SLOCAN LAKE

FORESHORE FISH & WILDLIFE HABITAT ASSESSMENT

INCLUDING

FORESHORE INVENTORY AND MAPPING (FIM)
AQUATIC HABITAT INDEX (AHI)

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EXECUTIVE SUMMARY

Responding to concerns about water quality in Slocan Lake and the potential increase in the use of the lake, local residents formed the Slocan Lake Stewardship Society (SLSS) in June 2006. Expanding development pressures in the Slocan Lake area and increasing use of the foreshore areas provided the impetus to develop a strategy that will serve to direct lake and foreshore use in a manner which would respect community values and protect the existing ecosystem. One of the goals of the Society is to lead the development of a set of community-driven guidelines, in accordance with Regional, Provincial and Federal policies and regulations. These guidelines would serve to direct land and water use in and around the lake and to achieve a uniform standard for the activities of developers, local governments, the tourism industry and local residents.

To serve as a basis for the development of future land-use guidelines, the SLSS undertook to complete a study of the present state of Slocan Lake. The present report documents the results of three components of that study: a Fish and Wildlife Habitat Assessment, a Foreshore Inventory and Mapping (FIM), and an Aquatic Habitat Index (AHI).

In 2007, staff from Fisheries and Oceans Canada, Nelson, carried out an Overview Foreshore Inventory and Mapping of the Slocan Lake shoreline (Arnett 2009). The lake shoreline was divided into a number of segments which were then characterized according to level of impact, land use designation, shore type, and foreshore modifications. A more detailed FIM was conducted in 2008 and 2009 in collaboration with Galena Environmental Ltd.

Galena Environmental also conducted a Slocan Lake Foreshore Fisheries and Wildlife Habitat Assessment in 2008. Using this information, together with the FIM results, EcoScape Environmental Consultants Ltd. was able to compile an Aquatic Habitat Index, providing a quantitative ranking of the ecological value of each segment.

The fish and wildlife habitat survey was the largest component of the field work program, covering 28 different segments along the shoreline. These segments included a range of different shore types (e.g. Gravel, Sand, Rocky, etc.) and different levels of development. Fish and wildlife observations and habitat assessments were carried out using different techniques. The foreshore was found to contain a wide variety of species including 15 native species and one non-native species (brook trout). Some of these species are considered sensitive species by the provincial and federal governments (bull trout, white sturgeon, westslope cutthroat trout, etc.) or regionally significant species (burbot) due to population declines. Redside shiners were the most abundant non-sport fish species, representing 67.3% of the total fish community. Mountain whitefish followed, at 16.7%. Except for the mountain whitefish, the sport fish observed (i.e., burbot, rainbow trout, kokanee) were found in relatively low numbers. The presence of birds, mammals, amphibians and reptiles was recorded, as was their habitat use, along with wildlife trees, veteran trees and wildlife signs. In total, 21 different species of birds, five mammal species, two amphibians and one reptile

were observed. The survey indicated that wetland areas and well established riparian areas contained the greatest diversity of wildlife.

The objective of the present survey is to contribute to the effectiveness of any foreshore management plans which may be developed to protect and restore ecosystem structures on and around Slocan Lake. It is hoped that the results and recommendations of the present report will be used to direct and assist in decisions on development projects around the lake, especially in areas of sensitive wildlife habitat.

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GLOSSARY

Alluvial fan: Areas where a stream has a potential to have a direct active influence (e.g., sediment deposition or channel alignment changes) on a lake.

Adfluvial species: Fish species that live in lakes and migrate into rivers or streams to spawn.

Aquatic Habitat Index (AHI): Ranking system design based upon the biophysical attributes of different shoreline types.

Best Management Practices (BMP): Methodology by which natural resources are protected during development or construction. These BMPs can be found at the Ministry of Environment website.

Biophysical: Refers to the living and non-living components or attributes of an ecosystem such as type, substrate, presence of aquatic vegetation, etc.

Endemic: Species being unique to a particular geographic location.

Eutrophic lake: A lake with a high primary productivity due to excessive nutrients and is subject to algal blooms resulting in poor water quality. The bottom waters of such bodies are commonly deficient in oxygen. These waters commonly lack fish species such as trout that require cold, well-oxygenated waters.

Fisheries Sensitive Zones: Fisheries-sensitive zones (FSZs) are side and back channels, ponds, swamps, seasonally flooded depressions, lake littoral zones, and estuaries that are seasonally occupied by over-wintering fish.

Fluvial species: Species found in or pertinent to rivers and streams.

Foreshore: Foreshore is commonly defined as the land area lying below the natural boundary of a lake, stream or ocean. The natural boundary is distinguished by the change in the character of the soil and vegetation from the upland to the foreshore. Beaches are a part of the foreshore since they lie below the natural boundary.

Foreshore Inventory Mapping (FIM): Methodology used to collect and document fish and riparian habitats along lake or stream shores.

Georeferencing: Methodology to establish 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 perpendicular to the shoreline and made of wood, rocks, concrete, or other materials, that is used to stop sediments from shifting along a beach.

Herptiles: The reptiles and amphibians.

Lacustrine species: Fish species which stay in a lake for all of their life history stages.

Lentic species: Belong to the ecosystems of waters such as lakes and ponds.

Life history: Refers to the life history of a fish species (i.e. the reproductive cycle, maturity stages, species habitats, etc.).

Limnetic zone: The open surface waters in a lake, away from the shore. It can be defined as the lighted surface waters in the area where the lake bottom is too deep and unlit to support rooted aquatic plants.

Lotic species: Belong to the ecosystems of rivers, streams and springs.

Macrophytes: Aquatic vegetation in general.

Meristics: Area of ichthyology which relates to counting quantitative features of fish such as the number of fins or scales.

Oligotrophic lake: A lake with low primary productivity, the result of low nutrient content. These lakes have low algal production, and consequently, often have very clear waters.

Orthophotographs: Aerial photos geometrically corrected such that the scale is uniform. Orthophotographs are commonly used in the creation of a Geographic Information System (GIS).

Periphyton: Periphyton is a complex mixture of algae, bacteria, microbes, and detritus that is attached to submerged surfaces (rocks, woody debris) in most aquatic ecosystems. It serves as an important food source for invertebrates, tadpoles, and fish.

Primary production: Production of organic compounds from atmospheric or aquatic carbon dioxide, principally through the process of photosynthesis. All life on earth is directly or indirectly reliant on primary production. The organisms responsible for primary production are known as primary producers and form the base of the food chain. In aquatic ecosystems, algae are primary producers.

Resident population (or Stream residents): Fish population spending all its life stages within a specific stream (opposed to "adfluvial").

Shore zone: All the upland properties that front a lake, the foreshore, and all the land area below the high water mark.

Stream mouth: Zone where a stream meets with the lake.

