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FINAL WORKING DRAFT

Shuswap Watershed Mapping Project

Shuswap Lake, Mara Lake, Little Shuswap Lake and Little River

FORESHORE INVENTORY & MAPPING : JUNE 2009

THE REAL ESTATE FOUNDATION OF BRITISH COLUMBIA

Fraser Salmon & Watersheds Program

Pacific Salmon Foundation · Fraser Basin Council · Living Rivers

CSRD Columbia Shuswap Regional District

British Columbia Ministry of Environment

Fisheries and Oceans Canada · Pêches et Océans Canada

FORESHORE INVENTORY AND MAPPING

Columbia Shuswap Regional District &
Fisheries and Oceans Canada

Shuswap and Mara Lakes

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June, 2009

File No. 08-329 and 08-329.01

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EXECUTIVE SUMMARY

Throughout the first years of the new millennium, the Shuswap experienced intensive development activity. More and more, people were drawn to the Shuswap for its natural beauty and high recreational values. There are an increasing number of baby-boomers that have been turning their seasonal cabins on the lake into year-round retirement homes. The increase in development highlighted the lack of regulation, the need for better base-line information and more planning to ensure the long-term integrity of the watershed.

In response to the need for better lake planning and management, the CSRD undertook several Official Community Plans, Liquid Waste Management Plans and zoning bylaw amendments. Concurrently, the Province initiated the Shuswap Lake Integrated Planning Process (SLIPP), which focuses on better coordination among government agencies around Shuswap Lake. This report has been prepared based upon the belief that it is possible manage our watersheds and their natural surroundings in a sustainable manner and is supported by these initiatives.

The Shuswap watershed contributes significantly to the overall production of salmon in the Fraser River Basin and to the genetic diversity of Fraser salmon populations. Shuswap Lake and its tributaries support sockeye, chinook, coho and small populations of pink salmon. Coupled with these sea run species, there are also important populations of rainbow trout and char. Finally, shoreline areas also provide important habitat for numerous wildlife species, including the Western Grebe and Osprey.

Currently, lake management projects in the province follow a three step process described below:

1. Foreshore Inventory and Mapping (FIM) is a protocol that is used to collect baseline information regarding the current condition of a shoreline. The FIM uses a mapping based (GIS) approach to describe shorelines. These inventories provide information on shore types, substrates, land use, and habitat modifications. This new information has been combined where possible, with other mapping information such as previous fisheries inventories, recent orthophotos, and other information;

2. An Aquatic Habitat Index (AHI) is generated using the FIM data to determine the relative habitat value of the shoreline. This index follows similar methods that were developed for Okanagan Lake and Windermere Lake and is similar to other ongoing assessments along Wasa, and Moyie and Monroe Lakes. The Aquatic Habitat Index uses many different criteria, such as substrate information, known sockeye shore spawning locations, known char spawning locations, etc. to estimate the habitat value of a shoreline segment. The Habitat Index classifies this information in a 5-Class system from Very High to Very Low.

3. Shore Line Management Guidelines are prepared to identify the Shore Line Vulnerability or sensitivity to changes in land use or habitat modification. Shoreline Vulnerability zones are based upon the Aquatic Habitat Index described above. The Shoreline Vulnerability uses a risk based approach to shoreline management, assessing the potential risks of different activities (e.g., construction of docks, groynes, marines, etc.) in the different shore segments. The Shore Line Management Guidelines document is intended to provide background information to stakeholders, proponents, and governmental agencies when land use changes or activities are proposed that could alter the shoreline thereby affecting fish or wildlife habitat.

In early 2008, as part of the move towards better governance and environmental stewardship, the CSRD, in partnership with Fisheries and Oceans Canada (DFO) and the BC Ministry of Environment, applied and received funding from the Real Estate Foundation of BC and the Fraser Salmon Watersheds Program to conduct the Foreshore Inventory Map (FIM) of the Shuswap Lake watershed. The FIM study area includes Shuswap Lake, Mara Lake, Little Shuswap Lake and Little River. This funding has been used to complete Step 1 above, providing the baseline inventory information necessary to develop an Aquatic Habitat Index. To compliment this work, DFO also provided additional funding to use the FIM data to identify sensitive shoreline segments through the development of an "Aquatic Habitat Index" (AHI) (Step 2 above). The FIM / AHI study area includes Shuswap Lake, Mara Lake, Little Shuswap Lake and Little River.

Foreshore Inventory and Mapping results (FIM) for this project provide valuable information regarding features, habitats, and other information for the shorelines of these lakes. A summary of the data collected indicates the following:

- It is estimated that 42.8% of the shoreline has a high level of impact which accounts for 174 km of shoreline. Areas of moderate and low impact account for 17.4% or 70.7 km and 31.53% or 128.2 km of the shoreline respectively. There is only an estimated 33.3 km or 8.2% of shoreline that is believed to have little to no impact. Impacts along the shoreline include lakebed substrate modification, riparian vegetation removal, construction of retaining walls, etc.;
- The most predominant land use around the lake is natural areas (32%), followed by Single Family residential areas (21.7%). Other common land uses include transportation corridors, parks, and recreational areas;
- Wetlands are the most rare shore type around the lake, accounting for only 3.5% of the shoreline length. The most predominant shore types around the lake are Gravel and Rocky shores;
- Aquatic vegetation occurs along 22.7% of the shoreline length and is an important habitat feature for juvenile salmonids. Of this, emergent vegetation was the most commonly observed (e.g., emergent grasses, willows, or other areas with vegetation inundated during high water). Native beds of submergent vegetation were only documented along 2% of the shoreline, and areas of floating vegetation were only observed along 0.1%.
- The following summarizes habitat modifications observed:
    - Docks were the most common modification observed, with a total of 2,789 observed.
    - Retaining walls were the next most common modification, with a total of 1,529. In many cases, retaining walls extended beyond the high water level of the lake, and construction practices were not compliant with Best Management Practices. It is estimated that nearly 48% of the retaining walls observed were constructed below the high water level[1]. These retaining walls occupied approximately 13% of the shoreline, or over 52,000 m (i.e., 52 km). ;
    - Groynes were the next most commonly observed modification, with over 1,170 observed. Lakebed rocks and boulders were most commonly used to construct groynes and often construction required the use of heavy equipment. The use of lakebed substrates to construct groynes has resulted in significant impacts to emergent vegetation and shore spawning areas, among others. Groynes along the shoreline were not typically constructed to protect boats or for sediment control, but rather, the groynes were constructed to improve access and create gravel/sand beaches.

[1] The retaining wall survey of walls below the mean annual high water level was not completed on Little River or Little Shuswap.

- There were a total of 200 concrete boat launches and 51 marinas.
- Substrate modification was observed on 25% of the shore length and was most commonly associated with the large number of groynes, retaining walls, transportation land uses, and sand importation to create beaches,

The findings of the FIM indicate that the foreshore areas of the Shuswap Watershed have been impacted by our current land use practices. The current trend of reliance on Best Management Practices and voluntary compliance with the regulations and guidance documents are not resulting in the required protection of important fish and wildlife habitats along the shoreline. Active construction that was not in compliance with best management practices was observed nearly each day during the surveys. It was readily apparent that neighbors tended to mimic each others activities. Finally, there was a significant number of shoreline modifications that encroached onto crown land (i.e., below the high water level) and several instances of land owners without foreshore, constructing or modifying sections of foreshore to their liking. Given this, all agencies and stakeholders need to work with the public on better communication and education to ensure that everyone is aware of the habitats present and their values. Recommendations for public awareness and education are presented to facilitate public involvement and compliance in the protection of foreshore areas. The combination of education and cooperative enforcement will help reduce the continued losses of habitat along the shoreline and help improve attitudes regarding foreshore protection.

The Aquatic Habitat Index (AHI) for Shuswap Lake provides valuable information regarding the estimated habitat values of different shoreline areas. The following summarizes the results of the AHI analysis:

- The AHI found that approximately 15% of the shoreline is ranked as Very Low or Low habitat value. These areas are mostly found along highly developed shorelines that show little resemblance to the natural shore types they would have been;
- The AHI found that approximately 47% of the shoreline is ranked as High or Very High. Many of these areas occurred in known shoreline spawning areas, stream mouths, wetlands, and other habitats around the lake;
- Approximately 38% of the shoreline was of Moderate relative habitat value.
- One or more important salmon habitats (e.g., staging areas, rearing areas, spawning habitats) related to an important life history stage (i.e., juvenile, migrating adult, etc.), were documented in nearly all segments around the lakes. Thus, even in low value habitats, there is still potential to affect important fisheries resources in the lakes;
- The AHI highlights the importance of the connection between our diverse stream side, wetland and lakeshore habitats. Stream confluences and their adjacent features (e.g., shore marshes, large woody debris, and diverse riparian vegetation communities) are areas that tend to contain the highest fish and wildlife diversity, are extremely important for maintaining viable populations, and most importantly are water quality buffers that are required to preserve source drinking waters;
- The AHI also includes a restoration analysis. This analysis indicates that there are opportunities to repair impacted habitats. Habitat restoration opportunities include removal of groynes, bioengineering retaining walls, planting or native riparian vegetation, etc. These habitat benefits will work to restore impacted habitats and reverse the current trends of habitat degradation. Habitats restoration opportunities should be pursued as part of any development or redevelopment applications. It may be useful to identify the potential for restoration opportunities in the standard terms of reference

A variety of different recommendations have been presented that are intended to aid foreshore protection, guide future data management, and for future biophysical inventory works. One of the key recommendations presented was as follows:

- Shoreline Management Guidelines are recommended to facilitate informed land use planning decisions across multiple agencies, with the intention of streamlining the permitting and regulatory processes at these different agencies.

The inventories and analysis completed as part of this study should help protect important shoreline resources around Shuswap Lake. At this time, important shoreline areas have been inventoried (FIM) and the sensitivity (AHI) has been determined. Although there were many impacts observed along the lake shorelines, there are extremely important habitats present that are in good to excellent condition. Now that these shoreline areas have been identified, they should be considered as part of any shoreline land use proposal.

ACKNOWLEDGEMENTS

The following parties carried out fieldwork for this assessment:
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Bob Harding, Fisheries and Oceans Canada
Sheldon Romaine, Fisheries and Oceans Canada
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Sarma Liepens, Ministry of Environment
Jason Hwang, Fisheries and Oceans Canada
Dale Haberstock, Columbia Shuswap Regional District
Valerie Cameron, Ministry of Environment

Funding and or in kind donations for this Project were provided by the following different agencies or parties:
Columbia Shuswap Regional District
Fisheries and Oceans Canada
Fraser Salmon and Watersheds Program (and their partners)
Real Estate Foundation of British Columbia
Ecoscape Environmental Consultants Ltd.

The following parties contributed to the development of the Aquatic Habitat Index:
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Bruce Runciman, Fisheries and Oceans Canada
Andy Morris, Ministry of Environment

The following different people have contributed to the success of this project:
Hamish Kassa, Marcin Pachcinski, and Olive Dodd of the Columbia Shuswap Regional District
Brad Mason, Bob Harding, and Bruce Runciman with the Fisheries and Oceans Canada

The following parties contributed to the development of the Aquatic Habitat Index for the project:
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Recommended Citation:
Schleppe, J., 2009. Shuswap and Mara Lake Foreshore Inventory and Mapping. Ecoscape Environmental Consultants Ltd.. Project File: 09-329. April, 2009. Prepared for: Fisheries and Oceans Canada and Columbia Shuswap Regional District & Fisheries and Oceans Canada

DISCLAIMER

The results contained in this report are based upon data collected during surveys occurring over a one-year period. Biological systems respond differently both in space and time and exhibit extreme variability. For this reason, conservative assumptions have been used and these assumptions are based upon field results, previously published material on the subject, and air photo interpretation. Due to the inherent problems of brief inventories (e.g., property access, GPS/GIS accuracies, air-photo interpretation concerns, etc.), professionals should complete their own detailed assessments of shore zone areas to understand, evaluate, classify, and reach their own conclusions regarding them. Data in this assessment was not analyzed statistically and no inferences about statistical significance should be made if the word significant is used. Use of or reliance upon conclusions made in this report is the responsibility of the party using the information. Neither Ecoscape Environmental Consultants Ltd., Fisheries and Oceans Canada, the Columbia Shuswap Regional District, nor the authors of this report, are liable for accidental mistakes, omissions, or errors made in preparation of this report because best attempts were made to verify the accuracy and completeness of data collected and presented.

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1.0 INTRODUCTION

The desire to live and recreate in the Shuswap watershed has resulted in a dramatic increase in development pressure on the system. The Columbia Shuswap Regional District (CSRD) has undertaken a number of planning initiatives to better manage growth and develop land use policies by updating Official Community Plans, introduction of development permit areas, zoning bylaws, and other documents as necessary. Provincial and Federal agencies have responded through the creation of the Shuswap Lake Integrated Planning Process (SLIPP). Through these planning processes and initiatives, it has become readily apparent that development along Shuswap has the potential to or has already impacted fish, wildlife, and/or water quality in the lakes and rivers. The CSRD is working cooperatively with other agencies, including the Ministry of Environment (MoE), and Fisheries and Oceans Canada, and SLIPP to ensure that land use decision making processes are consistent between the different levels of government.

It is a complex relationship between development pressure, the natural environment, and social, economic and cultural values. To balance these various community values, a solid understanding of aquatic and riparian resource values, land use interests, concerns of local residents and the long-term planning objectives of the CSRD, provincial and federal agencies are important components. Further, a detailed understanding of the shoreline habitats increases understanding of the environmental resources present, allowing all stakeholders to understand how development may affect these habitat features. With this understanding, more informed land use planning decisions can be made that better balances the different pressures that exist and protect our important natural resources.

Managers at all levels of government and the general public recognize the importance of managing these systems in a sustainable manner. Current management practices being implemented throughout British Columbia in the Okanagan and Kootenay regions are utilizing a three step process to help integrate environmental data with land use planning information to facilitate review and decision making processes. The process involves the following three steps:

1. Foreshore Inventory and Mapping (FIM) – FIM is a broad scale inventory process that attempts to define and describe the shoreline of our large and small lake systems. The inventory provides baseline information regarding the current condition and natural features of the shoreline and the level of development (e.g., # of docks, groynes, etc.). Sufficient data is collected that will allow managers and the public to monitor shoreline changes over time and to measure whether proposed land use decisions are meeting their intended objectives. This baseline inventory provides sufficient information to facilitate identification of sensitive shoreline segments as part of step 2 below.

2. Aquatic Habitat Index or Ecological Sensitivity Index (AHI) – The AHI utilizes data collected during the FIM, field reviews, and other data sources (e.g., Land and Data Warehouse, previously published works, etc.) to develop and rank the sensitivity of the shoreline using an index. An index is defined as a numerical or categorical scale used to compare variables with some reference. In this case, the index is used to compare the sensitivity of the different shoreline areas defined and collected during the FIM to other shoreline areas along the lake (i.e., the index compares the ecological or aquatic sensitivity of different shoreline areas within the lake system).

3. Development of Shoreline Management Guidance Documents - Guidance documents are the final step in the process. Guidance documents are intended to help land managers at all levels of government quickly assess applications and is intended to be the first step for review, planning, and prescribing shoreline alterations (i.e., land development) by applicants and review agencies.

