deposition**: Nutrients originating from Lower Mainland and Fraser Valley air pollution and fertilizers from nearby farms are deposited into the lake from the air and precipitation.
- **Surface and groundwater runoff**: Nutrients enter the lake from streams and water flowing over land and through substrate. Some nutrients are contained in the runoff naturally, while some is from farming operations in Columbia Valley.
- **Septic Systems**: Nutrients in the treated wastewater effluent from septic systems flow into and leach through the ground into the lake. This source increases in the summer with the increase of seasonal visitors to the beaches and campgrounds around the lake.
- **Gull guano**: Nutrients from gull waste are deposited in the lake when the birds roost there, primarily during the winter months.

A new septic wastewater treatment plant on the north side of the lake will reduce some of the nutrient loading. Plans are in place for additional treatment sites on the south end of the lake with the goal of reducing nutrient loads even further. Currently, the harmful effects of nutrient loads are increasing and are expected to impact the lake in the following ways:

- **Algae blooms**: The excess nutrients in the lake provide an good environment for algae and other bacteria to grow. This can cause the water to become greenish, murky and may even have a bad taste or smell.
- **Health risks**: Some types of bacteria/algae can be toxic to humans and animals, so algae blooms in Cultus Lake could pose a health risk. There are also health risks from E. coli and fecal coliform from septic effluent, and swimmer's itch.
- **Eurasian watermilfoil**: This invasive plant species thrives in nutrient-rich water. Nutrient loading leads to an increase in E. watermilfoil in Cultus Lake, which can be a nuisance to boaters and unpleasant for swimmers. Significant E. watermilfoil growth also displaces native aquatic plants.
- **Cultus Lake sockeye salmon and pygmy sculpin**: These species unique to Cultus Lake are already at risk. The nutrient overload leads to a process called eutrophication that causes areas of the lake to lose oxygen, which reduces the area in which fish can live. This situation places these species at even more risk, and their populations are expected to decline. Other currently healthy fish species may also be at risk. A decline in lake water habitat will impact other aquatic species, and as well as other species that rely on aquatic ecosystems.

In addition to the numerous impacts on the lake system and ecosystems, a change in the nature of the lake water quality will highly impact the local economy in the following ways:

- **Visits:** All the above impacts make Cultus Lake a less desirable location for recreational activities on the lake. This will most likely lead to fewer visitors to the lake.

- **Water-based activities:** People may be less likely to use Cultus Lake for recreation. For those who continue to use the lake, their enjoyment of recreation will decline.
- **Recreational fishing**: It is possible that other fish species that live in the lake will be affected as well, such as cutthroat trout and Dolly Varden.
- **Cultus Lake Park Board revenue**: This entity obtains revenue from charging a fee to moor boats on the lake, camping and residential revenues. If fewer people want to moor their boats, camp, or live in the community, the CLPB may lose revenue.
- **Local economy:** If there are fewer visitors who visit the lake then there will be fewer paying customers for local businesses. This could impact local businesses' bottom line and possibly cause some to leave the Cultus area or close altogether.
- **Regional businesses:** Businesses in nearby areas such as Chilliwack may also be affected by declining tourism attendance at Cultus Lake.
- **Property prices**: Property prices may fall if Cultus Lake becomes less desirable as a place to live or visit, which could negatively impact the economy of the immediate community and beyond.

These are the some predicted impacts, but it is not a complete list of what may happen if Cultus Lake undergoes more advanced stages of eutrophication. As time progresses, we will gain more knowledge and have a better understanding of how Cultus Lake will be affected. To fully understand the impacts on Cultus Lake we also need to understand what is important to those who have a stake in Cultus Lake, which is what we hope to accomplish with this interview today.

Appendix C: Interview Consent Forms

THE UNIVERSITY OF BRITISH COLUMBIA

Department of Economics
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Consent Form

Cultus Lake Environmental Services Valuation: Interview

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Introduction: Thank you for participating in this interview. This work is affiliated with the study "Cultus Lake Environmental Services Evaluation" with funding from the Fraser Valley Regional District, the Cultus Lake Park Board, the Cultus Lake Aquatic Stewardship Strategy (CLASS), and Lindell Beach Residents Association.

Purpose: The purpose of this interview is to gain insight from key groups that may be impacted by changes in Cultus Lake water quality. This will help identify key services provided by the lake, which will aid in conducting a literature review.

What you will be asked to do: After you have read this document, I/we will respond to any questions or concerns that you may have. Once you have signed the consent form, you will be asked to answer some interview questions. We will be recording your answers using an audio recording device.

How the data collected will be used: Your answers to the interview questions will be used to create a summary of key themes emerging from the interviews, and the important services provided by the lake and its surroundings as recognized by the interviewees.

Confidentiality: The results of your participation will be reported without any reference to you specifically. All information that you provide will be stored in Canada. It will be treated confidentially and your identity will not be revealed in reporting the study results.

Data Retention: Audio recordings will be stored securely in a password protected computer account. All data from individual participants will be coded so that their anonymity will be protected in any reports, research papers, thesis documents, and presentations that result from this work.

Contact for information about the rights of research subjects: If you have any concerns about your treatment or rights as a research subject, you may contact the Research Subject Information Line in the UBC Office of Research Services at 604-822-8598.

I, _____, have read the explanation about this interview. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I hereby consent to take part in this interview. However, I realize that my participation is voluntary and that I am free to withdraw at any time.

Participant's Signature Date

THE UNIVERSITY OF BRITISH COLUMBIA

Department of Economics
1147 Research Road
Kelowna, BC V1V 1V7

Consent to be Interviewed

Cultus Lake Environmental Services Valuation: Interview

Hello, my name is _____ and I am working as a research assistant at the Okanagan campus of the University of British Columbia.