AHI: Aquatic Habitat Index
BMP: Best Management Practices
DFO: Fisheries and Oceans Canada
FIM : Foreshore Inventory Mapping
LoI: Level of Impact
M: Macrophyte ZOS
MOE: Ministry of Environment
OCP: Official Community Plan
RDCK: Regional District of Central Kootenay
SLSS: Slocan Lake Stewardship Society
Spp.: Abbreviation for species (plural). Fish identified to its Family but not to species.
WC: Watershed code of a stream or lake for identification purposes
YOY: Young of the year
ZOS: Zones of Sensitivity

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1 INTRODUCTION

Slocan Lake is one of the few remaining large lakes in British Columbia about which very little scientific information has been gathered to date. It is obvious that comprehensive lake management guidelines cannot be developed without the requisite collection of scientific data which will serve as the basis for any proposals, recommendations and conclusions. Thus, after some research and consultations with representatives of the Regional, Provincial and Federal government agencies, the Slocan Lake Stewardship Society undertook to implement a scientific baseline study, completing a data collection project describing the current state of the lake from an ecological perspective. The recent increase in housing development along the shore of the lake and the concomitant increase in the recreational use of the lake waters strongly suggest that such a project be conducted in order to mitigate any future serious impact upon the lake's ecology.

1.1 STUDY AREA

Slocan Lake is located in the West Kootenay Region in the southern interior of British Columbia. The lake lies on a north-south axis between the Selkirk and the Valhalla mountain ranges (Figure 1). The lake drains south into its only outlet, the Slocan River, which flows into the Kootenay River, which in turn flows into the Columbia River, in Castlegar, BC. The lake is situated at an elevation of 541 m and is located within the ICHmw2 (Interior Cedar Hemlock, moist, warm) biogeoclimatic zone (Forests & Ranges BC 2002). The upland ecosystem is characterized as being in the ESSF (Engelmann Spruce-Subalpine Fir) and the AT (Alpine Tundra) biogeoclimatic zones containing pockets of open forest.

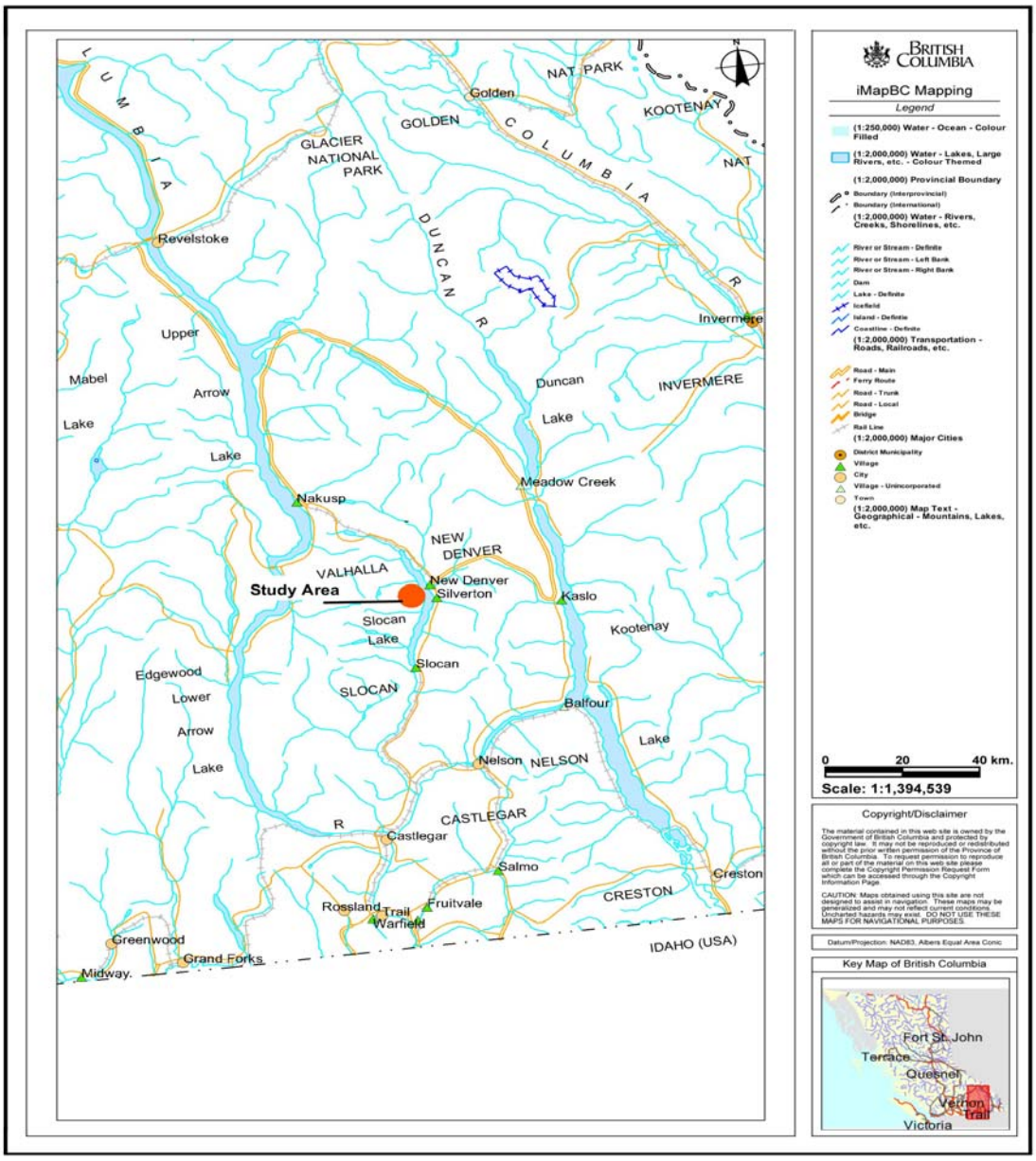

Figure 1: Location of Slocan Lake

1.2 IMPORTANCE OF FORESHORE AREA TO FISH & WILDLIFE

The foreshore area of Slocan Lake is the primary focus of this report. The foreshore area is defined as the section of shore between the high and low watermarks and constitutes an important link between the aquatic and terrestrial environment. The proximity of differing habitats found in this area provides benefits for a wide variety of wildlife species. Invertebrates and vertebrates both find habitat here which is suitable for nesting, feeding, resting and protection from the elements and predators. In general, foreshore vegetation is distinct from upland vegetation due to the abundance of water, and in ecological terms this

zone is considered more productive than drier or wetter habitats, though the latter do have their function within the ecosystem.

The foreshore is extremely sensitive to disturbance. Shoreline development often results in alterations of the foreshore environment. Land use designation, foreshore modifications, shore type, foreshore conditions, and levels of impact all combine to determine the quality of the foreshore and its suitability for fish and wildlife use (Taillon & Fox 2004). Therefore, management of development pressures around lakes must take into account all foreshore and riparian habitat attributes.

Lakeshore vegetation, habitat structure and species use is commonly altered by anthropogenic disturbance. Effects of this disturbance include direct habitat loss, loss of native plant communities, avoidance, alteration of predator-prey relationships and direct mortality. For instance, road and house construction results in direct habitat loss and alterations of natural drainage patterns. Conversion of natural vegetation to ornamentals results in removal of native nesting and foraging habitats. Most predator species tend to avoid areas with human development which results in prey species congregating in these areas and abnormal population levels.