2.0 PROJECT OVERVIEW

Many of the areas around Shuswap, Mara, and Little Shuswap Lake have historically been small, rural back country areas. However, in recent years these small rural areas are transitioning to village or town like settlements as people discover these different areas. People are attracted to these small communities because they offer excellent retirement and recreational destinations.

The Shuswap watershed supports many different anadromous (sea run) and non-anadromous (non-sea run) fish stocks, which significantly contribute to First Nations', commercial, and sport fisheries. These fish stocks also have significant cultural value, contributing to local eco tourism opportunities (e.g., sockeye spawning observations in the Adams River). Also, the watershed provides critical habitats for numerous different wildlife fish species. Finally, the watershed is also source water for the residents of the area. For these reasons, protection of the various different environmental values (i.e., fish, wildlife, and water) is extremely important.

The local residents have expressed strong desires to preserve and protect these different public resources. The intent of this project is to provide a baseline overview of the shoreline condition of Shuswap Lake, Mara Lake, Little River, and Little Shuswap. The methodology employed for this assessment is discussed in detail below and is a provincial standard that is being used to map shorelines around the province. The mapping protocol will allow stakeholders to understand what the current condition of the shoreline is, to set objectives for better shore management in Official Community Plans or other policy documents, and measure and monitor changes in the shoreline overtime.

2.1 Project Partners

Numerous different parties have contributed to the success of this project. Foreshore Inventory and Mapping (FIM) protocols have been developed over the last 5 years and have become a standardized approach to shoreline inventory. Numerous different local governments, non-profit organizations, biological professionals, and provincial and federal agencies have contributed to the development of the FIM protocol and Appendix A (Detailed methods) provides a more accurate list of contributing parties.

This project was funded by the following agencies and organizations:

1. Columbia Shuswap Regional District provided financial support, staff resources, and equipment such as the boat to complete this assessment.

2. Fisheries and Oceans Canada provided financial support, staff resources, and equipment to complete this project.

3. Fraser Salmon and Watershed Program – This program has numerous different government and non profit organizations that contribute to it and provided financial support for the project. Details for this program are available at: http://www.thinksalmon.com/fswp_project/

4. Real Estate Foundation of British Columbia – This association provided financial support for completion of this project.

5. Thompson Nicola Regional District and Regional District North Okanagan contributed towards the costs of orthophotos used as part of this project.

Ecoscape Environmental Consultants Ltd. also provided an in kind donation, via reduction in standard hourly rates, to complete this project. This contribution was made as part of our ongoing commitment to better shoreline management in the province.

2.2 Objectives

The following are the objectives of this project:

1. Compile existing map base resource information for Shuswap Lake and watershed;

2. Foster collaboration between the CSRD, DFO local staff and the Province and utilize available expertise when possible;

3. Provide an overview of foreshore habitat condition on the lake;

4. Inventory foreshore morphology, land use, riparian condition and anthropogenic alterations;

5. Obtain spatially accurate digital video of the shoreline of the lake;

6. Provide access to the video and GIS geo-database through the Community Mapping Network at ww.cmnbc.ca.

7. Collect information that will aid in prioritizing critical areas for conservation and or protection and lake shore development;

8. Make the information available to planners, politicians and other key referring agencies that review applications for land development approval; and,

9. Integrate information with upland development planning, to ensure protection of sensitive foreshore areas; so that lake management planning is watershed based.

The FIM and AHI completed as part of this assessment will begin to address many of these objectives. Completion of Step 3, Shoreline Management Guidelines is required to address the more detailed planning aspects to address some of the objectives.

2.3 Description of the Shuswap Lake Watershed

The Shuswap Lake watershed consists of six different oligotrophic lakes including Shuswap Lake, Adams Lake, Little Shuswap Lake, Mara Lake, Sugar Lake, and Mabel Lake (Williams *et al*, 1989). Each of these different lakes has important tributaries including the Eagle River, Adams River, Seymour River, Anstey River, and Shuswap/Little Shuswap Rivers. It has been noted that 35 of the 37 tributaries of Shuswap Lake contains one ore more important fish stocks (DFO, 1995). These lakes provide important habitats for a variety of different fish and wildlife and there are numerous assessments that have investigated the salmonid populations within the lake system.

The watershed occurs over multiple different local government jurisdictions including the Columbia Shuswap Regional District, City of Salmon Arm, District of Sicamous, Village of Chase, and others. The watershed is an important Source Drinking Water for residents of the various different jurisdictions and maintaining a high quality drinking water is critical to maintaining the current lifestyle that occurs there.

The importance of the watershed cannot be underestimated. Reports have shown that the watershed is one of the most important tourist destinations in the interior, second only to the Okanagan Valley (CSRD, 1988). It is possible that the watershed contains one of the larger houseboat industries in the world, highlighting the importance of tourism to the region.

2.4 Description of the Study Area

For this project, focus was on completion of shoreline mapping in the following areas:

1. Shuswap Lake including the Main Arm, Seymour Arm, Anstey Arm, Salmon Arm, Sicamous Arm[2] and Narrows, and Cinnemousun Narrows.
2. Little Shuswap Lake and Little River;
3. Mara Lake

The general location of the study area is found in Figure 1 and a summary of the different jurisdictions is found in Figure 2. The different municipal jurisdictions surrounding the study area include numerous different local governments. In general, Little Shuswap is surrounded by the Thompson Nicola Regional District, while the southern part of Mara Lake is within the North Okanagan Regional District. The majority of the study area lies within the Columbia Shuswap Regional District, which encompasses areas of Little River, Mara Lake, and nearly all of Shuswap Lake.

2.5 Important Fisheries Resource Information

The Shuswap watershed contributes significantly to the overall production of salmon in the Fraser River Basin and to the genetic diversity of Fraser salmon populations. Shuswap Lake and its tributaries support sockeye (*Oncorhynchus nerka*), chinook (*O. tshawytscha*), coho (*O. kisutch*) and small populations of pink salmon (*O. gorbuscha*). In 2002, Interior Fraser River coho salmon (IFC) which are present in the Shuswap watershed were designated as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The Shuswap is one of the most important salmon producing lake systems in British Columbia and is one of only a few that supports “multiple timing” sockeye salmon stocks which is an important diversity attribute to maintain. This diversity of different fish stock, genetic strains, and multiple timing is very important because it creates a buffer against major changes in habitat, such as those attributes to changing land uses or climate.

The salmon stocks are also very important to First Nations’. The stocks contribute substantially to First Nations’, commercial and sport fisheries, as well as having significant cultural value and contributing to local eco-tourism opportunities (e.g. sockeye spawning viewing at the world famous Adams River). Coupled with the important sea run salmon stocks, there are numerous resident salmonid fish species. These species also contribute to local First Nations’ and recreational fisheries including rainbow trout (*O. mykiss*), kokanee (*O. nerka*), bull trout (*Salvelinus confluentus*) and lake char (*S. namaycush*).

There are numerous different foreshore areas around Shuswap Lake(s) that provide important habitat for spawning salmonids. Lake Char are known to spawn in certain shoreline areas on all years and sockeye in the tens to hundreds of thousands have been

[2] Sicamous Arm refers to the areas from Sicamous to the Salmon Arm and the Cinnemousen Narrows. This name is not commonly used, was observed in literature reviews.

observed shore spawning on dominate cycle years (i.e., 2010). The numbers of shore spawning sockeye are less during sub-dominate years (i.e., 2011). Finally, shore line areas of Shuswap Lake(s) provide vital staging habitats for migrating adult salmon and vital rearing and migration habitat for hundreds of millions salmon juveniles originating from lake or stream spawning streams.

Salmon are a “keystone species” in the Shuswap watershed. Adult salmon are a critical fall food source for bears, eagles and other species and the spawned out carcasses of the adults provide fertilizer for terrestrial and aquatic ecosystems. Salmon also act as an indicator species for the overall health of the Shuswap ecosystem because they are highly sensitive to changes in their habitat, such as a reduction in water quality.

The above section provides a brief overview of the importance of fisheries resources in the Shuswap Lake(s) systems. The importance of these fishery resources must be considered during land use planning exercises, and provides the basis and rationale for completion of this shore line inventory project.

2.6 Foreshore Management Overview

A three step process is currently being used as a Shoreline management in the province. This three step process generally proceeds as follows:

1. Foreshore Inventory and Mapping (FIM) is a protocol that is used to collect baseline information regarding the current condition of a shoreline. The FIM uses a mapping based (GIS) approach to describe shoreline. This inventory provided baseline information on shore types, substrates, land use, and habitat modification. This new information was combined where possible, with other mapping information such as previous fisheries inventories, recent orthophotos, and other information;

2. An Aquatic Habitat Index (AHI) is generated using the FIM data to determine the relative habitat value of the shoreline. This index follows similar methods that were developed for Okanagan Lake and Windermere Lake and is similar to other ongoing assessments along Wasa and Shuswap Lake. The Habitat Index uses a many different criteria, such as substrate information, known Sockeye shore spawning locations, known char spawning locations, etc. to estimate the habitat value of a shoreline segment. The Habitat Index classifies this information in a 5-Class system from Very High to Very Low.

3. Shore Line Management Guidelines are prepared to identify the Shore Line Vulnerability. Shoreline Vulnerability is based upon the Habitat Index described above. The Shoreline Vulnerability uses a risk based approach to shoreline management, assessing the potential risks of different activities in the different shore segments. The Shore Line Management Guidelines are intended to provide background information to stakeholders, proponents, and governmental agencies when land use changes or activities are proposed that could alter the shoreline thereby affecting fish or wildlife habitat.

The Shuswap Lake Integrated Planning Process (SLIPP) is a multi agency process that has arisen in response to the increasing development and recreation pressures on Shuswap Lake. In recent years, several issues including cumulative foreshore impacts and degraded habitat, large-scale developments, recreational use conflicts, park capacity, threatened aquifers, and water quality impacts have presented a case for change in the way Shuswap Lake is managed. The purpose of SLIPP, therefore, is to bring together all 14 regulatory agencies to establish a planning process for land and water use on Shuswap and Mara Lakes to address issues that are better managed through collaboration. SLIPP strategic direction is guided by a steering committee consisting of political and senior agency representatives. Three working groups were formed to address the issues and make recommendations for the SLIPP Strategic Plan: (1) foreshore development, (2) water quality and waste management, and (3) recreation management. The majority of SLIPP recommendations focus on improvements to coordinating mechanisms among governments, including the formation of an inter-agency technical committee; streamlining the development review process; developing a coordinated water quality monitoring program; and delivering a coordinated education, compliance and enforcement program.

The completion of Step 1 – FIM and Step 2 - AHI of the three step process is required by SLIPP to achieve amongst other goals & strategies;

- Creating a comprehensive foreshore and upland area site sensitivity map for Shuswap and Mara Lakes.

- Tool development to support the proposed " Interagency Technical Committee to manage cross agency development applications and lake issues".

- Tool development to support improving the development application process.

This project builds on the existing partnerships between the CSRD, DFO, and MOE and facilitates the land us planning goals of SLIPP. The foreshore zones identified within this assessment (Shore Segments) can also be easily integrated with CSRD “Foreshore Zoning Template” and Development Permit Requirements.
The Columbia Shuswap Regional District (CSRD) encompasses almost the entire Shuswap Lake and surrounding watershed in the highlands, and part of Mara Lake. There are nearly 25 different community areas surrounding the lake, most of which are located within the jurisdiction of the Columbia Shuswap Regional District. Most of these communities are small, rural and lie in remote areas of the watershed (i.e., some do not have services). This, combined with dozens of destination tourism operations and resorts that reach capacity in the summer months, creates a challenging environment for planning.

In 2008, the CSRD completed its four-year Strategic Plan which provides a policy framework based on a number of guiding principles. Several of the principles in the Strategic Plan relate to the environment and are complemented by this project. Specifically, this project advances the following principles in the CSRD Strategic Plan:

5.3 To enhance environmental awareness and promote activities that protects and restores the natural environment.

5.4 To protect sensitive plant, wildlife and fish habitats, as well as lands that include distinctive geologic features as environmentally sensitive areas (ESAs);

5.5 To ensure that new development is respectful of environmentally sensitive areas, including significant plant, wildlife, and fish habitats.

In 2008, the CSRD also signed on to the BC Climate Action Charter, which promotes compact and efficient communities, reducing sprawl, and focusing on transit-oriented development, all of which will work toward reducing greenhouse gas emissions in the CSRD.

Additionally, the CSRD has in place or is working on a number of Official Community Plans, zoning bylaws, Liquid Waste Management Plans, Parks Plans, a Solid Waste Management Plan and an enhanced Subdivision Servicing Bylaw, all of which will help to better manage land and water uses in the Shuswap watershed.

3.0 FORESHORE INVENTORY & MAPPING METHODOLOGY

The Foreshore Inventory and Field Mapping detailed methodology (FIM) is found in Appendix A. This inventory is based upon mapping standards developed for Sensitive Habitat Inventory and Mapping (SHIM) (Mason and Knight, 2001) and Coastal Shoreline Inventory and Mapping (CSIM) (Mason and Booth, 2004). The development of mapping initiatives such as SHIM, FIM, and CSIM by the Community Mapping Network is an integral part of ecologically sensitive community planning. The following sections summarize specific information for the Shuswap and Mara Lakes Foreshore Inventory and Mapping.

3.1 Field Surveys

Field surveys were conducted between October 6 to 21, 2008 using a CSRD boat and operator. Pre field reviews were completed daily and mapping was conducted in an organized fashion. Safety reviews, and daily weather reviews and assessments were conducted routinely to ensure that all members participating in the survey were familiar with field conditions.

Field surveyors were each assigned data to collect during the surveys. Field assessors used 2 ft by 3 ft, scaled colour air photos with cadastre and topographic information to assist with field data collection. Two TRIMBLE GPS units with SHIM Lake v. 2.6 (FIM Data dictionary name) were carried and a hurricane antennae was also used. Finally, several thousand digital photographs, with a GPS stamp, were also collected.

Other field surveys completed included the GPS digital video, discussed in the FIM methodology. This work was completed on May 24th through May 28, 2008 and is an extremely important part of documenting the current condition of the shoreline. Finally, a photographic survey of retaining walls was completed when the lake was nearing the mean Annual High water Level (MAHWL) of Shuswap Lake (348.3 m geodetic) and Mara Lake (348.4m geodetic). This assessment was conducted by two teams of CSRD, DFO and MOE staff on July 2&3, 2008 when the lake was at 348.23 and 348.24m respectively. The timing of surveys allowed assessors to determine whether the walls were constructed below the MAHM. Surveyed retaining walls were considered either as wet or dry, and conventional or bioengineered.

The principle objectives of these video and photographic surveys were to:

- Provide a photographic documentation of the shoreline for the main areas of development;
- To record data relating the the presence or absence of retaining walls and boat launches.

Weather during the surveys was generally overcast, and no significant storm events occurred. Weather is an important consideration, particularly during the photo and video documentation portions of the assessment. Good photo documentation is extremely important because data analysis following datat collection can be hindered by poor photography.