We are conducting a number of interviews to understand better how people see themselves being impacted by changes taking place in Cultus Lake. Your name was given to us by _____ as someone who might be able to help us. We expect that these conversations will identify a few key 'services' provided by Cultus Lake that people are worried about loosing. This will be used to find places where similar challenges have been faced, which we will use to estimate how the Cultus community may be affected as the lake continues to be affected by nearby human activities and climate change. These interviews are part of a study, "Cultus Lake Environmental Services Valuation," funded by the Fraser Valley Regional District, Cultus Lake Park Board, the Cultus Lake Aquatic Stewardship Strategy (CLASS), and Lindell Beach Residents Association.

This research is being supervised by Dr. John Janmaat, associate professor of Economics at the Okanagan campus of the University of British Columbia.

We are committed to following ethical research practices. For these interviews, we are not collecting personal information and will not be using anything that you may provide as part of our research. We will be recording this interview, so that we can review what was said, to ensure that our notes are complete. The recording will not be released, and will be deleted soon after it has been listened

to. Prior to their deletion, the recordings will be stored on a password protected computer. We will not publish or share anything from our notes that would reveal what you have said. If at any point you do not wish to continue, we will end the interview.

Do you have any questions or concerns about this interview that you would like to discuss?

By continuing with this interview, we are assuming that you have heard and understood our commitment to respecting your privacy and confidentiality, and that you understand your rights in the context of this interview.

Are you willing to continue with this interview?

Participant's Name Date

Appendix D: Interview Questionnaires

Cultus Lake Interview Form Date:

Name:

Stake in Cultus Lake:

Questions

1. What do you think people like best about Cultus Lake?
   (Why do they care about Cultus Lake? What keeps them here? What is important to them?)

2. What do you think people like least about Cultus Lake?
   (What are aspects of Cultus Lake do they not like? What can be improved? Find out what they value in Cultus Lake by finding out what should be changed?)

3. What are the most popular activities in Cultus Lake?
   (Same purpose as previous two questions, but more specific. Ask questions regarding the activities they mention. Why do they do those activities at Cultus Lake? What would prevent them from doing those activities?)

4. What are some key services you think that Cultus Lake provides?
   (If question is not understood, provide interviewees with examples such as: Cultus Lake serves as a habitat for the Sockeye salmon and pygmy salmon, serves as a place that people can go boating, provides nice aesthetics for those doing activities or people living near the lake)

5. What aspect of Cultus Lake's well-being concerns you the most?
   (May have been answered with question 2. What do they think harms the Lake? Is there specific activities or operations that they think case harm to the Lake? How do they think the well being of Cults Lake will affect the community?)

6. (If water quality/nutrient loading not already mentioned) Are you concerned that nutrient loading will affect tourism and what concerns you the most?
   (Same guidelines as previous question, just more direct at nutrient loading.)

7. Have visitors or anyone else complained about the water quality of Cultus Lake? Have they complained about anything relating to eutrophication? (Trying to figure how concerned visitors are about the lake quality.)

8. What aspects of Cultus Lake's local economy are most important to you? How do you think the Chilliwack economy benefits from Cultus Lake? (What do people spend money on and where?) Are you concerned that the local economy will be impacted by deteriorating water quality in Cultus Lake? (Try to figure out what is important to them in the community instead of focusing just on the lake.)

9. Is there anything else that you would like to add?

Cultus Lake Interview Form Date:

Name:

Stake in Cultus Lake:

Questions

1. What do you/visitors like best about Cultus Lake?

    - Why do they care about Cultus Lake?

    - What keeps them here?

    - What about the lake is important to them?

2. What do you/visitors like least about Cultus Lake?

    - What are aspects of Cultus Lake do they not like?

    - What can be improved?

    - Find out what they value in Cultus Lake by finding out what they think should be changed?

3. What are the most popular activities in Cultus Lake?

    - Same purpose as previous two questions, but more specific.

    - Ask questions regarding the activities they mention.

    - Why do they do those activities at Cultus Lake?

    - What would prevent them from doing those activities?

4. What aspect of Cultus Lake's wellbeing concerns you the most?

   - May have been answered with question 2.

   - What do they think harms the lake?

   - Is there specific activities or operations that they think cause harm to the lake?

   - How do they think the well being of Cultus Lake will affect the community?

5. (If water quality/nutrient loading not already mentioned) Are you concerned with the nutrient loading/water quality in Cultus Lake, and what concerns you the most?

   – (Same guidelines as previous question, just more direct at nutrient loading)

6. How do you think that the issues of nutrient loading in Cultus Lake should be addressed?

   - What nutrient loading sources are they the most concerned with, and why?

   - Can give some indication of support to some of the alternative scenarios

7. Have visitors or anyone else complained about the water quality of Cultus Lake?

   - Have they complained about anything relating to eutrophication?

   - Trying to figure how concerned visitors are about the lake quality. For probing, ask questions regarding what the residents mentioned in that interview

8. What aspects of Cultus Lakes local economy are most important to you?

    - How do you think the Chilliwack economy benefits from Cultus Lake?

    - Are you concerned that the local economy will be impacted by deteriorating water quality in Cultus Lake?

    - Try to figure out what is important to them in the local economy/community instead of focusing just on the Lake

9. How do you think that the Soowahlie First Nation answers to these questions might differ from yours?

    - What aspects of Cultus Lake do you think are the most important to the Soowahlie first nations?

    - Do you have any insight on the Cultural significance of Cultus Lake/ Sockeye salmon to the Soowahlie First Nation?

10. Is there anything else that you would like to add?