1.3 FORESHORE MANAGEMENT

Results of a 2007 Regional District of Central Kootenay (RDCK) Slocan Valley population survey indicated a general concern about human-induced impacts on the Slocan Lake foreshore and riparian areas. The Slocan Lake Stewardship Society (SLSS) was formed to respond to these concerns and with the objective to protect Slocan Lake. The priority of the SLSS became to gather basic scientific knowledge of the lake, to facilitate ongoing outreach through education regarding Slocan Lake, to create environmental guidelines based on the data collected and to help guide future development practices by supporting sustainable lake uses along Slocan Lake.

In 2007, the SLSS began to act as an environmental advisory group for the RDCK for the proposed Official Community Plan for area H (north Slocan Valley). The SLSS functions as a distinct not-for-profit independent organization, separate from the RDCK. Recommendations developed from the Baseline Study were to be taken into consideration by the RDCK to help draw up a comprehensive lake management plan containing clear guidelines to protect the ecology of Slocan Lake. Several public meetings were held with the participation of a core group including the RDCK of Nelson, the Ministry of Environment in Nelson, Fisheries and Oceans in Nelson and the Integrated Land Management Bureau of Cranbrook. The main participants all agreed that the more knowledge we have of the current status of the lake, the more effective future management choices will likely be.

Similar foreshore assessment projects were previously conducted on Windermere Lake (McPherson & Hlushak 2008) and on Moyie and Monroe Lakes (Schleppe 2009). To ensure compatibility with the FIMs conducted on these lakes in the Kootenay Region, Galena Environmental used these studies as a template for this report.

1.4 PROJECT OBJECTIVES

This project was initiated in order gather information that would serve to identify the areas on Slocan Lake that would benefit from conservation measures or protection from future lakeshore development. The specific objectives of this project are to:

- Review, compile and summarize existing data on Slocan Lake watershed;
- Summarize key features along the Slocan Lake shoreline;
- Conduct a review of modifications along Slocan Lake using historical aerial photographs;
- Provide an overview of foreshore habitat and conditions on Slocan Lake;
- Conduct an overview on life history of the native fish assemblage within Slocan Lake;
- Assess the foreshore morphology, land use, riparian conditions and anthropogenic alterations;
- Assess fish and wildlife shoreline habitat;
- Assess fish and wildlife environmental sensitive areas within the lake foreshore;
- Prioritize foreshore areas for conservation and protection;
- Provide an accessible GIS geo-database for the Slocan Lake foreshore; and
- Make the collected information available for planners and other key referring agencies related to land development approval.

1.5 DESCRIPTION OF SLOCAN LAKE WATERSHED

Slocan Lake is a 39 km long, cold, oligotrophic lake that covers a surface area of 6908 ha (Appendix A). The lake has a foreshore length of approximately 87km, a mean depth of 171 m and a maximum depth of 298 m. The lake differs from its neighbors in that it does not have a major river flowing through it. As a result, its bulk water residence time is 7 years, compared to Arrow Reservoir (< 1year) and Kootenay Lake (1.5 years). The longer residence time for Slocan Lake is somewhat misleading due to its deep water volume (Andrusak 2006). The Slocan Lake watershed code is 340-047200 and the waterbody identifier is 00115SLOC (FISS 2010).

Several tributaries flow into Slocan Lake. The largest tributary is Wilson Creek which enters on the east side of the lake and accounts for approximately 1/3 of the drainage area. Bonanza Creek is located at the head (north) of Slocan Lake. Carpenter Creek, which flows through New Denver, and Silverton Creek, which flows through Silverton, account for 10% and 6% of the drainage respectively (Andrusak 2006). The lake undergoes seasonal stratification, during which a thermal gradient is formed during the summer months. As the lake cools off during the fall months, it is not completely de-stratified until December.

According to Pieters *et al.* (2001), Slocan Lake has recently become the focus of limnological and fish production studies because it is relatively pristine and serves as a good control site for the nearby fertilization experiments on Arrow Lakes and Kootenay Lake.

2 METHODOLOGY

2.1 FORESHORE FISH & WILDLIFE HABITAT ASSESSMENT

2.1.1 Background Review

Literature Review

The objective of the literature review was to collect general information which could be used to classify and define important biophysical characteristics of the habitats used during different life history stages of the native fish assemblage in Slocan Lake. Unfortunately, very few fish and wildlife studies have been conducted on Slocan Lake and the existing literature on the ecology and life history of fish species in Slocan Lake is very slim. The lake is known to have a high diversity of fish species but the precise number is not known. The studies consulted for the present report include one study on the lake kokanee population, four studies on the lake white sturgeon and several tributary assessments from the Resources Inventory Program of the Forest Renewal Plan.

Since very little fisheries information was available for Slocan Lake, life history information was not compiled for this report. An overview summary was conducted of the ecology of sport fish and non-sport fish species, on the blue and red-listed fish species known to be present in the lake and on species of importance for the area.

Historical Aerial Photograph Review

Aerial photographs taken in the 1980s, and archived at the Ministry of Environment in Nelson, were examined in order to identify significant changes along the shoreline over the last twenty years. For the purposes of this study, the shoreline was considered to extend 50 m upland from the lakeshore. Anthropogenic modifications and disturbances were recorded and compared with present-day data. The sequence of shoreline modifications over the years could not be assessed.

2.1.2 Differentiation of Foreshore Segments

In order to facilitate assessment and provide more accurate descriptions and ratings of the natural features and levels of impact along the lakeshore, some of the segments differentiated in the 2009 Overview FIM (Arnett 2009) were divided into shorter segments during the later field surveys. A detailed description of the 28 segments and of the creeks and wetland assessments can be found in Appendix B. Table 1 indicates how the original segments were modified.

Table 1: Correspondence of 2011 FIM segments to 2009 FIM segments

2009 FIM Segments #	2011 FIM Segments #
1	1
	2
	3
2	4
	5
	6
3	7
4	8
5	9
6	10
7	11
8	12
9	13
10	14
	15
	16
	17
	18
11	19
12	20
	21
13	22
	23
	24
14	25
15	26
	27
16	28
TOTAL = 16	TOTAL = 28

2.1.3 Fish & Wildlife Habitat Assessment

Fish and wildlife surveys were conducted in Slocan Lake in the fall of 2008 by Galena Environmental. Information on fish and wildlife was collected on a segment-by-segment basis. Logistical constraints made sampling of the entire length of each segment impossible. Consequently, only representative sections, at least 100 m in length, were surveyed. Before a representative section could be chosen, the entire segment was surveyed from a boat. The sections which were chosen best represent the different biological, physical and anthropogenic properties found in the different shore types along the lake. The boundaries of each segment were identified using GPS coordinates. Photographs were taken within each shoreline segment during this assessment.

Fish observations were taken visually in 100 m by 50 m representative sections of each segment. This was done from the side of the boat as it slowly moved along the shoreline. An AquaVu underwater camera was used and snorkeling passes were also made. The snorkeling survey was the most important component and was conducted at all assessed sites except for segments 2 and 3 where a log boom made conditions too hazardous. Snorkeling was carried out following the general methods outlined in Taillon and Fox (2004), Thurow (1994) and Helfman (1983). All activities were conducted during the day. The survey area was consistent in each of the segments surveyed. Aquatic habitat observations taken during these surveys included: fish habitat quality, aquatic vegetation, substrate type and foreshore impacts.