First Nations were contacted to help conduct field surveys for this assessment. However, due to other inventory commitments during the surveys were unable to participate.

3.2 Methodology

All of the methods outlined in Appendix A for Foreshore Inventory and Mapping projects were carried out for this assessment. Daily information collected was downloaded to a laptop as a backup. Once downloaded, the entire database was reviewed for accuracy and corrections were made as necessary. Ecoscape has attempted to ensure the data is as accurate as possible. However, due to the large size of the dataset, small errors may be encountered. These errors, if found, should be identified and actions initiated to resolve the error.

The following additional information was collected during field surveys to provide additional information:

1. The spatial extent of aquatic vegetation (emergent, floating, and native submergent – milfoil was not generally recorded as other surveys have been conducted for this weedy species. Further, the timing of the assessment precluded good mapping of this one species due to poor growth and water clarity) were mapped and photographed to determine the area of aquatic vegetation. Aquatic vegetation includes any plants growing below the high water level of the lake because these areas are important fish habitat. Also, areas of good overhanging vegetation (from the high water level) were also mapped.

2. Substrate mapping of significant breaks or changes in substrate was conducted to determine where major changes in substrates occur. This substrate mapping was cursory, until a more defined methodology can be developed.

3. Small stream confluences, seepage areas, and other features were also recorded.

4. Attempts were made to map the locations of boat launches, house boat mooring zones / haul outs, good riparian areas, and other features of interest.

3.2.1 Aquatic Vegetation Mapping and Classification

Aquatic vegetation mapping was carried out for the entire shoreline. For the purposes of this assessment, aquatic vegetation includes any plant life occurring below the high water level of the lake. Although some of the plants are not truly aquatic, all are hydrophilic (water loving) and contribute to fish habitat. Vegetation mapping was completed by marking up field air photos of the shoreline and using air photo interpretation during data management and review to map the location of aquatic vegetation communities. Aquatic Vegetation polygons are similar to Zones of Sensitivity identified by the Okanagan and Windermere projects. Vegetation communities were classified using the Wetlands of British Columbia – A guide to identification (Mackenzie and Moran, 2004) and were categorized as:

1. Low Flood Benches (e.g., Fl06) - Tall shrub thickets that occur on regularly flooded riparian sites

2. Mid Flood Benches (e.g., Fm02) - Broadleaf thickets that occur on flooded riparian sites.

3. Marshes (e.g., Wm00) were permanently to seasonally flooded shorelines dominated by emergent grass like vegetation. These sites needed to be nutrient rich and submerged for longer periods of time. They generally occurred in areas with a wide littoral zone and low gradient.

Not all areas could be classified using this system. In all other areas, vegetation was generally referred to as:

1. Emergent Vegetation (EV) generally refers to grasses, *Equisetum* spp. (i.e., horsetails), sedges, or other plants tolerant of flooding. Coverage's within polygons needed to be consistent and well established to be classified as EV. These areas were generally not dominated by true aquatic macrophytes and tended to occur in steeper sloping areas.

2. Sparse Emergent Vegetation (SEV) refers to the same vegetation types as emergent vegetation, but in these areas coverage waas generally not very dense or was very patchy. This vegetation was often patchy, due to the association with rocky beaches or due to intensive beach grooming.

3. Overhanging Vegetation (OV) was mapped where it observed. Overhanging vegetation also occurred with Emergent Vegetation (EVOV) and with Sparse Emergent Vegetation (SVOV).

4. Submergent Vegetation (SUB) areas generally consisted of *native Potemogeton* spp. and in a few areas with floating vegetation. These areas were uncommon and only occurred in a few shallow bay areas.

5. Floating Vegetation (FLO) areas generally consisted of species such as *native Potamogeton*, pond lilies, and other types of vegetation that floats.

3.2.2 GIS and FIM Database Management

Data management for this project followed methods provided in Appendix A and generally involved the following steps:

- Data and photos were backed up to a computer/laptop on a daily basis;
- A GPS camera that stamps photos and creates GIS shapefiles was used to facilitate data review and interpretation;
- Air photo interpretation was completed using high resolution air photos that were flown during the summer of 2008.
- During data analysis, numerous checks were completed to ensure that all data was analyzed and accounted for.
- A spatial elevation model was run using GIS software, in combination with air photo interpretation and TRIM shoreline files to accurately determine the high water level of the lake. It is believed that for the length of the shoreline, the high water level used is within 5 m of the mean annual high water level for at least 80% of the lake. However, a site specific survey must be conducted to accurately determine the high water level for any site specific considerations.

The following data fields were added to the FIM data dictionary

1. An Electoral Area field was added to define the electoral area within a Regional District that shoreline segments were part of.

2. A Community Field was added to the database to analyze data by community. Community areas were provided by the Columbia Shuswap Regional District as a GIS shapefile and are summarized in Figure 2.

3. Several fisheries fields were added. When adding fisheries fields, in cases where fisheries data overlapped a segment, the segment defaulted to the highest category as long as it occupied at least 40% of the shoreline. In general, fisheries data corresponded well with segment breaks and in only a few instances was this decision tool used. When differences are noted, the original data set should be referred to as necessary. These fisheries field are considered similar to the Zones of Sensitivity that were developed for the Okanagan and Windermere projects. The following describes fisheries fields added and the original data source for the fields:

    a. Sockeye Shore Spawning (Sock_Spawn) areas were provided by the Community Mapping Network and have been mapped by the Fisheries and Oceans Canada on several occasions.
    b. Char Shore Spawning (Char_Spawn) areas provided by the Community Mapping network. Original assessments of shore spawning char were completed by Bison and Associates (1991), who identified suitable shore spawning shorelines. Subsequent shoreline mapping for char was completed in 2004 (MWLAP, 1994; MWLAP, 1995).
    c. Juvenile Rearing shoreline habitat value (High, Moderate, and Low) was provided by the Community Mapping Network. Original surveys to determine these areas were completed by Graham and Russell (1979) and Russell *et al* (1981) who documented juvenile utilization of the shoreline for
    d. Migration – Juvenile fish migration routes are the most important migration corridors and these were digitized from information contained in Studies of the Lacustrine Biology of the Sockeye Salmon (*Oncorhynchus nerka*) in the Shuswap System (Williams *et al*, 1989). Although this research focuses on sockeye salmon, it is thought that all anadramous salmon follow similar routes. This document does indicate the presence of juveniles of all species, and indicates that in some instances the densities of sockeye are so great they displace the other species. These areas were digitized. Professional judgment was used in some instances where data was not as readily available.

e. Staging – Staging areas were digitized based upon liaison with Department of Fisheries Oceans field staff through the course of field work and the assessment. Field staff indicated to Ecoscape where fish were known to stage or hold prior to migrations. In general, these areas are loosely defined and vary over space and time. The information presented is located to areas around the narrows and mouths of streams, where fish are known to congregate before migrations. It may not entirely reflect all locations or spatial extents of staging areas. Future surveys should be used to better understand where mature adults hold during migrations.

4. Aquatic Habitat Index (AHI_CUR) field was added. This field reflects the results of the AHI discussed below.

5. An Aquatic Restoration potential analysis (AHI_POT) was also completed by removing instream features from the AHI results. This analysis provides a summary of potential locations where habitat improvements are possible along the shoreline. This analysis *does not consider improvements to riparian vegetation*.

4.0 AQUATIC HABITAT INDEX METHODOLOGY

An Aquatic Habitat Index (AHI) is a tool that is used to help assess the habitat value or environmental sensitivity of a shoreline. An index is a numerical or categorical scale used to compare variables with one another. Use of an index to assess shoreline sensitivity has been utilized on Okanagan Lake (Schleppe and Arsenault, 2006) and Windermere Lake (McPherson S, and D. Hlushak, 2008). Indices are also currently in preparation for Wasa, Moyie and others. The purpose of the Aquatic Habitat Index (AHI) is to facilitate land use planning around shorelines by identifying the relative sensitivity of a shoreline.

The Aquatic Habitat Index utilizes a number of different parameters collected during the FIM. The index uses a points based mathematical model to assign the relative habitat value to each different parameter. Features that have impaired the habitat value (e.g., groynes) are assigned negative scores to better reflect the current condition of the shoreline. The intent of this analysis was to compare the shoreline to its natural state.

A subsequent analysis was conducted to determine the habitat potential of a segment. This analysis involved removing ALL negative habitat parameters to determine if shoreline restoration could achieve a measurable benefit. This Habitat Potential index can be used to help assess where restorative efforts should be directed.

4.1 Parameters

The parameters of the index each reflect a certain type of habitat found along the shoreline. The parameters were broken down into three categories as follows:

1. Biophysical;
2. Fisheries;
3. Shoreline Vegetation; and,
4. Modifications;

The following table identifies the parameters and logic used in the index.

Table 1: The parameters and logic for the Aquatic Habitat Index of Shuswap Lake.

Category	Criteria	Maximum Point	Percent of the Category[1]	Percent of the Total[1]	Logic	Uses Weighted FIM Data	Value Categories
Biophysical	Shore Type	15	31	10	% of Segment * Shore Type Value	Yes	Stream Mouth = Wetland (15) > Gravel Beach = Rocky Shore (12) > Sand Beach (8) = Cliff /Bluff (8), Other (5)
	Substrate	12	25	8	% Substrate * Substrate Value	Yes	Cobble (12) > Gravel (10) > Boulder = Organic = Mud = Marl (8), Fines = Sands (4) > Bedrock (2)
	Percentage Natural	5	10	3	% Natural * Natural Score	No	
	Aquatic Vegetation	8	17	6	% Aquatic Vegetation * Aquatic Vegetation Score	No	
	Overhanging Vegetation	4	8	3	% Overhanging Vegetation * Overhanging Vegetation Score	No	
	Large Woody Debris	4	8	3	# of Large Woody Debris/km * Relative Value * LWD Score	No	**Relative Value** >15 LWD (1) > 10 to 15 LWD (0.8) > 5 - 10 LWD (0.6) > 0 - 5 LWD (0.4) > 0
Fish	Sockeye Confirmed Spawning	12	19	8	Present (12), Absent (0)	No	Present (12), Absent (0)
	Char Confirmed Spawning	12	19	8	Present (12), Absent (0)	No	Present (12), Absent (0)
	Juvenile Rearing	10	16	7	High (10), Moderate (6), Low (2)	No	High (10), Moderate (6), Low (2)
	Migration Corridor	5	8	3	Present (5), Absent (0)	No	Predominant (5), Minor (0)
	Staging Area	3	7	2	Present (3), Absent (0)	No	Predominant (3), Minor (0)
	Special Area	20	32	14	Present (20), Absent (0)	No	Present (20), Absent (0)
Shoreline Vegetation[2]	Band 1	8	66.7	6	Vegetation Bandwidth Category * Vegetation Quality * Vegetation Score	Yes	**Vegetation Bandwidth Category** 0 to 5 m (0.2) < 5 to 10 m (0.4) < 10 to 15 m (0.6) < 15 to 20 m (0.8) < 20 m (1)
	Band 2	4	33.3	3	Vegetation Bandwidth Category * Vegetation Quality * Vegetation Score	Yes	**Vegetation Quality Category** Natural Wetland = Disturbed Wetland = Broadleaf = Shrubs (1) > Coniferous Forest = Mixed Forest (0.8) > Herbs/Grasses = Unvegetated (0.6) > Lawn = Landscaped = Row Crops (0.3) > Exposed Soil (0.05)
Modifications	Retaining Wall	-3	14	-2	% Retaining Wall * (-3)	No	% Retaining Wall * (-3)
	Docks	-5	22	-3	# Docks * (-0.1)	No	# Docks per Kilometer * (-0.1)
	Groynes	-6	27	-4	# Groynes* (-.1 per groyne)	No	# Groynes per Kilometer * (-.1)
	Boat Launch	-4	16	-2	# Launches * (-0.25 per launch)	No	# Launches * (-0.25 per launch)
	Marina	-4.25	20	-3	# Marina * (-0.25 per marina)	No	# Marina * (-0.25 per marina)

1. Numbers have been rounded to the nearest whole number. All calculations were completed without rounding.

2. The Shoreline vegetation category has been calculated to include an estimate of quantity (i.e., bandwidth) and quality (i.e., relative value). In cases where two bands are present, there is a higher diversity which is more productive, resulting in a higher score.

The parameters selected for the index were similar to the other indices developed. A description of each is found below.

4.1.1 Biophysical Parameters

The following summarizes the biophysical parameters of the index:

1. Shoretype – A shoreline type is related to many aspects of productivity. Previous habitat indices (e.g., Schleppe and Arsenault, 2006) have used a habitat specificity table to determine the value of a shoreline. This similar approach was used for Windermere Lake (McPherson and Hlushak, 2008). However, in these previous versions, wetlands were difficult to account for because these segments tended not to be valuable utilizing a fish habitat specificity approach, when it is generally accepted that they are highly valuable. Other aspects of the habitat specificity were fine. The general habitat specificity for Shuswap Lake follows that of Windermere and Okanagan, except that Wetlands were considered as valuable as Stream Mouths. Given the rarity of these features on this or any lake, this assumption is valid.

2. Substrate – Substrates also relate directly to productivity. There are generally two types of productive substrates, those utilized for spawning, and those that produce more biomass. The substrates values and parameters used for Shuswap Lake are similar to the Okanagan and Windermere. More information regarding the rational of this parameter please refer to the indices developed for the Okanagan and Windermere.

3. Percent Natural – This parameter is similar to the Okanagan and Windermere. However, the relative percentage of the parameter was dropped slightly to ensure that previous habitat alterations did not impact existing habitat values too much.

4. Aquatic Vegetation – In more recent versions of the FIM database, more detailed information regarding aquatic vegetation was collected. In the Shuswap system, all vegetation below the HWL is considered productive. Since the FIM now allows analysis of this parameter, it was added. The benefits of aquatic vegetation are many and include forage, biomass production, cover, etc.

5. Overhanging Vegetation – In the more recent versions of the FIM, more detailed information regarding overhanging vegetation was collected. In the Shuswap system, overhanging vegetation was not frequently documented. Since it provides nutrients and opportunities to forage, it was added to the index.

6. Large Woody Debris – In the more recent versions of the FIM, more detailed information regarding large woody debris was collected. In the Shuswap system, Large Woody Debris was not present in many areas because some areas are far from significant sources such as large rivers and the wood had been removed by residents for firewood or to "clean up" the foreshore. Since it provides nutrients and opportunities to forage, it was added to the index.