Wildlife observations were also taken for each segment. General observations were taken from the boat, while a foot-survey provided further details on the riparian zone and included wildlife trees, veteran trees, and the composition of the forest and its abundance.

Information collected during the fish and wildlife surveys was used in conjunction with historical fisheries information for incorporation into the AHI (see below), as applicable, and to identify important habitat features as zones of sensitivity.

In addition to the assessment of the 28 segments, a wildlife overview survey was conducted of the Bonanza Marsh area adjacent to the lake. Bonanza marsh is the only wetland around Slocan Lake. Wetlands in general are not associated with oligotrophic lakes such as Slocan Lake. Wetlands contribute significantly to lake ecosystems because they support a wide variety of plant species and offer protection and habitat for several animal species. Birds are particularly abundant due to the abundance of food sources and the diversity of available habitat for nesting and rearing. Many red- and blue-listed species are wetland-dependent (Mitsch & Gosselink 2000). Invertebrates are especially abundant in wetlands and constitute a food source food for many animals. In British Columbia, wetlands are recognized as an Environmental Sensitive Area under the Sensitive Areas in the Sensitive Ecosystems Inventory (Ecosystem Branch of the Ministry of Environment, Section 12.2 of the Water Resources). The main types of wetlands (marshes, swamps and bogs) are defined by their dominant vegetation. The Bonanza Marsh meets the criteria for a marsh established by the Canadian Wetland Classification System (Environment Canada 1997, Canadian Wildlife Services 1992). Importance of Bonanza Marsh for the lake ecosystem is summarized below:

- Utilized by several species of birds and mammals, including vulnerable, endangered or threatened species;
- Acts as a migratory corridor for birds and mammals; and
- Acts as an important rearing, feeding and migration path for indigenous fish species.

2.1.4 Rare & Endangered Species

Fish and wildlife observations for rare and endangered fish, avian, mammal and herptile species were also conducted at each segment. The Slocan Lake foreshore is diverse and contains a variety of habitat types for wildlife, but the seasonal timing of this assessment did not allow for much observation of wildlife species, especially birds, most migratory bird species being already absent from the area. Additional surveys during spring and summer would be required to provide a more complete inventory.

Data on wildlife and fish species at risk in the Slocan Lake watershed was found on the British Columbia Conservation Data Center (CDC 2011) website. A search was conducted for species at risk for the Slocan Lake lacustrine (lake), palustrine (wetland) and terrestrial habitat areas within the ICHmw biogeoclimatic zone, in the Arrow Boundary Forest District (DAB) in the Interior Cedar-Hemlock (ICH) Biogeoclimatic Zone where Slocan Lake is located. Due to the late seasonal timing of the survey, a search for the plant species at risk was not conducted.

Species at risk in Canada are evaluated and ranked provincially by the BC Conservation Data Centre (CDC) and nationally by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The CDC maintains a dynamic 'tracking list' with observation and ecological information regarding species of conservation concern, commonly referred to as 'Red- and Blue-listed' species (CDC 2011).

Taxa that are not at risk in British Columbia are 'Yellow-listed'. Taxa that are 'vulnerable' (Blue-listed) are particularly sensitive or vulnerable to human activities or natural events. Taxa that are 'endangered' (Red-listed) presently face imminent extirpation or extinction.

COSEWIC also maintains a regularly updated list of Canadian species at risk at the national level (COSEWIC 2011). These species are designated 'Special Concern,' 'Threatened,' 'Endangered,' 'Extirpated,' or 'Extinct' according to the level of threat which they face. For both lists, ranking is applied to species, subspecies, populations, and ecotypes. Recent legislation in Canada protects endangered species on the COSEWIC list through the Species at Risk Act (SARA 2011). In general, the federal policy regarding species at risk is to defer to provincial management agencies, so SARA only applies to species and habitat that occur on federal land. For this project, both provincially and federally listed species were reviewed. All wildlife and fish species were cross-referenced with the species at risk lists obtained from the CDC. All listed species were ranked for their potential of occurrence according to the following categories:

- Occurs : Species was directly observed at the study site;
- Likely : Species is known to occur in the local area and in similar habitats;
- Possible : Species has been found in similar habitats, but has not been found in the immediate local area. Species has the potential to occur in area;
- Unlikely : Species closest known occurrence is a significant distance away or site has predominantly unsuitable habitat; and
- Extremely unlikely: Study area has unsuitable habitat and/or is located far from known populations.

2.2 FORESHORE INVENTORY & MAPPING (FIM)

Foreshore Inventory and Mapping (FIM) is a project where GIS, GPS and field observation are used to identify and document the land uses (e.g. residential development), shoreline modifications (e.g. docks), and biophysical attributes (e.g. marshes) along the lake shoreline. The report identifies baseline inventory information that can assist with monitoring, the development of land management objectives for the shoreline and the development of management plans and policies.

Standardized FIM surveys were conducted on Slocan Lake using a Fisheries and Oceans boat and operator. An initial survey was conducted in 2007 and then, with the collaboration of Galena Environmental, further field surveys were conducted in 2008, 2009 and 2010. The foreshore of the lake was mapped and foreshore characteristics collected using a handheld Magellan 515 GPS and Trimble GPS.

2.2.1 Segment Descriptors

A total of 28 segments were assessed during this study. In addition to the length of each segment, segment descriptors, such as Level of Impact, Land Use, and Slope were used to generate a proper segment analysis. The following is a brief description of these descriptors:

1. ***Level of Impact (LoI):*** The Level of Impact of the Slocan Lake shoreline was rated during the Overview FIM (Arnett 2009) field assessment conducted by DFO. Natural shorelines have greater fisheries, wildlife, and ecological values because habitat integrity has not been diminished by anthropogenic disturbance (e.g. docks) and are therefore more environmentally sensitive. Studies have proven that fish assemblages are directly influenced by development. Percentage of shoreline disturbance represents the amount of level of impact. The LoI categories used in this study are:

None
Low (<10%)
Medium (10% - 40%)
High (>40%)

2. ***Land Use:*** The Land Use of each segment was determined during the Overview FIM and during the 2009 assessment. The 14 categories of Land Use along Slocan Lake are:

Agriculture	Park
Commercial	Recreation
Conservation	Rural
Forestry	Single Family
Industrial	Urban Park
Multi Family	Transportation
Natural Area	Institutional

3. ***Slope:*** The slope was also determined during the field visits. The slope is represented in percent (i.e., 1m drop for 100m). The five slope categories used for the Slocan Lake foreshore are:

Very Steep (60%)
Steep (20-60%)
Moderate (5-20%)
Low (0-5%)
Bench

2.3 AQUATIC HABITAT INDEX

The Aquatic Habitat Index (AHI) is a tool which rates the habitat values of the shoreline. Condition indices such as these can subsequently indicate management needs and directions.