4.1.2 Fisheries Parameters

The fisheries parameters used for the Aquatic Habitat Index were those described above in Section 3.2.2 – GIS and Data Management. These different parameters are considered important for fish production in the Shuswap system and were prioritized in the AHI accordingly. These are similar to areas identified as Zones of Sensitivity in the Okanagan and Windermere projects. The following were the fisheries parameters added:

1. Sockeye Shore Spawning (Sock_Spawn) areas were provided by the Community Mapping Network and have been mapped by the Fisheries and Oceans Canada on several occasions. Shoreline spawning areas were given a high weighting in the index. Other data added to the FIM data set included Little River Sockeye spawning locations, which were provided by the DFO stock assessment branch.
2. Char Shore Spawning (Char_Spawn) areas provided by the Community Mapping network. Original assessments of shore spawning char were completed by Bison and Associates (1991), who identified suitable shore spawning shorelines. Subsequent shoreline mapping for char was completed in 2004 (MWLAP, 1994; MWLAP, 1995). Shore spawning areas were given a high weighting in the index.
3. Juvenile Rearing shoreline habitat value (High, Moderate, and Low) was provided by the Community Mapping Network. Original surveys to determine these areas were completed by Graham and Russell (1979) and Russell *et al* (1981) who documented juvenile utilization of the shoreline for. Juvenile rearing areas are very important and were given moderate weighting in the index.
4. Migration – Juvenile fish migration routes are the most important migration corridors and these were digitized from information contained in Studies of the Lacustrine Biology of the Sockeye Salmon (*Oncorhynchus nerka*) in the Shuswap System (Williams *et al*, 1989). Migration routes were given a low weighting.
5. Staging – Staging areas were digitized based upon liaison with Department of Fisheries Oceans field staff through the course of field work and the assessment. Field staff indicated to Ecoscape where fish were known to stage or hold prior to migrations. This parameter was considered because staging fish can be impacted by adjacent land uses such as marinas. However, the parameter was not considered heavily in the index because staging generally occurs offshore.

6. Special Areas – Special areas are places that have a habitat features have not been identified by another parameter. In the Okanagan, the known location of the Western Ridged Mussel has been used as a example, as there are very few locations where this species is known to occur. On Shuswap Lake, the Sicamous Narrows region has long been known to be an important habitat type. This region, if in a natural state would have been a low lying riparian area with associated habitat features. Specific management objectives for this area have been set and numerous inventories of the area have been completed. It is also a known pinch point for migrating salmonids. For these reasons, this location was considered unique.

4.1.3 Shoreline Vegetation Parameters

The Riparian parameters added to the model were similar to those added in the Okanagan and on Windermere Lakes. However, the newer versions of the FIM provided a distinction between the lakeside vegetation (Band 1/Riparian) and the areas behind (Band 2/Upland). To address this new data available, the index was modified slightly. The index was modified to include a factor assessing vegetation quality (i.e., tall shrubs thickets or wetland areas have a higher quality than landscaped yards). As with the other indices, vegetation bandwidths were categorized and points were assigned. Vegetation bandwidth categories included 0 to 5 m, 5 m to 10 m, 10 to 15, 15 to 20 and greater than 20. The Band 1 vegetation, directly adjacent to the lake was given more points than the Vegetation Band 2 higher than the Band 2 vegetation.

4.1.4 Habitat Modifications

Habitat modification parameters are described by Schleppe and Arsenault (2006). These descriptions provided a good rationale for inclusion of these different parameters. Other habitat modifications parameters, such as Percent Substrate Modification or Percent Roadway were not included in the analysis because they may compound (i.e., groynes typically constructed from shoreline substrate modification, therefore gets counted twice). The following is quoted directly (shown in italics) from Schleppe and Arsenault (2006) completed by EBA Engineering Consultants Ltd. The City of Kelowna provided permission to utilize data from their assessment. Further information on these parameters can also be found in the Windermere Lake assessment (McPherson and Hlushak, 2008).

> *Retaining Walls*
>
> *Retaining walls are considered to be negative habitat features for a variety of reasons. These structures are generally constructed to armour or protect shorelines from erosion. Kahler et al (2000) summarized the effects of piers, docks, and bulkheads (retaining walls) and suggested that these structures may reduce the diversity and abundance of nearshore fish assemblages because they eliminate complex habitat features that function as critical prey refuge areas. Kahler et al. (2000) found evidence of positive effects for armouring structures along a shoreline in the published literature. Carrasquero (2001) indicated in his review of overwater structures that retaining walls might also reduce the diversity of benthic macroinvertebrate communities more than*

other structures such as riprap shoreline armouring because they reduce the habitat complexity.

Natural erosion along a shoreline can be the result of removal of riparian or lakeside vegetation, which may have been the cause of the erosion in the first place. In other cases, retaining walls have been constructed to hold up soil material, possibly reclaiming land, so that lawns can be planted or for other landscaping purposes. As indicated in the FIM report by the RDCO, the construction of structures by residents, may lead to neighbours imitating their neighbours. Also, construction of one retaining wall may lead to energy transfer via waves resulting in erosion somewhere else. The above arguments highlight the consequences of retaining wall construction and the potential negative habitat effects that they have.

On the Shuswap system, many retaining walls have been constructed to create level building areas, or level areas for turf and landscaping. This construction has resulted in significant impacts to riparian vegetation and foreshore substrates. Also, this construction practice has resulted in approximately 48% of the retaining walls being constructed below the MAHWL.

Docks

The negative effects of docks on fish habitat are controversial. On one hand docks may provide areas of hiding from ambush predators, reductions in large woody debris inputs, and these structures are often associated with other anthropogenic disturbances such as retaining walls (Kahler et al. 2000; Carrasquero 2001). On the other hand, docks also provide shaded areas that can attract fish and provide prey refuge, and pilings can provide good structure for periphyton growth (Carrasquero 2001). Numerous factors, such as the scale of study and the cumulative effects of these structures, are also important and should be considered when discussing overwater structures (Carrasquero 2001).

Docks have also been documented to increase fish density due to fish's general congregation around structure, but decrease fish diversity in these same areas (Lange 1999). Coupled with this result, Lange also found that fish diversity and density were negatively correlated with increased density and diversity of shoreline development, meaning that increases in dock density may reduce fish abundance and diversity. Chinook salmon have been documented to avoid areas of with increased overwater structures (e.g., docks) and riprap shorelines, and therefore, construction of these structures may affect juvenile migrating salmonids (Piaskowski and Tabor, 2000).

Regardless of the controversy, it is apparent that docks do affect fish communities and the degree of effects are most likely related to the intensity of the development, the scale of the assessment, and fish assemblage life history requirements. Different fish assemblages may respond differently to increased development intensity, and fish assemblages containing salmonids may be more sensitive than southern or eastern fish assemblages (e.g., bass, perch, and sunfish, etc.). It is for these reasons that dock density was included in the index, and that docks were treated as a negative parameter, *with increasing dock density considered as having more negative effects than lower dock densities.*

In the Shuswap system, docks pose there own interesting concerns in addition to those above. In this system, the large natural drawdown of the lake, results in construction of mostly floating docks. These floating docks cover the substrate in spawning areas and deter fish from utilizing these areas (J. Schleppe and K. Hawes, personal observation during shore spawning surveys on Okanagan Lake), degrade / shade shoreline vegetation, result in requests for dredging, facilitate moorage in shallow water resulting in prop scour, disrupt of littoral beach drift, among others. These impacts pose unique challenges to site specific and lake wide dock management practices on this lake system.

Groynes

Groynes are structures that are constructed to reduce or confine sediment drift along a shoreline. These structures are typically constructed using large boulders, concrete, or some other hard, long lasting material. Reducing the movement of sediment materials along the shoreline can have a variety of effects on fish habitat, including increasing the embeddedness of gravels. Published literature regarding the specific effects of groynes on fish habitat are few, but because these structures are often considered Harmful Alterations, and Disruptions of Fish Habitat (HADD) as defined under the federal Fisheries Act, they are believed to have negative effects, mostly associated with the loss of area available for fish (e.g., Murphy 2001)

In the Shuswap watershed, groynes were quite significant habitat modifications. Construction of these features was most often accomplished by utilizing local lake bed substrates. Removal of these substrates to groynes has resulted in significant impacts including loss of emergent vegetation zones, sediment deposition in shore spawning sockeye areas, destabilization of shoreline susbtrates, etc. Migration of juvenile fish may also be affected by groynes. Although not as well understood, it is probable that these structures are forcing migrating juveniles to deeper water zones where they are more susceptible to predation.

Boat Launches

Boat launches were considered to be a negative parameter within the AHI. Boat launches are typically constructed of concrete that extends below the high water level. The imperviousness of this material results in a permanent loss of habitat, which ultimately reduces habitat quality and quantity for fish. Concrete does not allow growth of aquatic macrophytes, and reduces foraging and/or refuge areas for small fish and macroinvertebrates. The extent of the potential effects of boat launches relates to their size. Thus, multiple lane boat launches tend to have a large effect on fish habitat than smaller launches with fewer lanes because there is more surface area affected. The AHI treated each different boat launch lane as one unit, and therefore one launch could have multiple boat ramps. The intent of using the data in this fashion was to incorporate the size of the structure (i.e., more ramps, decrease in available habitat).

Other impacts o boat launches include prop scour of substrates in shallow water launches.

Marinas

Marinas are a concentration of boat slips, offering a place of safety to vessels. Marinas likely have a variety of effects, but there is very little literature investigating the positive or negative habitat consequences of marinas. Large marinas also tend to have breakwaters, which can further affect wave action, sediment scour and deposition, and circulation. In general, when marinas are constructed in the littoral zone there tends to be a large increase in shading, which reduces the potential for aquatic macrophyte growth and therefore reduces the productivity of a particular shoreline area. Also, marinas tend to have other activities associated with them, including extensive boat movements, which can reduce the use of an area by more timid species (e.g., rainbow trout). Other activities in marinas include fuelling stations, boat cleaning, bilge water, and sanitary waste disposal stations. Each of these activities has the potential to alter benthic communities, possibility altering the fish assemblage (i.e., congregations of more tolerant species and displacement of less tolerant species) and potential resulting in a loss in biodiversity, which can ultimately affect fish and/or fish habitat. Marinas also tend to be associated with other high intensity land developments, which may have a variety of effects including reducing water quality through inputs of chemicals, etc., increases in water turbidity, reduction in oxygen concentration, etc.

The above were common modifications that were observed that could be easily quantified and added to the habitat index. There were numerous other observations around the lakes, which could not be easily quantified to be included in the AHI. Examples of these different features include log handling areas, fill from transportation corridors, sand importation, proliferation or moorage buoys / anchors etc. These features, once more accurate information has been gathered, could be added to the AHI.

4.2 Index Ranking Methodology

The AHI was used to analyze the relative habitat value of a segment to those compared around the different lakes assessed. The output of the index is a five class ranking system, ranging from Very Low to Very High. Two different runs of the index were completed as follows:

1. Current Value (AHI_CUR) – This is the current index value for each shore segment based upon the total biophysical, riparian, fisheries, and modifications present.

2. Potential Value (AHI_POT) – This is the value of habitat index when the modifications are removed. It is the total value based upon the biophysical, riparian, and fisheries parameters only. This highlights segments where restoration is possible and would have the most potential benefit.

4.2.1 Calculating the Index

The AHI consists of a variety of parameters and each parameter has a range in potential scores based upon the physical properties of each shore segment. The table above, containing the logic contains the maximum score possible for a particular habitat parameter. To calculate the index score, the score for a shore segment was applied based upon the physical characteristics in the FIM database for that segment. Weighted averages were used where possible to most accurately evaluate the score. Once the scores had been assigned to all parameters, the total score for each different category 1)Biophysical, 2) Fisheries, 3) Shoreline Vegetation; and, 4) Modifications, were summated for each segment. The total habitat value for each shoreline segment included all positive and all negative index parameters.

The output of the AHI is a five class ranking system, ranging from very low to very high. This ranking reflects the current value of the shoreline. To calibrate the index, numerous iterations were run (i.e., the index was run at least 50 times). For each iteration of the index, the minimum, maximum, median, and distribution of scores was reviewed. After reviewing the distribution of the data from the iterations, logical score breaks were used to determine the category for Very High, High, Moderate, and Low. These breaks were made because of the clustering of scores in the middle, with a few outliers. Ultimately, the value of habitat is a continuum, and there is room for some interpretation of this information. Further review, addition, and improvements to the index are encouraged and this database has been designed to allow inclusion and update of information. The ultimate purpose of the index is to act as a flagging tool.

5.0 DATA ANALYSIS

5.1 General

General data analysis and review was completed for the FIM database. Data collected was reviewed and analysis focused on shore segment length. Analyses for this project were generally completed as follows:

1. The shoreline length for the shore segment was determined using GIS and added to the FIM database;

2. For each category, the analysis used the percentage natural or disturbed field to determine the approximate shoreline segment length that was either natural or disturbed. This was done on a segment by segment basis. In some cases, the percentage natural or disturbed was reported because it made comparison easier than comparing shoreline lengths.

The above summarizes the general analysis approach. The following sections provide specific details for the biophysical analyses.

5.2 Biophysical Characteristics and Modifications Analysis

Biophysical characteristics of the shoreline segments were analyzed. For definitions of the different categories discussed below, please refer to Appendix A (Detailed Methods) for a description / definition. The following summarizes the different analyses that were completed:

1. The total shoreline length that remains natural or has been disturbed was determined for the entire area surveyed including Shuswap Lake, Mara Lake, and Little Shuswap / River;
2. The total shoreline length that remained natural or has been disturbed was determined for each different lake or arm of Shuswap, Mara, and Little Shuswap / River;
3. The *percentage* of natural shoreline length or shoreline disturbed was determined for each different jurisdiction found around the lake. For more information regarding jurisdictions, please see the sections below. Percentage was used for this analysis because the shoreline lengths in some jurisdictions were small when compared to others. Thus, by using percentage, direct comparisons between jurisdictions could be made.
4. The total shoreline length that remains natural of has been disturbed was determined for each different land use category;
5. The total shoreline length that remained natural or has been disturbed was determined for each different shore type category.
6. The total length of shoreline that contained aquatic vegetation, emergent vegetation, floating vegetation, or submergent vegetation was presented.\
7. The total number of different modifications collected is presented. This data represents point counts taken during the survey and is reported for groynes, docks, retaining walls, marinas, marine rails, and boat launches.
8. The total shoreline length of different shoreline modifiers (railways, roadways, substrate modification, and retaining walls) was determined for the entire lake.

5.3 Jurisdictions and Communities Analysis

The jurisdictional /community analysis was completed for communities that occur around Shuswap Lake, Mara Lake, Little River, and Little Shuswap Lakes. The following provides definitions for Jurisdiction and Community:

- Jurisdiction - The jurisdiction field identifies the governmental entity that has governance along the shore segment. Typically, this would be a local government, regional district or first nations band/reserve. In some cases, the shoreline may occur along crown land or within a provincial park. This information was obtained from the Land and Data Warehouse of British Columbia and Columbia Shuswap Regional District.

- Community – Communities for the Shuswap and Mara Lake FIM assessment are community areas that are commonly referred to or referenced. These areas may correspond to groupings of first nation's lands, rural community areas, or regions under municipal governance. The community boundaries were provided by the Columbia Shuswap Regional District and are mapping areas that they use for land use planning purposes. These areas may not necessarily reflect any particular governing body.

A general jurisdictional analysis was completed for this project but detailed summaries for each jurisdiction were not compiled. It should be noted that the predominant jurisdiction is recorded in the FIM database. The community analyses completed were generally the same as those described above. In the community analysis, all segments and portions thereof were analyzed (i.e., if Segment 32 had X and Y communities, Segment 32 would be included in the community analysis for both X and Y communities).

5.4 Aquatic Habitat Index Analysis

A brief summary of the shoreline lengths, shore types, and shoreline lengths is presented. The summary provides information regarding the AHI results (Very High to Very Low), shore type, percent of the shoreline and shore length.