The data collected during FIM surveys can be integrated with additional fish and wildlife information to identify the natural features and levels of impact along the shoreline of a lake. An AHI can then be developed which will rate the aquatic habitat values of the segments differentiated during the FIM survey. The results are produced in a manner which identifies habitat vulnerability zones on a categorical scale (Very Low to Very High) which are then colour-coded and mapped. The AHI has been used on other lakes, including Okanagan, Windermere, Moyie and Mabel lakes, making use of inventory data, field sampling and air photo interpretation to rank the habitat value of shoreline segments.

The purpose of the AHI is to facilitate land use planning around shorelines by identifying the relative value of shoreline areas within a lake system. The relative habitat value of an area can then be used to infer the environmental sensitivity of the shoreline (i.e., areas of higher relative value have greater environmental sensitivity). The AHI utilizes a number of parameters collected during the FIM. The index uses a point-based mathematical index to assign relative habitat value to each different parameter.

The AHI index used for Slocan Lake followed that developed for Mabel Lake (Schleppe 2010), so that future comparisons may be possible between inventoried lakes throughout the Kootenays. It was developed by Ecoscape Environmental Consultants Ltd. The Mabel AHI assigns higher scores to 'natural' and sensitive aquatic habitat features (e.g., confluence and wetland areas), while modifications present along the natural shoreline (e.g., retaining walls, docks, marinas) receive a lower score. Scores were assigned to each AHI category and tallied for each segment within Slocan Lake as outlined in Table 2.

The index generated has only utilized information that is presently available. In many instances, data gaps were identified. As more information is collected regarding shoreline areas of Slocan Lake, the Aquatic

Habitat Index may need to be updated. Each parameters of the index reflect a certain type of habitat found along the shoreline. The parameters were broken down into the following categories:

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

These parameters, and their relative value to Slocan Lake, were agreed upon during a Stakeholder Group meeting held in Nelson on April 22, 2009 at the Ministry of Environment office. Attendees included Hillary Elliott (Slocan Lake Stewardship Society), Bruce MacDonald (DFO Nelson office), Kristen Murphy (MOE Nelson office), David Derosa (fisheries biologist and local resident), Meeri Durand (Regional District of Central Kootenay), and Luce Paquin (Galena Environmental Ltd). Table 2 identifies the parameters and logic used in the index.

Table 2 : Parameters and logic for the Aquatic Habitat Index

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	27.3	17.1	% of Segment * Maximum Point	Yes	Stream Mouth = Wetland (15) > Gravel Beach = Rocky Shore (12) > Sand Beach (8) = Cliff /Bluff (8), Other (5)
	Substrate	12	21.8	13.7	% Substrate * Maximum Point	Yes	Cobble (12) > Gravel (10) > Boulder = Organic = Mud = Marl (8) = Fines (8), Sands (4) > Bedrock (2)
	Percentage Natural	10	18.2	11.4	% Natural * Maximum Point	No	
	Aquatic Vegetation	10	18.2	11.4	% Aquatic Vegetation * Maximum Point	No	
	Overhanging Vegetation	4	7.3	4.6	% Overhanging Vegetation * Maximum Point	No	
	Large Woody Debris	4	7.3	4.6	# of Large Woody Debris/km * Relative Value * Maximum Point	No	**Relative Value** >15 LWD (1), 10 to 15 LWD (0.8), 5 - 10 LWD (0.6), 0 - 5 LWD (0.4), and 0
Fisheries	Juvenile Rearing	10	62.5	11.4	High (10), Moderate (6), Low (2)	Yes	High (10), Moderate (6), Low (2)
	Migration Corridor	3	18.8	3.4	Present (3), Absent (0)	No	Present (3), Absent (0)
	Staging Area	3	18.8	3.4	Present (3), Absent (0)	No	Present (3), Absent (0)
Shoreline Vegetation[2]	Band 1	8	66.7	9.1	Vegetation Bandwidth Category * Vegetation Quality * Maximum Point	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	4.6	Vegetation Bandwidth Category * Vegetation Quality * Maximum Point	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	-2.00	41.3	-2.3	% Retaining Wall * (-2)	No	% Retaining Wall * (-2)
	Docks	-0.76	15.7	-0.9	# Docks/km * (-0.05)	No	# Docks per Kilometer * (-0.05)
	Groynes	-2.08	43.0	-2.4	# Groynes/km * (-0.1per groyne)	No	# Groynes per Kilometer * (-0.1)
	Boat Launch	0.00	0.0	0.0	# Launches * (-0.25 per launch)	No	# Launches * (-0.25 per launch)
	Marina	0.00	0.0	0.0	# Marina * (-1 per marina)	No	# Marina * (-1 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.

A description of each parameter is presented below. As the AHI for Slocan Lake is based on the same methodology as the one produced for Mabel Lake by Ecoscape Environmental Consultants, the descriptions of the parameters are taken from their Mabel Lake report.

2.3.1 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 utilizing the fish habitat specificity approach originally developed for Okanagan Lake (Schleppe & Arsenault 2007). Wetlands are considered to be highly valuable shoreline areas for several reasons, including their contributions to biodiversity, biomass, and water quality. Other aspects of the fish habitat specificity approach developed for Okanagan and Windermere Lakes are appropriate and have been utilized in this assessment. The general habitat specificity for Slocan Lake follows that of Windermere and Okanagan, except that Wetlands have been defaulted to the highest value possible shore value (i.e., equivalent to a stream confluence) because of their rarity on this lake, their contributions to habitat diversity, and their contributions to biomass and water quality.

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.

3. ***Percent Natural:*** Areas of natural shoreline have a relative habitat value that is greater than disturbed shoreline areas because the condition of the habitat is better. The level of impact for each segment was based on the percent of natural versus disturbed shoreline. The percent of natural versus disturbed provides a qualitative indication of the overall health of the foreshore and the extent of disturbance and shoreline modification. Incorporation of a parameter that quantifies the level of impact is important because more natural areas likely function better and are more similar to historical ecosystems than highly disturbed shorelines. Since habitat quality is known to be better in areas of natural shoreline than in disturbed areas (excavation works, docks, retaining walls, landscaping, etc.), natural shorelines were accorded a relative habitat value greater than the disturbed shorelines. Percentage Natural was rated to a maximum of 10 points.

4. ***Aquatic Vegetation:*** In more recent versions of the FIM database, more detailed information regarding aquatic vegetation was collected. All vegetation below the High Water Mark (HWM) is considered productive. Since the FIM now allows analysis of this parameter, it was added to the index following the same methods as Shuswap Lake. 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. 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 Slocan Lake system, Large Woody Debris was not present in many areas. Woody debris was absent for several reasons including proximity to significant sources such as large rivers or from "beach grooming" activities by residents. Since large woody debris provides nutrients, cover, and opportunities to forage, it was added to the index. Numerous studies have identified the importance of large woody debris to salmonids in lake and stream systems.

2.3.2 Fisheries Parameters

The fisheries parameters used for the Aquatic Habitat Index were based on different factors considered important for fish production in the Slocan Lake system and were prioritized accordingly in the AHI. The window below describes the three habitat types for juvenile species in Slocan Lake. Table 3 describes the parameters and logic for the juvenile rearing habitat suitability.