6.0 RESULTS

The following section provides an overview analysis of Shuswap Lake system. Data is generally presented graphically in the text for ease of interpretation. Data tables for the different analyses are presented in Appendix B.

6.1 Biophysical Characteristics of the Lakes

Foreshore Inventory and Mapping was completed on 406,703 m (406.7 km) of shoreline in Shuswap Lake, Mara Lake, Little Shuswap Lake and Little River. The total length of disturbed shoreline was 173234 m (173 km), which represents 42.5% of the shoreline (Figure 4). The total length of natural shorelines was 233,469 m (233 km), which represents 57.5% of the shoreline (Figure 4).

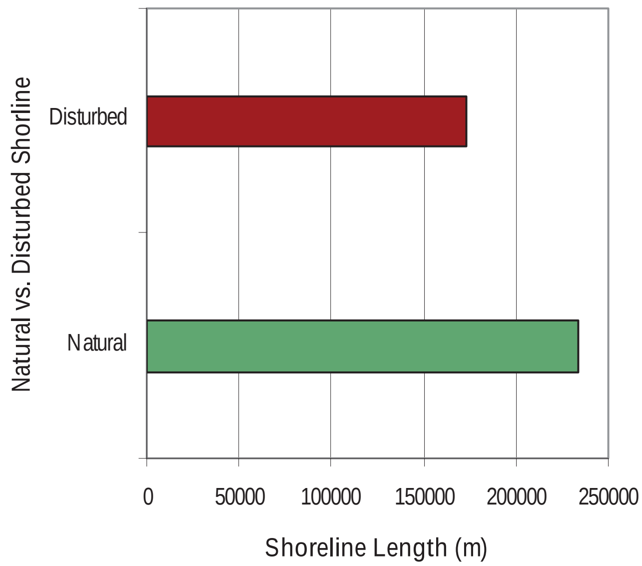

Figure 4 The total shoreline length that is either natural or disturbed on Shuswap Lake, Mara Lake, Little Shuswap Lake, and Little River.

The analysis of the different arms and narrows of the lake system indicated that those arms with more development or that were close to municipal centers tended to be more heavily impacted. Mara Lake, the main Arm of Shuswap Lake, and the Salmon Arm of Shuswap Lake are the most disturbed.

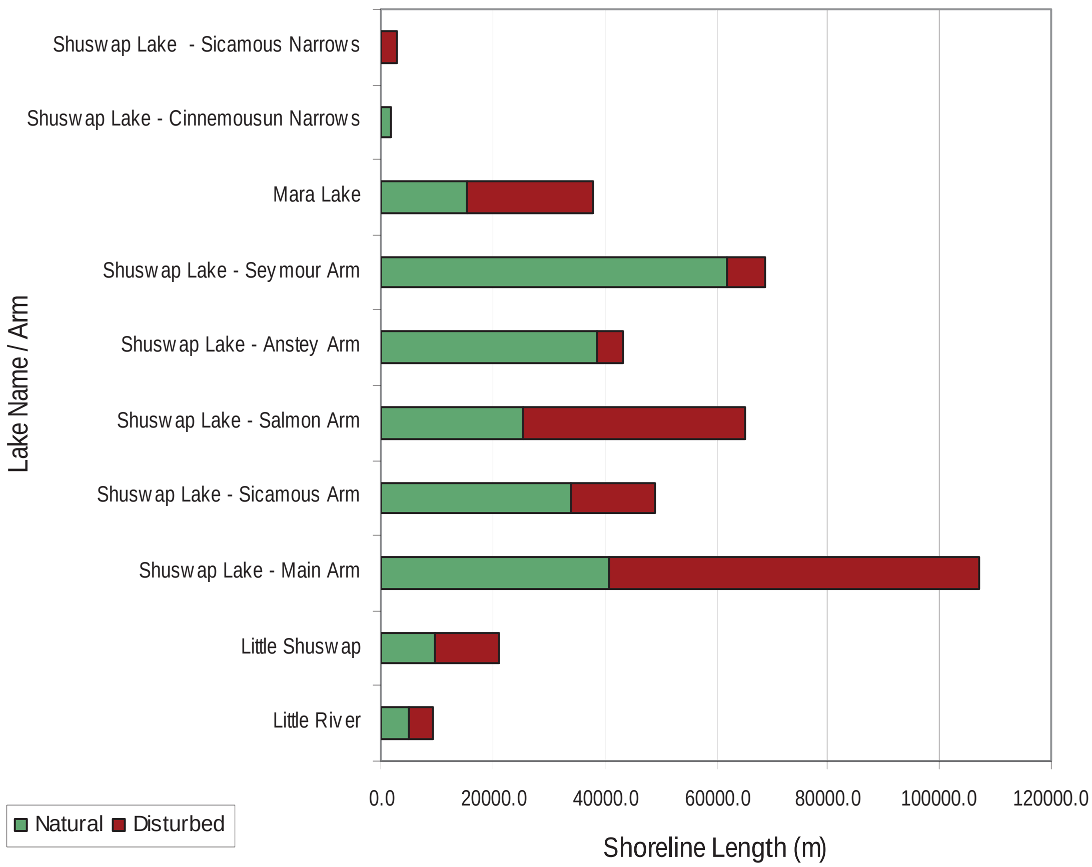

Figure 5 presents the shoreline length of natural and disturbed shorelines within the different arms of Shuswap Lake, Mara Lake, Little River, and Little Shuswap.

Data from the different municipal jurisdictions was analyzed using percentages. This was done because some jurisdictions had little shoreline length within the study area, making interpretation of graphs difficult if shoreline length was used. The high variability between jurisdictions partially relates to the proximity to major centers. At this time, over 50% of the shoreline is disturbed in over 50% of the different jurisdictions (i.e., 1 out of 2 jurisdictions is 50% impacted).

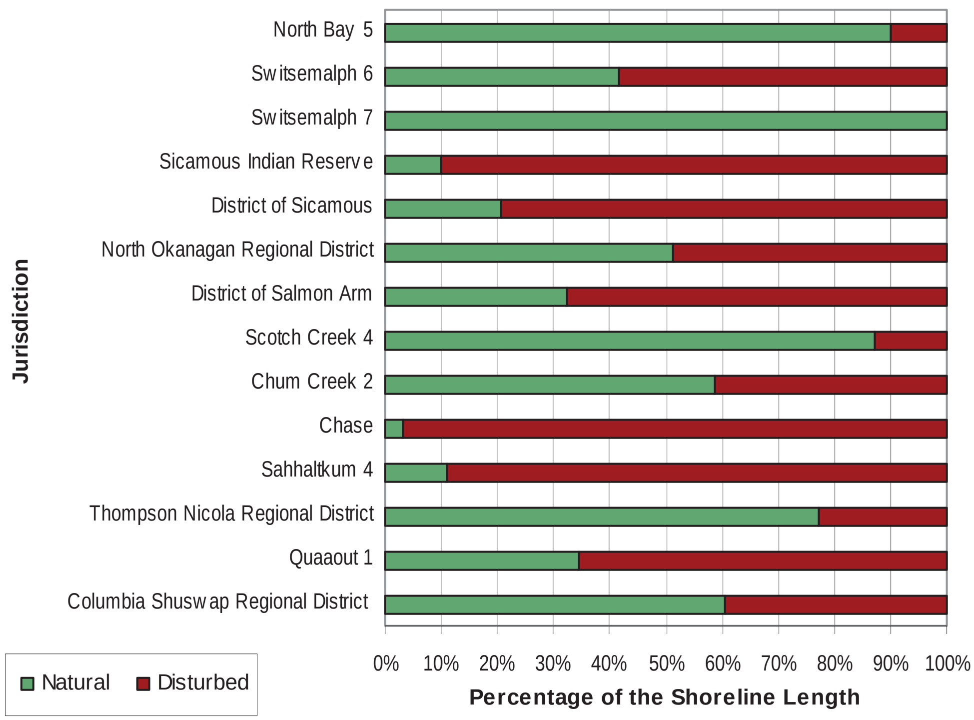

Figure 6 presents the percentage of the shoreline length that is natural or disturbed within the different jurisdictions around Shuswap Lake, Mara Lake, Little River, and Little Shuswap Lake.

Around the lakes, the largest land use type observed was natural areas which accounted for 130 km of shoreline. These natural areas along the shore zone were approximately 92.9% natural. The next most predominant land use along the shorelines was single family residential, which accounted for 21.7% of the total shoreline length or approximately 88 km of shoreline. Within the single family areas, approximately 77.3% or 68.2 km of shoreline is disturbed while only 22.7% or 20.8 km remains natural. The next most significant land use occurring around the lake was major transportation routes, followed rural areas and parks. Areas of recreational use only covered 4.2% of the shoreline, but in these areas the shoreline was 68.5% disturbed which covered 11.8 km of shoreline. Riparian impacts and substrate modification to construct groynes were the most significant impacts observed in these different areas.

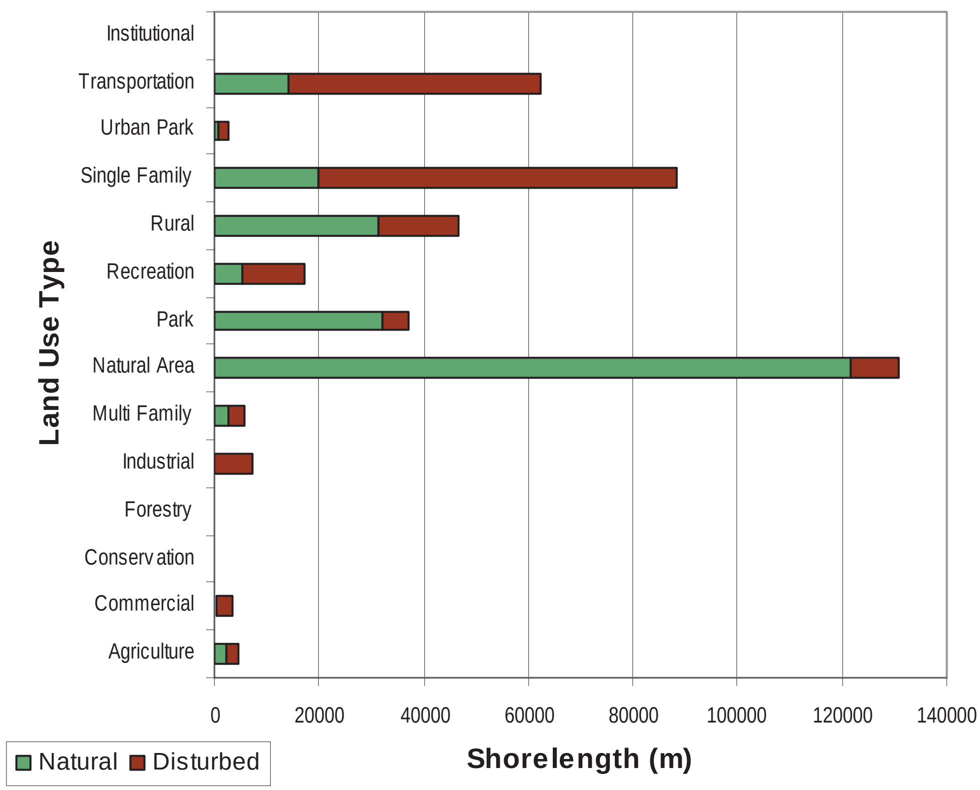

Figure 7 presents the natural and disturbed shoreline length by the different types of land us occurring around the Shuswap Lake, Mara Lake, Little River, and Little Shuswap Lake.

The most predominant shore types observed around Shuswap, Mara, and Little Shuswap areas were and gravel beaches and rocky shores, which accounted for 40% or 162.6 km and 36.7% or 149.9 km of shoreline respectively. Data was collected documenting current condition of the shoreline and it should be noted that groyne construction along rocky shorelines has created areas of gravel or sand beaches. Sand and gravel beaches and rocky shores also had the most disturbance associated with them, with each being 66.7%, 54.3%, and 31.8% disturbed respectively. Wetland shore types were not very common around the lake, and represented only 3% of the total shoreline length. Within wetland shore areas, 57.9% still remain natural (~8.6 km) and 42.1% are disturbed (~5.4 km). Stream mouths or confluences accounted for 7.0% or 28 km of the shoreline length. Within stream mouth areas, there was 69.8 % or 19.9 km of natural areas and 30.2% or 8.6 km of disturbed shoreline.

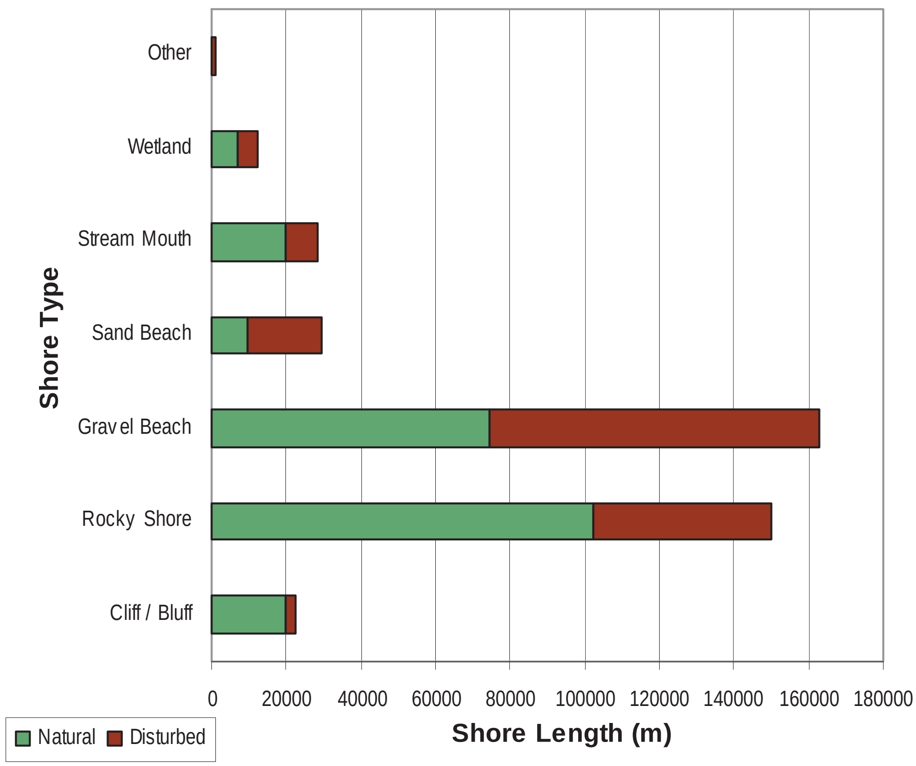

Figure 8 presents the length of natural and disturbed shoreline along each of the different shoreline types on Shuswap Lake, Mara Lake, Little River, and Little Shuswap Lake.

Aquatic vegetation is loosely defined as any type of emergent, submergent, or floating vegetation that occurred below the high water level. Thus, the aquatic vegetation field includes true aquatic macrophytes and those plants that are hydrophilic or tolerant of periods of inundation during high water level. Studies have shown that even terrestrial vegetation, during periods of inundation provides important food for juvenile salmonids and other aquatic life and this is why it has been included (Adams and Haycock, 1989). There is approximately 92 km of shoreline that has aquatic vegetation, which represents approximately 23% of the total shoreline length. The total area of both dense and sparsely vegetated areas with aquatic vegetation is 482,930 m^2. Most of the vegetation that was observed was emergent and grass like, which occurred along 21% of the shoreline or 85.3 km. Areas of native submergent vegetation and floating vegetation were very rare on these lakes and were only observed in along 2% or 8.2 km and less than 1% or 0.2 km respectively.

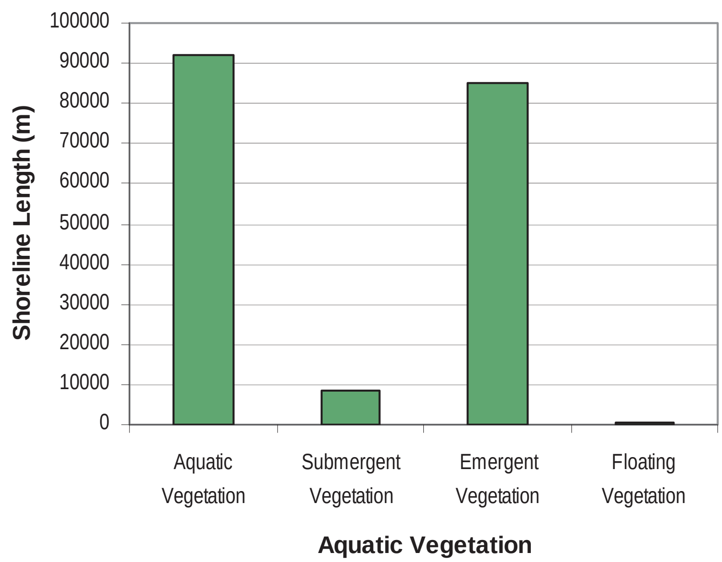

Figure 9 presents the total shoreline length that has aquatic, submergent, emergent, and floating vegetation along Shuswap Lake, Mara Lake, Little River, and Little Shuswap Lake.

Docks were the most commonly observed type of shoreline modification. There were a total of 2,795 docks observed during the assessment. Retaining walls and groynes were the next common type of modification observed and they each had 1,530 and 1,170 respectively. There are a total of 51 marinas with greater than 6 boat slips and there are a total of 200 **concrete** boat launches[3]. The above numbers highlight the significant number of different structures that occur on, over, and around the shore zone areas of Shuswap Lake, Mara Lake, Little River and Little Shuswap Lake.

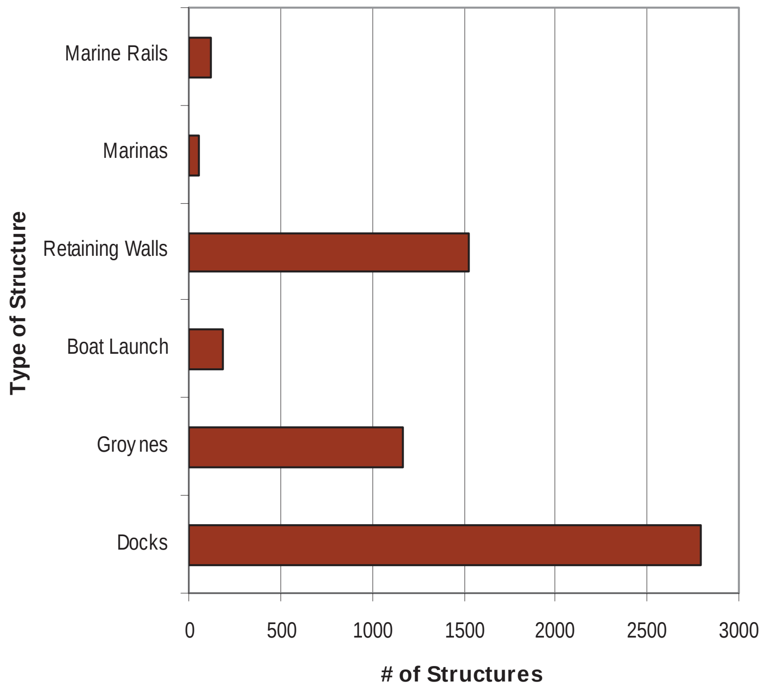

Figure 10 presents the total number of different shoreline modifications that occur around Shuswap Lake, Mara Lake, Little River, and Little Shuswap Lake.

[3] Only concrete boat launches were counted during the assessment. This total does not include gravel accesses to the lake. It is probable that there is at least an additional 50% or more vehicular accesses to the lake on private and public lands.

The percentage of the shoreline that was impacted by roads, railways, retaining walls, and where substrate modification has occurred was recorded. These estimates allowed an approximation of the total shoreline length that has been impacted by these different mechanisms (Figure 11). By far, substrate modification was the most substantial impact that was observed along the shoreline. In total, it is estimated that 25% or 101 km of shoreline has experienced substantial substrate modification. Substrate modification was variable and was most commonly associated with construction of groynes to create gravel beaches, importation of sands, or associated with road or railways (i.e., structural fill material). Retaining walls were the next most substantial impact to the shoreline and it is estimated that 13% or 52.1 km has been impacted by retaining walls. Finally, roadways and railways accounted for 7% or 27.7 km and 8% or 32.0 km of the shoreline length disturbed respectively.

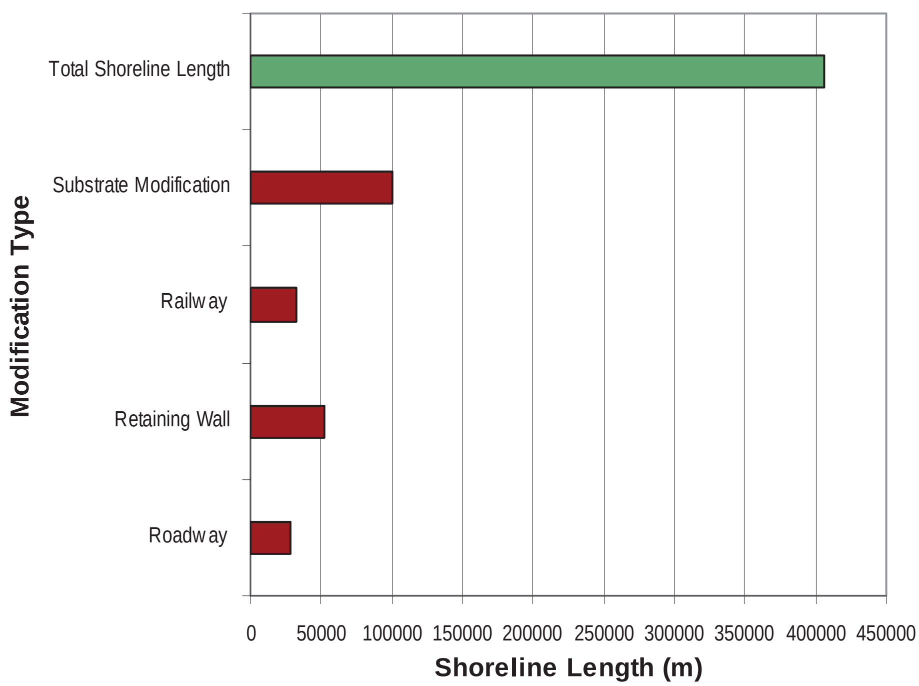

Figure 11 presents the total shoreline length that has been impacted by substrate modification, road and railways, and retaining walls along Shuswap Lake, Mara Lake, Little River, and Little Shuswap Lake.

The extensive amount of foreshore modification by these different mechanisms may seem high, but is corroborated the estimated level of impact observed. It is estimated that 42.8% of the shoreline has a high level of impact which accounts for 174 km of shoreline. Areas of moderate and low impact account for 17.4% or 70.7 km and 31.53% or 128.2 km of the shoreline respectively. There is only an estimated 33.3 km or 8.2% of shoreline that is believed to have little to no impact.

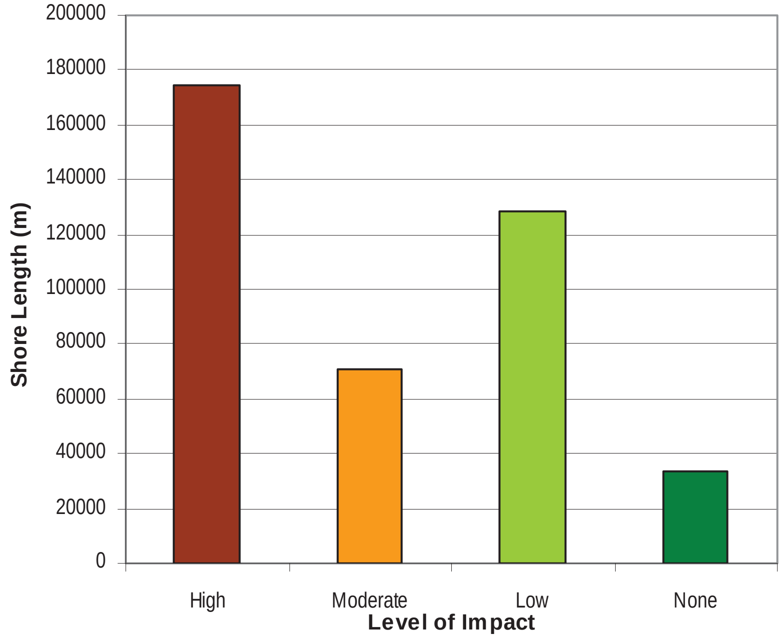

Figure 12 presents the level of impact (High, Moderate, Low, or None) observed along Shuswap Lake, Mara Lake, Little River, or Little Shuswap Lake.

6.2 Jurisdiction and Community Analysis

There was a high degree of variability between the different jurisdictions and communities around the entire system. In total, there were 24 different communities analyzed. The locations of the different communities are found in Figure 3. Appendix C contains the data tables and graphs for the different communities analyzed. Community areas closer to major centers tended to have more significant impacts than those in further settings. However, it was observed that even though many areas only contained seasonal use cabins, the shoreline development occurring mimicked single family residential development. In particular, newer developments tended to be quite large and associated with a higher degree of land clearing than older cottages that were constructed. A full written summary of the 24 different community analyses is not contained in this document to promote better readability. Readers are encouraged to review the data for particular communities of interest, as it largely reflects the general observations made in the larger overview summary above.

6.3 Summary of Foreshore Modifications

The lakeshores of Shuswap Lake, Mara Lake, Little River, and Little Shuswap are all important watercourses, containing critical wildlife (e.g., Western Grebe, Bald Eagle, etc.) and fish populations (various salmonids). The lake systems are also source drinking waters for many different local government and first nation's jurisdictions. This combination of important fish, wildlife, and water quality considerations make it extremely important to identify, manage and protect these important resources. The data collected during this assessment provides the information necessary to begin to manage these resources effectively because it provides a baseline upon which goals and objectives can be created and monitored.

The shorelines of this water system are estimated to remain 57% natural based upon the results of this survey. Seymour Arm, Sicamous Arm, Cinnemousun Narrows and Anstey Arm are the most natural areas. The remaining 43% of the shoreline has been classified as disturbed based upon the results of this assessment. Sicamous Narrows, Mara Lake, Little Shuswap, and the main Arm and Sicamous Arm of Shuswap Lake are the most impacted of the different watercourses. This is due to the proximity to the more urban centers of Sicamous, Salmon Arm, and Chase and due to access constraints in more remote areas of Seymour and Anstey Arm.

As with other shoreline studies (e.g., Okanagan Lake), lower gradient areas tended to have higher disturbance, with the exception of floodplains of the major tributaries (e.g., Adams River). The most notable disturbances that were observed were foreshore modification typically in the form of substrate alteration (e.g., boat launches or groynes) and riparian vegetation disturbance. Large scale industries, such as commercial moorages and forestry log yards, have also resulted in foreshore impacts. Despite these impacts however, many natural aquatic vegetation communities remain and many "pockets" of natural shoreline exist. Although many areas have been impacted, most of the floodplains and narrows around the lake still contain important and critical habitat features supporting important economic fish and wildlife species. These areas can be impacted by future land use decisions.

The Aquatic Habitat Index uses biophysical information to assess the relative value of a shoreline area. The AHI indicates that approximately 47.1% of the shoreline is ranked as Very High and High. Thirty eight (38%) of the shoreline length is moderate, and the remaining 15% is ranked Low and Very Low. Areas of high and very high habitat value were typically located adjacent to natural flood plain, stream mouth, or wetland areas, or were associated with gravel and rocky shorelines of higher spawning suitability for sockeye and char. Most of the lower value sites were located adjacent to sand beaches, where habitat modifications such as vegetation disturbance were typically greater.

The foreshores of Shuswap Lake, Mara Lake, Little River, and Little Shuswap have all experienced varying degrees of impacts along the shoreline. During the field surveys, numerous different observations were made and are summarized in point form below:

- The most significant impact observed below the high water level along the shorelines was the construction of groynes. The construction of groynes has resulted in the loss of aquatic vegetation (actual loss has not been determined), a loss of productivity along the shoreline, the alteration of shorelines from a rocky shore to gravel or sand beaches, has covered valuable fish habitat, has resulted in the erosion of shoreline and lake bed substrates, and has most likely resulted in reduced shore spawning success due to sedimentation impacts. In many cases, the construction of groynes required the use of heavy equipment, and in one circumstance a groyne of over 6 vertical feet with large boulders was observed. All groynes observed were constructed on crown lands below the high water level, and it is likely that many, if not all, were not permitted under the BC Water Act or Federal Fisheries Act.

- In many areas, it is apparent that aquatic vegetation[4] has been lost due to foreshore disturbance such as substrate modification. In these areas, emergent riparian vegetation (e.g., willows and cottonwoods), grasses and sedges, and other types of vegetation have all been cleared. It is believed that most of this vegetation removal is the result of beach creation (i.e., beach grooming). The losses of soil material that aquatic vegetation grows will likely take years or decades to naturally regenerate, if it does at all. In one instance, a "beach mining" operation was observed on the foreshore, which included equipment for moving substrates and gravel screeners. The continued losses of this vegetation will further impact juvenile salmonids during high water in the spring when they are known to feed upon organisms within the vegetation (Adams and Haycock, 1989).

- Riparian vegetation disturbance has changed the vegetation type from natural broadleaf or coniferous associations to landscaped, lawn, or un-vegetated associations along many shore segments. The significant losses of riparian vegetation have not been quantified as part of this assessment. There are significant opportunities for riparian habitat enhancements along the shoreline of the lakes.

- Numerous private boat launches constructed out of concrete were observed. These boat launches were almost all associated with vehicular access, which has impacted riparian vegetation. It is conservatively estimated that these boat launches have resulted in the loss of at least 2,500 m^2 of habitat around the lakes (assuming the average boat launch is 2.4 m wide and 6 m long, which is presumed to be an underestimate given the large drawdown on Shuswap Lake). It is likely that most of these boat launches were constructed without a provincial Water Act or federal Fisheries Act approval.