- The Juvenile Rearing suitability was based on the type of shore type and substrate, and on the presence/absence of aquatic vegetation, overhanging vegetation, large woody debris and proximity of migration corridors. Ranking for this parameter consists of Low=2, Moderate=6 or High=10 suitability for fish.
- The Migration Corridor parameter encompasses shoreline areas where fish must either migrate out from or into a river or a creek system. These areas overlap with Staging Areas species such as rainbow trout, cutthroat trout, kokanee and bull trout were considered. Ranking of this parameter consists of Presence (3) or Absence (0) of a migration corridor within a segment.
- The Staging Areas generally encompass shoreline areas where fish must either migrate out from or into to. Ranking of this parameter consists of Presence (3) or Absence (0) of such areas within a segment.

Table 3: Parameters and Logic for the Juvenile Rearing Habitat Suitability

Category	Maximum Point	% per Category[1]	Logic	Uses Weighted FIM Data	Value Categories
Shore Type	12	22.6	% of segment* Maximum point	Yes	Stream mouth (12) Wetland & Sand Beach (8) Gravel Beach & Rocky Shore (6) Cliff/bluff (4) Others (1)
Substrate	9	17.0	% of substrate Maximum point	Yes	Organic & Mud & Marl & Fines (9) Boulder (8) Cobble & Gravel (7) Sand (6) Bedrock (4)
Aquatic Vegetation	5	9.4	Aquatic Vegetation Category Score	No	>80%=5 50% to 80%=3 <50%=1
Littoral Width	12	22.6	Littoral Width Category Score	No	Wide (>50m)=12 Moderate (10 to 50m)=8 Narrow (<10m)=3
Overhanging Vegetation	1	1.9	% of Overhanging Vegetation* Maximum Score	No	
Large Woody Debris (LWD)	4	7.5	LWD Category Score Maximum point	No	>15 LWD=1 10 to 15 LWD=0.8 5 to 10 LWD=0.6 0 to 5 LWD=0.4 0
Migration Corridor	5	9.4	Present/Absent	No	Present (5), Minor (0)
Salmonid Spawning Stream Present	5	9.4	Present/Absent	No	Present (5), Minor (0)

1. Numbers have been rounded to the nearest whole number. All calculations were completed without rounding.
2. 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.

2.3.3 Shoreline Vegetation Parameters

The Riparian parameters added to the index were similar to those used in other lakes throughout the Kootenays. However, the newer versions of the FIM provided a distinction between the lakeside vegetation (Band1/Riparian) and the areas behind (Band2/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 m to 15 m, 15 m to 20 m and greater than 20 m. The Band 1 vegetation, directly adjacent to the lake was given more points than the Vegetation Band2 because of its direct proximity to aquatic habitats.

Band1/Riparian: Predominantly, the average vegetation bandwidth of each segment was used in the AHI and is considered to be representative of the shoreline segment. Band1 was rated based on its bandwidth; 0 to 5m (0.2) , 5m to 10m (0.4), 10m to 15m (0.6), 15m to 20m (0.8) and greater than 20m (1). The scoring for different classes of Band1 vegetation appears below:

Band1: Value per vegetation categories		
Class	Bandwidth (m)	Score
Landscaped	50	2.4
Herbs/Grasses	50	4.8
Coniferous forest	50	6.4

Band2/Upland: Band2 ratings were assigned a habitat value based on the vegetation quality. The higher score was given to Broadleaf shrubs (1), then Coniferous or Mixed Forest (0.8), Herbs/Grasses/Unvegetated (0.6), Land/Landscaped (0.3) and Exposed Soil (0.05). The values given for vegetation categories and bandwidth appear below:

Band2: Value per vegetation categories		Band2: Value per bandwidth categories		
Vegetation Categories	Value	Bandwidth (m)	Maximum	Value
Conferous forest	0.8			
Broadleaf forest	1	0-5	5	0.2
Mixed forest	0.8	5-10	10	0.4
Shrubs	1	10-15	15	0.6
Herbs/Grasses	0.6	15-20	20	0.8
Exposed soil	0.05	20	20	1
Landscaped	0.3			
Lawn	0.3			
Natural wetland	1			
Disturbed wetland	1			
Row crops	0.3			
Unvegetated	0.6			

2.3.4 Habitat Modifications

Habitat modifications were noted where obvious shoreline modifications occurred. Attributes for Habitat Modifications were based and calculated on perceived importance to fish in Slocan Lake, as agreed by the Stakeholder Group. In general, habitat modifications are considered to be negative habitat features. The five categories used for the Slocan Lake are described below.

Modifications	Score
Retaining Wall	-2
Docks	-0.05
Groynes	-0.1
Boat Launch	-0.25
Marina	-1

1. ***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 near shore 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. 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.

2. ***Docks:*** The negative effects of docks on fish habitat are controversial. On one hand docks may provide areas of hiding for 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 with increased overwater structures (e.g., docks) and riprap shorelines, and therefore, construction of these structures may affect juvenile migrating salmonids (Piaskowski & 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.

3. ***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).

4. ***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 of boat launches include prop scour of substrates in shallow water launches.

5. ***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.

2.3.5 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:

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

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 of removal of instream works. This category does not consider riparian restoration impacts.

2.3.6 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. Table 2 contains the logic and 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 scores for each different category 1) Biophysical, 2) Fisheries, 3) Shoreline Vegetation; and, 4) Modifications were totalized 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, the Shuswap Lake index was used as a baseline because of the many similarities between the two systems. From this base, numerous iterations were run (i.e., the index was run at least 50 times) and changes were made as necessary to reflect current conditions. 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, Low and Very Low. These breaks were made because of the clustering of scores based upon the output of the results. 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 based upon information currently available.

The AHI was calibrated by testing the model with the Stakeholder Group. Numerous iterations of the index were run and the outcomes of each run were compared to perceived habitat value based upon the stakeholder knowledge of each tested segment. Changes in scores of each parameter were adjusted for each different run to ensure that items were not overly weighted in the AHI.

2.4 DATA COLLECTION/ANALYSIS/REPORTING

Raw data from the field survey was provided by Bowers Consultants Ltd, Galena Environmental Ltd and DFO Nelson office. Reporting for this project was completed by Galena Environmental Ltd. The information provided in the Slocan Lake Overview FIM report (Arnett 2009) was also used as a baseline for this project. The Windermere (McPherson and Hlushak 2008) and the Moyie and Monroe Lakes Foreshore Fish and Wildlife Habitat Assessment reports (Schleppe 2009) were used as templates for this report.

1. Aquatic Habitat Index Analysis: A brief summary of the shoreline lengths and shore types is presented. The summary provides information regarding the AHI results (Very High to Very Low) analyzed by shore type, including the percent of the shoreline that is within each of the AHI categories.

2. GIS and FIM Database Management: Data management for this project was as follows:

- Data and photos were backed up to a computer/laptop on a daily basis;
- A GPS video was used to facilitate data review and interpretation;
- A total of 23 mapsheets were produced to represent the entire lake;
- Air photo interpretation was completed using high resolution air photos; and
- An Electoral Area field was added to define the municipal boundary within the Regional District area.