[4] Aquatic vegetation is defined here as any vegetation below the high water level, including shrubs, herbs, and grasses, whether they are true aquatic macrophytes (e.g.,*Potamogeton* spp.) or hydrophilic species (e.g., reed canary grass).

- Retaining wall construction around the lake was apparent in nearly all areas, even remote cottage areas. Retaining walls were constructed out of varying materials, but often time's substrates from the lakebed were used to construct the walls. Surveys during the spring at high water level were conducted and it is estimated that 746 retaining walls have been constructed below the high water level. In one observation, a retaining wall was constructed below the high water level in a newly created subdivision with a Section 2.19 restrictive no build / no disturb covenant registered to protect riparian and foreshore areas. The above example highlights that even in cases where riparian and foreshore protection mechanisms are being used, impacts are still occurring. As mentioned above, it is probable that many of the retaining walls observed have been constructed without a Water Act or Fisheries Act approval.

- Roadway and railway impacts were prevalent along many areas. In these areas, there was little evidence of bioengineering to soften constructed edges along the shoreline. However, in cases where the roadway was offset from the high water level, riparian conditions between the roadway/railway and the lakes tended to be better than those riparian areas observed in single family residential areas.

- Docks were the most commonly observed shoreline modification. However, nearly all docks observed were not constructed following best management practices which require elevated walkways on piles to floating portions in deeper water zones at low water level. In many areas, these docks were observed grounding (i.e., floating portions were not elevated at low water level), the docks were not elevated, or were left at the waters edge. Further, in many cases, the structures were so large that motorized equipment (e.g., quads, trucks, etc.) was required to pull them up on shore for winter. Although individually the impact of non compliance is small, cumulatively the impacts are noticeable (i.e., numerous grounding docks in shore spawning zones can potentially limit access to spawning areas).

- Numerous other impacts from log handling sites, boat wake erosion, abandon docks, crown land trespass, and moorage buoys were observed. However, detailed assessments and quantification of these impacts was not fully assessed.

6.4 Aquatic Habitat Index Results

The results of the Aquatic Habitat Index are best reviewed graphically. The attached Figure Binder presents the spatial results of the assessment. The figure binder has been prepared to show a summary of all the information contained within this report.

Most of the shoreline currently has Moderate Habitat Value (38%). This is followed by High Value habitat (33.8%) and Low (14%). Only 13% of the shoreline is currently estimated to have Very High value. Very Low habitat values account for only (0.7%) and this is due to the 57% of the shoreline still remains natural (see FIM results). The Very Low value sites were only documented in highly developed areas, and were typically associated with marina complexes where there was little to any resemblance to a natural shoreline area.

Table 2: Summary of the Current Value and Potential Value shoreline lengths, segments, and percentage of the shoreline for the different habitat index categories (Very High to Very Low)

Categories	Current Value			Potential Value		
	# of Segments	Shoreline Length (m)	% of Shoreline	# of Segments	Shoreline Length (m)	% of Shoreline
Very High	27	54106.2	13.3	32	58749.8	14.4
High	87	137534.6	33.8	105	157025.4	38.6
Moderate	102	155062.2	38.1	93	144115.8	35.4
Low	50	57096.4	14.0	38	45014.3	11.1
Very Low	5	2903.6	0.7	3	1797.8	0.4
Total	271	406703.1	100.0	271	406703.1	100

The Current Value of the shorelines was analyzed for each different shore type (Table 3). The analysis indicated that Very High Value shorelines occurred mostly adjacent to Stream Mouth areas or Rocky and Gravel shores. Most of the Very Low value habitat was found on sand or gravel beach areas.

The Potential Value summary presents what that habitat value would be if the modifications were removed (Table 4). This analysis highlights areas where restoration may result in a benefit. It is important to note that this analysis does not consider riparian improvements. Riparian improvements would also likely to result in habitat improvements. In general, there was a shift from very low upwards. Subsequent analysis may help better interpret where restoration may be more feasible and result in the most improvement.

The following segments have potential for restoration:

> 10-11,51-53,62,80,114,116,118-120,123,129,136,139,141,144,146,153,156-157,174,178,184,190,193,195,197,199,202-203,205,207-209,217,219,228,230,233,251-252, and 257.

Table 3: Summary of the Aquatic Habitat Index results for the different shoretypes for the Current Value of the Shoreline.

Categories	Current Value			Cliff / Bluff		Rocky		Gravel		Sand2		Stream Mouth		Wetland		Other	
	# of Segments	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline
Very High	27	54106.2	13.3	379.0	0.7	11536.8	21.3	14742.4	27.2	0.0	0.0	26966.8	49.8	481.3	0.9	0.0	0.0
High	87	137534.6	33.8	1715.1	1.2	55677.1	40.5	55803.4	40.6	2966.0	2.2	11531.4	8.4	9841.6	7.2	0.0	0.0
Moderate	102	155062.2	38.1	13166.1	8.5	65446.3	42.2	59324.5	38.3	7881.7	5.1	3238.8	2.1	5662.8	3.7	342.0	0.2
Low	50	57096.4	14.0	7221.5	12.6	14998.7	26.3	22143.6	38.8	7537.0	13.2	2679.6	4.7	694.7	1.2	1821.3	3.2
Very Low	5	2903.6	0.7	0.0	0.0	0.0	0.0	82.0	2.8	2637.9	90.8	0.0	0.0	0.0	0.0	183.7	6.3

Table 3: Summary of the Aquatic Habitat Index results for the different shoretypes for the Potential Value of the Shoreline.

Categories	Potential Value			Cliff / Bluff		Rocky		Gravel		Sand2		Stream Mouth		Wetland		Other	
	# of Segments	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline
Very High	32	54106.2	13.3	0.0	0.0	11728.3	21.7	16441.5	30.4	925.1	1.7	28159.1	52.0	1116.7	2.1	0.0	0.0
High	105	137534.6	33.8	2082.3	1.5	60636.2	44.1	71388.0	51.9	2040.9	1.5	11460.8	8.3	9206.2	6.7	211.1	0.2
Moderate	93	155062.2	38.1	12868.2	8.3	63714.3	41.1	49566.5	32.0	8326.0	5.4	3847.1	2.5	5662.8	3.7	130.9	0.1
Low	38	57096.4	14.0	7152.2	12.5	11580.2	20.3	14617.9	25.6	8198.4	14.4	949.6	1.7	694.7	1.2	1821.3	3.2
Very Low	3	2903.6	0.7	0.0	0.0	0.0	0.0	82.0	2.8	1532.1	52.8	0.0	0.0	0.0	0.0	183.7	6.3

7.0 RECOMMENDATIONS

7.1 Foreshore Protection

The following provides a list of recommendations for foreshore protection. Some of the recommendations below are similar to other recent FIM reports (e.g.., Schleppe and Arsenault, 2006). In cases of similarity, credit to the work should be given to the original authors. The following are recommendations for development of foreshore protection policies:

1. **Environmentally Sensitive Areas should be identified because they are extremely important**. For instance, The City of Kelowna has just recently completed a review of environmental development permit areas (EDP's) and has added over 400 properties to an EDP list for a variety of reasons. As the example above portrays, keeping environmental development permit areas up to date is important. EDP's are most accurately determined by appropriate inventory work such as the FIM, Sensitive Ecosystem Inventory (SEI, see below) and SHIM. It is recommended that areas that have been determined as environmentally sensitive be added to the Development Permit Areas within any policy documents applicable (e.g., OCP, Bylaws, etc.). It is important that addition of new inventory data be simple and easy to implement because the budgetary constraints for inventory often result in projects being completed over a series of years as data is collected. *All aquatic areas identified in this report should be designated as development permit areas.*

2. **Environmentally sensitive areas should be included in Official Community Plans, Bylaws, and policy documents within the different agencies.** The AHI provides a basis for identification of shoreline environmentally sensitive areas. It is possible to incorporate the AHI into OCP documents in a variety of ways. The following provides on example of how the AHI can be incorporated:

    - Very High and High Value Areas –These areas are considered to be the most valuable areas of the shoreline and comprise approximately 47% of the shoreline. Intensive development along these areas is strongly discouraged because it is likely very difficult to mitigate for potential impacts and not likely possible to compensate for losses to these habitat areas. An explicit terms of reference (mentioned below) for proposed significant changes in land use (i.e., large subdivisions) should be developed. If possible, an inter agency approach and terms of reference would streamline the referral and review process.

- In all other areas, a guidance document highlighting the risk of possible activities and a standard referral process should be prepared. This referral process would highlight different proposed activities, their risks, and associated permitting processes. Inter agency cooperation in the development of this risk document would facilitate a more streamlined and effective referral process. The Foreshore Development Interagency Technical Committee (FDITC), through SLIPP, will be meeting to discuss mechanisms to address these recommendations.

At this time, it is strongly encouraged that the Shoreline Management Guidelines (Step 3) be developed. These guidelines will ease integration into Official Community Plans because it uses a risk based approach that will aid local governments, and provincial and federal agencies with shoreline management.

3. **A standard terms of reference for professional reports should be developed for environmental assessments of development applications.** This document will ensure consistency in environmental reporting across agencies and jurisdictions. The Regional District Central Okanagan, City of Kelowna, and other Okanagan Valley municipalities have well developed terms of reference that could be used as templates. The Terms of Reference will outline professional requirements for assessments in the region and provide a list of considerations that environmental professionals must address as part of a development application. Site specific assessments are a critical component of a development permit process because every proposal is unique and the Terms of Reference will help address the uniqueness of different areas. The inventories and data within this document should be provided as part of the terms of reference (i.e., the GIS data, air photos, and other biological information contained in this report should be provided)

4. **Habitat restoration opportunities should be achieved wherever possible by identifying them during the development review processes.** In highly urbanized areas, examples include dismantling of groynes, placement of large woody debris, live staking and re-vegetating shoreline regions, riparian restoration, etc. It may be useful to identify the potential for restoration opportunities in the standard terms of reference discussed above. There is significant opportunity for partnerships (i.e., multi agency partnerships with stewardship groups) to be formed to help facilitate habitat restoration around the lakes.

5. **The Sicamous Narrows region is a unique ecosystem feature that has very high fisheries values. Specific management objectives developed by the Ministry of Environment that should be used to direct activities in this area.**

6. **Core habitat areas are extremely important to maintain and should be identified as early as possible in the development process.** Detailed assessments and identification of core habitat areas for conservation should be done as early in the development process as possible. Numerous different possibilities exist for areas identified as sensitive, including Section 2.19 No Build / No Disturb Covenants, creation of Natural Areas Zoning bylaws (i.e., split zoning on a property), or by other mechanisms (donation to trust, etc.).

7. **Environmental information collected during this survey should be available to all stakeholders, relevant agencies, and the general public.** Environmental information, including GIS information and air photos are an extremely important part of the environmental review process. This information should be available to the public, including all air photos, GIS files, and other electronic documents. One agency should take the lead role in data management and any significant studies that add to this data set should be incorporated and updated accordingly.

8. **An Environmental Advisory Commission or other suitable body should be created and be included in the development review process to involve local residents.** The Regional District of Central Okanagan has created an Environmental Advisory Commission, which functions similar to an Advisory Planning Commission. The commission was created based upon the belief that local residents should contribute to the stewardship of their natural resources. In the CSRD, the SLIPP process has incorporated both political and resident representatives. This may provide an avenue to address the environmental concerns of residents and act as an advising committee to relevant stakeholders and governmental agencies.

9. **Development and use of best practices for construction of bioengineered retaining walls is required.** Bioengineering has many different meanings. Concise guidelines and best management practices should be developed that is consistent with standard practices of bioengineering.

10. **A study that investigates the impacts of docks on shore spawning fish should be completed to address best construction practices for docks.** To better understand the cumulative impacts of docks on fish and fish habitat, agencies should consider conducting a study of the interaction of docks and sockeye and / or char spawning behavior. A similarly initiative was completed with Kokanee on Okanagan Lake and this study is still underway. The timing of this study needs to coincide with a dominate cycle which will occur again in 2010, to ensure that there are sufficient numbers of fish to assess impacts.

11. **A communication and outreach strategy should be developed to inform stakeholders and the public of the findings of this study and improve stewardship & compliance**. Initially, it is recommended that notice of the availability of this report and associated products are available on the Community Mapping Network. The information should be forwarded to the Shuswap Lake Integrated Planning Process, local First Nations, Integrated Land Management Branch, Ministry of Environment, Transport Canada, Indian and Northern Affairs Canada, City of Salmon Arm, Village of Chase, Village of Sicamous, Okanagan Regional District, Shuswap Lake lease holders associations and local stewardship groups.

12. **The Shuswap Lake Integrated Planning Process (SLIPP) should pursue funding to complete Step 3 which is the development of "Shoreline Management Guidance Documents"**. These documents are intended to help land managers at all levels of government quickly assess applications and is intended to be the first step for review, planning, and prescribing shoreline alterations (i.e., land development) by applicants and review agencies. Typically, this document creates a risk based approach that is easily interpreted and used by all stakeholders, applicants, and government agencies.

13. **Lake shore erosion hazard mapping should be conducted for private lands to identify areas at risk, which will stream line the review process and reverse the damaging trend of unnecessary hard armoring and construction of retaining walls along the shoreline of the lakes.** Also, this methodology would be helpful to identify areas that are sensitive to boat wake erosion. The province has formalized methodology for lakeshore hazard mapping and this methodology, or some adaptation of it, would be preferred (Guthrie and Law, 2005). This mapping should be integrated with the FIM data, and be completed for each segment. Flooding, terrain stability, alluvial fan hazard mapping should also be considered for developing areas along the lakeshore. Until lakeshore erosion hazard mapping is completed, it is advisable to only consider shoreline protection works on sites with demonstrated shoreline erosion. To accomplish this, an engineers or biologists report should accompany proposal for shoreline armoring to ensure that works are required, minimize impacts and use bioengineering techniques.

14. **Storm water management plans should be included in all development applications that alter the natural drainage patterns.** It appears that development along the lakeshore has been occurring without the benefit of comprehensive storm water management plans, which has resulted in small streams being diverted and discharge locations to the lake being relocated. This can result in erosion of non condition foreshores and impacts to shore spawning areas. It is recommended that storm water management plans be required as part of development processes.

15. **Local, provincial, and federal governments should only approve proposed developments with net neutral or net positive effects for biophysical resources, if feasible.**

16. **Developments that have "significant" adverse effects to any biophysical resource (e.g., spawning areas) should not be approved on the basis that compensatory habitat works may offset such effects, if feasible.**

17. **Compensatory works resulting from projects or portions of projects that could not be avoided must follow the DFO Decision Framework for the Determination and Authorization of Harmful Alteration, Disruption or Destruction of Fish Habitat and be consistent with the "No Net Loss" guiding principle of The Department of Fisheries and Oceans Policy for the Management of Fish Habitat.**

18. **Habitat enhancements should not be considered in cases where incomplete or ineffective mitigation is proposed. Habitat enhancement should only be considered when effective mitigation efforts are feasible (e.g., avoidance) and a strong business case proving mitigation feasibility has been prepared.**

19. **Habitat mitigation and compensatory efforts of biophysical resources should occur prior to, or as a condition of any approval of shoreline-altering projects.** To ensure that works are completed, estimates to complete the works and bonding amounts should be collected. These bonds will ensure performance objectives for the proposed works are met and that efforts are constructed to an acceptable standard.