4 RESULTS

4.1 FORESHORE FISH & WILDLIFE HABITAT ASSESSMENT

4.1.1 Wildlife Species & Habitat

It should be noted that it was not the intention of this survey to conduct a comprehensive assessment of the terrestrial wildlife populations inhabiting the shores of Slocan Lake. Wildlife observations were opportunistic. Habitat values can only be inferred from the assessments made of the shoreline and riparian zones. The foreshore of Slocan Lake contains a variety of natural habitat types for numerous mammal and herptile species.

In total, five mammal species, one salamander, one toad and one snake species were observed during the 2008 survey (Table 4). All species observed were listed as a 'Yellow' species (not threatened) under the BC Provincial Status (BCCDC 2011). Wildlife surveys indicated that wetland areas, such as the Bonanza Marsh, had the greatest wildlife signs of diversity, whereas highly developed areas had very low diversity ratings. Well established riparian areas near stream outlets were also important wildlife habitat areas.

Mammals, amphibians, reptiles and bird species observations and their preferential shore zone habitats around the lake are outlined in tables 5, 6 and 7. Appendix C outlines a detail list of wildlife observations for each surveyed site.

Table 4: Mammals, amphibians and reptiles observed during the survey

GROUP	COMMON NAME	SCIENTIFIC NAME	SEGMENTS #						
			6	9	12	13	19	20	25
Bears	Black bear	*Ursus americanus*	1						
Ungulates	White-tailed deer	*Odocoileus viginianus*		1					
Rodents	Red squirrel	*Tamiasciurus hudsonicus*			5	5			
Frogs/toads	Western toad	*Bufo boreas*					2		
Mustelides	River otter	*Lutra canadensis*					1		
	Mink	*Mustela vison*						1	
Salamanders	Salamander spp.	*Ambystoma spp.*							1
Snakes	Common Garter snake	*Thamnophis sirlalis*							1
Number of species observed per segment			1	1	1	1	2	1	2

Mammals: Only one bear was observed, feeding on shrubs, though numerous signs of bears were recorded along the foreshore including scats, bear trees and bear tracks (Table 5). A large portion of the Slocan Lake foreshore provides excellent bear habitat with high vegetation diversity providing food and shelter. The habitat along the shores of the lake has not changed dramatically over the years. Fruit bearing shrubs (huckleberries, hazelnut, etc.) are plentiful and are a critical part of the bear's diet. Abundant bear

signs were found on Galena Trail, which runs along the northeast side of the lake, and in the Bonanza Marsh. Bears most likely use the trail as a dispersion corridor. The plentiful berry shrubs and fish spawning habitats around the marsh and the Bonanza Creek well known fish spawning habitat can provide feeding habitat for bears.

Although only one white-tailed deer was observed during the survey, deer use of the shoreline is abundant around Slocan Lake. During this survey, numerous signs of deer presence were recorded, including scats, tracks, browses, beds and trails. Deer escape the deep snow in the higher altitudes by frequently descending to the lakeshore environment from late fall to early spring, except in the south-eastern section of the lake where cliffs make this impractical. Deer signs were plentiful on the Galena Trail but deer browses were mostly observed within mature forest areas. Galena Trail is obviously an important corridor for the movement of deer along the foreshore area.

A mink and a river otter were spotted along the foreshore of the lake. Mink are known to favour wetland areas and the site corresponds perfectly to typical mink feeding habitat, with its fish-bearing creek, amphibians, and waterfowls. The river otter observed was feeding on fish (spp.) on the lake foreshore. Slocan Lake foreshore offers some typical river otter shoreline habitat requirements. Otters are known to use holts, dens or natural hollows with an entrance preferably under water. The otter prefers the shallow, narrow areas of streams and along the edges of bodies of water close to wetlands or a complex stream mouth associated with good riparian cover (Lacki 2005, Edward 2000).

Amphibians & Reptiles: One western toad, one salamander spp. and one common garter snake were observed during the survey (Table 5). They were all observed on undisturbed foreshores with low impacted riparian areas. Shale formations and rocky outcrops associated with seepage grounds are the preferential habitat for these species. Garter snakes are very aquatic snakes, and are rarely found far from water. Shale formations and rocky outcrops within the site may act as a hibernating habitat (hibernacula) for amphibians and reptiles. Seepage within mossy grounds and angular rocks on the Galena Trail shoulders provide also good habitat for reptiles.

Table 5: Observed mammals and amphibians/reptiles and their shore zone habitat within Slocan Lake

Species Name	Occurences	General Living Habitats	Feeding Habitats	General Breeding Habitats & Requirements
Black bear	In riparian, in the rural land designation & close to a cottage area	All shore types	All shore types	Mixed forests with dens and tree crevices availability
White-tailed deer	In the riparian area along the foreshore	All shore types	All shore types	Forested areas with habitat such as large woody debris and tall grass to shelter the fawns
Red squirrel	In the riparian vegetation & in mature stands in public campgrounds	Near coniferous areas	Coniferous riparian areas	Coniferous forests with dens, old stumps or tree crevices availability
Western toad	On the foreshore, within the rural land designation	On foreshore, will avoid dense residential areas	Near seepage in forested areas along foreshore	Still water areas near springs, streams or meadows
River otter	On the foreshore, within the rural land designation	All shore types	The littoral and offshore zones of the lake and all creeks	Forested areas nearshore with hollow trees or large woody debris
Mink	At a stream mouth, within the rural land designation	Preferably alluvial fan shore types and wetland	The littoral zone of the lake, the wetland and creeks within a forested area	Forested wetland areas and dens within creek riparian areas
Salamander spp.	In a seepage zone on the foreshore	Most forest grounds near small creeks along the shore	Moist forest grounds near small creeks along the shore	Moist forests with rock outcrops and crevices
Common Garter snake	In a shale formation on the foreshore	Near damp riparian & rocky outcrops	Forested areas along foreshore & rocky outcrops	Forested areas along foreshore with rock outcrops, small dens and crevices

Avian Species: In total 21 different species of birds were observed along the foreshore during the survey (Tables 6 & 7). Due to the late timing of the survey, no migratory birds were observed during the survey. Observations of migratory species would likely be much more numerous during the spring/summer. These findings should thus only be considered as a general indication of bird presence around the lake. A summary of the different bird species known to occur along the different shoreline segments can be found in Appendix C.

The bird results indicate that the greatest number of species occurred in sites offering diverse habitat structure and an abundance of vegetation components (aquatic vegetation, riparian vegetation associated with creek mouths, wetland and forested areas). Segments with the most species observed where all located near a creek mouth. Most piscivorous species were observed foraging near creek outlets, away from urban areas. Segment 20, adjacent to the Bonanza Marsh, was by far the site with the most species observed.