20. **Development of land use alteration proposals should only be accepted if the compromises or trade-offs will result in substantial, long-term net positive production benefits for biophysical resources.**

21. **Low impact recreational pursuits (biking, non motorized boating, etc.), pedestrian traffic and interpretive opportunities should be encouraged**. These activities should be directed to less sensitive areas, and risks to biophysical resources should be considered. Only activities that will not diminish the productive capacity of biophysical resources should be considered.

7.2 Future Data Management

Future data management is extremely important. In our review, substantial information is available for the Shuswap system. This assessment has integrated much of it into one concise GIS dataset. However, future works will be conducted and they should be integrated into this data wherever possible. The following are recommendations for future use of the FIM dataset:

1. **One agency should take the lead role in data management and upkeep**. This agency should be responsible for holding the "master data set". Although the data may be available for download from numerous locations, one agency should be tasked with keeping the master copy for reference purposes.

2. **A summary column(s) should be added to FIM GIS dataset that flags new GIS datasets as they become available.** Examples of this include new location maps for rare species, fish, etc. Other examples include the addition of appropriate wildlife data. Where feasible, these new data sets should reference the shore segment number (see below).

3. **The Segment Number is the unique identifier. Any new shoreline information that is provided should reference and be linked to the shore segment number.**

7.3 Future Inventory and Data Collection

The following are recommendations for future biophysical inventory that will help facilitate environmental considerations in land use planning decisions:

1. **The Sensitive Habitat Inventory and Mapping (SHIM) is a GIS based stream mapping protocol that provides substantial information regarding streams and watercourses and should be conducted on all watercourses around the lake**. Mapping should focus on our significant salmonid rivers and streams first, and then one smaller tributaries containing resident fish habitat, followed by non fish bearing waters. This mapping protocol provides useful information for fisheries and wildlife managers, municipal engineering departments (e.g., engineering staff responsible for drainage), and others. This information is also extremely useful for Source Water Protection initiatives because it identifies potential contaminant sources in an inventory.

2. **Wetlands are extremely productive and important components of our ecosystems and these features should be inventoried**. Numerous low flood and mid flood benches and shore marshes were mapped during this survey. Detailed Wetland Inventory and Mapping (WIM) of these features are recommended. Detailed mapping of terrestrial wetlands is also important to ensure that linkages between foreshore and upland areas are achieved.

3. **Sensitive Ecosystem and Inventory (SEI) and Terrestrial Ecosystem Mapping (TEM) are useful terrestrial mapping tools and these inventories should be completed**. These assessments help land managers identify sensitive terrestrial zones which can be integrated into the FIM, SHIM, and WIM GIS datasets.

4. **An inventory of high value habitat islands in urbanized areas should be conducted.** In many cases, small sections of higher habitat quality were observed in segments ranked Moderate to Low. These areas were typically areas that had well-established native vegetation or relatively natural shorelines. Development applications proposed in these "islands" of higher habitat quality should avoid disturbance to these "islands" as much as possible. A survey of these small "islands" would clarify which segments contain "islands" and would help aid planning objectives. This could form part of a riparian mapping exercise.

5. **A carrying capacity analysis of the lake should be completed.** Biological systems are extremely difficult to predict and manage. Currently, these fish and wildlife ecosystems are experiencing rapid changes due to a variety of factors including but not limited to land development (e.g., water consumption may be exceeding the capacity of some streams, etc.) and climate change. At this point, it appears that the significant biological resources around the lake are maintaining viable populations. Determining the threshold upon which cumulative effects will have measurable and noticeable impacts is very difficult and therefore a conservative approach is required. The Carrying Capacity of a lake is defined as the point where a lakes ability to accommodate recreational use (e.g., boating) and residential occupation without compromising adjacent upland areas, biological resources, aesthetic values, safety, and other factors. Determining carrying capacities on our large, interior lake systems is currently one of the most significant challenges to lakeshore management because it impacts many cultural, social, and environmental values of residents.

6. **A survey, on a home by home basis, should be conducted to help educate home owners.** A home owner report card could be prepared that would provide land owners with a review of the current condition of their properties. The assessment should provide them with sufficient information to help land owners work towards improving habitats on their property. This assessment is not intended to single out individual owners, but rather to help owners understand the important habitat values present on their properties.

7. **The addition of additional or new segment breaks in long segments should be assessed in the future.** Some segments, predominantly in more natural areas, are quite long. Future mapping updates may wish to assess some new segment breaks on longer segments as more information is collected. Features should be considered as part of more detailed segment mapping include the locations of small tributaries, seepages, streams in natural areas, etc.

8. **Native beds of submergent and floating vegetation should be mapped in detail.** Native beds of submergent and floating vegetation were extremely rare on these lakes. More detailed mapping, maybe as part of a Wetland Inventory and Mapping project, would help better classify and described these rare, sensitive features. A good example of these communities is located in Segments 93 and 84

8.0 CONCLUSIONS

The following report has documented the current condition of 406 km of shoreline in Shuswap Lake, Mara Lake, Little Shuswap Lake and Little River. The assessment provides substantial background information summarizing the current condition of the upland and terrestrial zones and foreshores of these lakes. An Aquatic Habitat Index (AHI) was developed that used biophysical information collected during the survey to rank the relative environmental sensitivity of the shore zone areas around the lakes. Recommendations are presented to help integrate this information into local land use planning initiatives.

There is approximately 57% of the shoreline that remains in natural conditions, representing approximately 233 km of shoreline. In total, 13.3% of the shoreline is ranked as Very High Value and these very high habitat value areas tended to occur on either stream confluences or their associated floodplains, or on gravel and rocky shores with suitable spawning. Approximately 14.7% is ranked as low and very low value and these areas tended to be on low gradient gravel and sand areas that have been substantially impacted. Most of the habitats around the shoreline are ranked as having moderate aquatic sensitivity.

The most notable shoreline modifications that were observed were retaining walls and groynes. In total, approximately 25% of the shoreline has had substantial substrate modification from groynes, beach grooming and importation of sand, or construction of retaining walls. These impacts, along with riparian vegetation disturbance, are considered the most significant impact impacts observed around the lake.

REFERENCES

Adams, M.A., and R. Haycock. 1989. Shuswap Lake Mointoring Program. Completed by ECL Envirowest Consultants Ltd. Prepared for: Fisheries and Oceans Canada. Draft Report.

Bison and Associates, 1991. Population and Habitat Characteristics for Spawning Lake Char (*Salvelinus namaycush*) in Shuswap lake. Prepared for Ministry of Environment.

Carrasquero, J. 2001. Overwater Structures: Freshwater Issues. Prepared by: Herrera Environmental Consultants. Prepared for: Washington Department of Fish and Wildlife. April 12, 2001.

DFO, 1995. Salmon Escapement Data System. Unpublished data.

Graham, C.C., and L.R. Russell. 1979. An Investigation of Juvenile Salmonid Utilization of the Delta-Lakefront Areas of the Adams River, Shuswap Lake. Fisheries and Marine Service Report 1508. April 1979. Fisheries and Oceans Canada.

Guthrie, R.H., and P.D. Law. 2005. Lakeshore Erosion Hazard Mapping. B.C. Ministry of Environment, Nanaimo, BC. Technical Handbook No. TH1. 30 pp.

Kahler, T, M. Grassley, D. Beauchamp. 2000. A summary of the effects of bulkheads, piers, and other artificial structures and shore zone development on ESA-listed salmonids in Lakes. Prepared for: City of Bellevue, WA. Prepared by: Tom Kahler, The Watershed Company Kirkland, WA.

Mason, B. and J. Booth. 2004.Coastal Shoreline Inventory and Mapping. Community Mapping Network. Vancouver, BC.

Magnan, B. and T. Cashin. 2004. Regional District of Central Okanagan, 2005. Okanagan Lake Foreshore Inventory and Mapping:. Kelowna, BC.

Mason, B., and R. Knight. 2001. Sensitive Habitat Inventory and Mapping. Community Mapping Network, Vancouver, British Columbia. 315pp + viii. M. Johannes, Editor.

Mackenzie, W.H., and Jennifer Moran. 2004. Wetlands of British Columbia - A guide to identification. British Columbia Ministry of Forests, Forests Science Program. 287pp.

McPherson S. and D. Hlushak. 2008. Windermere Lake Fisheries and Wildlife Habitat Assessment. Consultant report prepared for the East Kootenay Integrated Lake Management Partnership. Prepared by Interior Reforestation Co. Ltd., Cranbrook, BC.

MoE, 1998. Field Manual for Describing Terrestrial Ecosystems. BC Ministry of Environment, Lands, and Parks and BC Ministry of Forests. Land Management Handbook 25.

MWLAP, 1994. Unpublished data.

MWLAP, 1995. Unpublished data.

Murphy, S.M. 2001. Development and Assessment of the Effectiveness of Fish Habitat Compensation Plans for infilling projects on Georgian Bay and Lake Simcoe, Ontario. Research and Development Monograph Series, 2001. Prepared by: Azimuth Environmental Consulting Inc.

Piaskoski, R.M., and R.A. Tabor. 2001. Nocturnal habitat use by juvenile Chinook salmon in nearshore areas of southern Lake Washington. U.S. Fish and Wildlife Service. Lacey, Washington.

Russell, L.R., C.C. Graham, A.G. Sewid, D.M. Archibald. 1981. Distribution of Juvenile Chinook, Coho, and Sockeye Salmon in Shuswap Lake – 1978 – 1979; Biophysical Inventory of Littoral Areas of Shuswap Lake 1978. Fisheries and Marine Service Manuscript Report No. 1479. Fisheries and Oceans Canada.

Schleppe, J. and D. Arsenault. 2006. The Kelowna Shore Zone Fisheries and Wildlife Habitat Assessment. EBA Consulting Engineers and Scientists. Project File: 0808-8840209. March 2006. Prepared for the City of Kelowna.

RIC. 2001. Reconnaissance Fish and Fish Habitat Inventory: Standards and Procedures. Prepared by: BC Fisheries Information Services Branch. Prepared for: Resources Inventory Committee.

Williams, I.V., T. Gjernes, R. Johnson, W. Saito. 1989. Juvenile sockeye lacustrine population dynamics. In: Studies of the Lacustrine Biology of the Sockeye Salmon (*Oncorhynchus nerka*) in the Shuswap System. International Pacific Salmon Fisheries Commission. Bulletin XXIV. Vancouver, BC. Canada.

GLOSSARY OF TERMS AND ACRONYMS

Alluvial Fan / Stream Mouth– Alluvial fans are considered to be areas where a stream has the potential to have a direct active influence (e.g., sediment deposition or channel alignment changes) on the lake.

Allocthonous Inputs - Organic material (e.g., leaf litter) reaching an aquatic community from a terrestrial community

Anadromous – Anadromous fish as sea run fish, such as Coho, Chinook, and Sockeye salmon.

Aquatic Habitat Index (AHI)-The index is a ranking system based upon the biophysical attributes of different shoreline types. The index consists of parameters such as shore type, substrate type, presence of retaining walls, marinas, etc. to determine the relative habitat value based upon a mathematical relationship between the parameters.

Aquatic Vegetation – Aquatic vegetation consists of any type of plant life that occurs below the high water level. In some instances, aquatic vegetation can refer to grasses and sedges that are only submerged for short periods of time.

Biophysical – Refers to the living and non-living components and processes of the ecosphere. Biophysical attributes are the biological and physical components of an ecosystem such as substrate type, water depth, presence of aquatic vegetation, etc.

Best Management Practice (BMP) - Is a method or means by which natural resources are protected during development or construction. For example, the Ministry of Environment have been recently creating documents containing guidelines for work in and around water.

Emergent Vegetation - Emergent vegetation includes species such as cattails, bulrushes, varies sedges, willow and cottonwood on floodplains, grasses, etc. Emergent vegetation is most commonly associated with wetlands, but is also occurs on rocky or gravel shorelines.

Fisheries and Oceans Canada (DFO) – Federal agency responsible for management of fish habitats

Fisheries Productivity - The maximum natural capability of habitats to produce healthy fish, safe for human consumption, or to support or produce aquatic organisms upon which fish depend.

Floating Vegetation - Floating vegetation includes species such as pond lilies and native pondweeds with a floating component.

Foreshore – The foreshore is the area that occurs between the high and low water marks on a lake.

Foreshore Inventory Mapping (FIM)-FIM is methodology used to collect and document fish and riparian habitats lake corridors and was performed by the Regional District of Central Okanagan and partners. A full discussion of this mapping can be found in Regional District of Central Okanagan (2005)

Georeferencing - Georeferencing establishes the relationship between page coordinates on a planar map (i.e., paper space) and known real-world coordinates (i.e., real world location)

Groyne – A protective structure constructed of wood, rock, concrete or other materials that is used to stop sediments from shifting along a beach. Groynes are generally constructed perpendicular to the shoreline

Instream Features – Instream features are considered to be construction of something below the high water mark. Instream features may include docks, groynes, marinas, etc.

Lacustrine – Produced by, pertaining to, or inhabiting a lake

Lentic - In hydrologic terms, a non-flowing or standing body of fresh water, such as a lake or pond.

Life History – Life history generally means how an organism carries out its life. Activities such as mating and resource acquisition (i.e., foraging) are an inherited set of rules that determine where, when and how an organism will obtain the energy (resource allocations) necessary for survival and reproduction. The allocation of resources within the organism affects many factors such as timing of reproduction, number of young, age at maturity, etc. The combined characteristics, or way an organism carries out its life, is a particular species' life history traits.

Lotic – In hydrologic terms, a flowing or moving body of freshwater, such as a creek or river.

Non Anadromous – Non anadromous fish are fish that do not return to the sea to mature. Examples include rainbow trout (excluding steelhead), bull trout, and whitefish.

Retaining Wall – A retaining wall is any structure that is used to retain fill material. Retaining walls are commonly used along shorelines for erosion protection and are constructed using a variety of materials. Bioengineered retaining walls consist of plantings and armouring materials and are strongly preferred over vertical, concrete walls. Retaining walls that occur below the Mean Annual High Water Level pose a significant challenge, as fill has been placed into the aquatic environment to construct these walls.

Sensitive Habitat Inventory Mapping (SHIM)- The SHIM methodology is used to map fish habitat in streams.

Shore zone - The shore zone is considered to be all the upland properties that front a lake, the foreshore, and all the area below high water mark.

Streamside Protection and Enhancement Area (SPEA) - The SPEA means an area adjacent to a stream that links aquatic to terrestrial ecosystems and includes both the existing and potential riparian vegetation and existing and potential adjunct upland vegetation that exerts influence on the stream. The size of the SPEA is determined by the methods adopted for the Provincial Riparian Areas Regulation.

Stream Mouth / Alluvial Fan – Stream mouths are considered to be areas where a stream has the potential to have a direct active influence (e.g., sediment deposition or channel alignment changes) on the lake.

Submergent Vegetation – Submergent vegetation consists of all native vegetation that only occurs within the water column. This vegetation is typically found in the littoral zone, where light penetration occurs to the bottom of the lake. Eurasian milfoil is not typically considered submergent vegetation as it is non native and invasive.