Table 6: Birds species observed during the survey

GROUP	COMMON NAME	SCIENTIFIC NAME
Shrikes/Vireos	American crow	*Corvus brachyrhynchos*
Raptors	American kestrel	*Falco spaverius*
Raptors	Bald eagle	*Haliaeetus leucocephalus*
Ducks/Geese	Barrow's goldeneye	*Bucephala islandica*
Chickadees	Black-capped chickadee	*Parus atricapillus*
Ducks/geese	Canada goose	*Branta Canadensis*
Passerines	Cedar waxwing	*Bombycilla cedrorum*
Woodpeckers	Common flicker	*Colaptes auratus*
Ducks/Geese	Common merganser	*Mergus merganser*
Shrikes/Vireos	Common raven	*Corvus corax*
Passerines	Dark-eyed junco	*Junco hyemalis*
Shore birds	Dipper	*Cinclus mexicanus*
Raptors	Eagle spp.	
Ducks/Geese	Eared grebe	*Podiceps nigricolis*
Gulls/Sterns	Gull spp.	*Larus spp.*
Raptors	Hawk spp.	*Buteo spp*
Shore birds	Killdeer	*Charadrius vociferous*
Ducks/Geese	Mallard	*Anas platyrhynchos*
Raptors	Osprey	*Pandion haliaeteus*
Woodpeckers	Pileated woodpecker	*Dyocopus pileatus*
Shore birds	Sandpiper spp.	

Even with the presence of a nearby creek, bird diversity was definitively lower at sites with greater human disturbance such as Segments 10, 12 and 17. Bonanza Marsh was expected to have a higher diversity of species due to the available habitats. Nesting areas for most species was not confirmed within the Bonanza Marsh but good nesting potential for shorebirds, ducks and geese was observed in the wetland.

Although not observed during the present site assessment, species such as the great blue heron *(Ardea herodias)*, the trumpeter swan (*Olor buccinator)* and the sandhill crane (*Grus Canadensis)* have been known, by amateur birdwatchers, to frequent the Bonanza Marsh on occasion. Canada geese and habitat generalists such as the American crow, cedar waxwing and common raven were found in or near the more urbanized settings while the undeveloped shoreline areas contained more habitat specialists such as shorebirds, raptors, woodpeckers and ducks.

Table 7: Birds species observed per segment

Bird Species	Segments														
	3	5	6	8	10	12	18	19	20	21	22	23	24	25	28
American crow									4			2			
American kestrel	2														
Bald eagle		1		4			1		4			2			
Barrow's goldeneye				3								2		2	
Black-capped chickadee											1				
Canada goose					2					26					
Cedar waxwing						5			10						10
Common flicker	1														1
Common merganser	3			2	5				9						
Common raven					3			1	7						
Dark-eyed junco									2						5
Dipper					1										
Eagle spp.									1			1			
Eared grebe									3						
Gull spp.					2				5				4		
Hawk spp.	2												1		
Killdeer									1						
Mallard					1				7						
Osprey			2	1											
Pileated woodpecker								1							
Sandpiper spp.									1						
Species observed	4	1	1	4	6	1	1	2	12	1	1	4	2	1	3

4. Veteran & Wildlife Trees: Key wildlife habitat features are present in many areas around the lake and include wildlife trees and veteran trees. Baseline information collected during this survey provides an overview of these features present around the lake (**Error! Reference source not found.**2).

Wildlife trees are any standing dead or living trees with characteristics that provide habitat for wildlife. These characteristics include large trunks, large branches, deformed and broken tops, internal decay and sloughing or loose bark. Wildlife trees are becoming increasingly scarce as old forests are harvested. Without these key features, the bird or mammal species that depend on them cannot survive (Fenger *et al* 2006). Veteran trees stand above the forest canopy and are species that develop increasingly thick bark over the years. The thick bark protects the trees from forest fire. Veteran trees have usually developed deformities and dimensions that attract many wildlife tree-dependant species. Douglas fir, ponderosa pine and western larch are the most common veteran trees.

In general, wildlife trees were found near creek outlets located within the rural areas and along the mature forest on the northwest and southeast shore of the lake. The Bonanza Marsh is the site with the most wildlife trees and with the most diversified use of these trees. Wildlife trees were found adjacent to a nearby wildlife trail.

There still exists a large riparian band (Band2) in most areas around Slocan Lake because of the low level of land development. Development has reduced or removed some of the riparian bands in flatter and more developable areas.

Photos 1:Wildlife tree on Segment 19

Photo 2: Mature forest on Segment 22

Photo 3: Wildlife trail on Segment 13

Photo 4: Shale formation on Segment 25

Photo 5: Shale on Segment 25

Photo 6: Wildlife tree on Segment 9

Photo 7: Wildlife tree on Segment 9

Photo 8: Veteran trees on Segment 22

Figure 2: Photographs of wildlife signs and habitats

5. Elk Winter Habitat: A single Elk Winter Habitat was identified during the survey. A small portion of the Slocan Lake foreshore is known to be used as part of a winter range for a small elk (*Cervus elaphus*) population (Mowatt 2010). This zone of sensitivity is located on the southern portion of Segment 19. Much of the Elk Winter Habitat lies in the upland areas but these animals do come down right to the lakeshore. Tall grasses and fibrous browses found on the steep slope are still available for the elk during the winter. Elk also depend on the foreshore grass-like vegetation and riparian shrubs found at this site.

4.1.2 Fish Species & Habitat

Fish observations and habitat assessments were conducted on 26 of the 28 segments. The industrial land use and the log booms at Segments 3 and 15 made snorkelling too dangerous in those areas. Bonanza Marsh was not assessed for fish.

The following sections present the fisheries results and a species summary has been prepared for all sport fish, some non-sport fish species, rare and endangered fish species and for species of interest in Slocan Lake (Appendix C). Table 8 presents a detailed list of all the fish species suspected to inhabit the lake and the species observed during the survey, together with fish habitat type (juvenile, rearing, staging) at each segments.

Table 8: Fish species suspected to inhabit Slocan Lake and observed during survey

COMMON NAME	SPECIES CODE	SCIENTIFIC NAME	FISH OBSERVED
Bull Trout	BT	*Salvelinus confluentus*	
Burbot	BB	*Lota lota*	x
Cyprinids spp.	C		x
Dace spp.	DC	*Rhinichthys spp*	
Dolly Varden[1]	DV	*Salvelinus malma*	
Eastern Brook Trout	EB	*Salvelinus fontinalis*	
Kokanee	KO	*Oncorhynchus nerka*	x
Lake Chub	LKC	*Couesius plumbeus*	
Largescale Sucker	CSU	Catostomus macrocheilus	x
Mountain Whitefish	MW	*Prosopium williamsoni*	x
Northern Pikeminnow	NSC	*Ptychocheilus oregonensis*	x
Peamouth Chub	PCC	*Mylocheilus caurinus*	
Prickly Sculpin	CAS	*Cottus asper*	
Rainbow Trout	RB	*Oncorhynchus mykiss*	x
Redside Shiner	RSC	*Richardsonius balteatus*	x
Sculpin spp.	CC	*Cottus spp.*	x
Slimy Sculpin	CCG	*Cottus cognatus*	x
Torrent Sculpin	CRH	*Cottus rhotheus*	x
Westslope Cutthroat Trout	WCT	*Oncorhynchus clarki lewis)*	
White Sturgeon	WSG	*Acipenser transmontanus*	

[1] Dolly Varden and bull trout are very similar species and the species are often mistaken for each other (McPhail 2007). Both species have been documented for Slocan Lake, although it is unknown whether Slocan Lake contains the Dolly Varden or a hybrid species.

Eleven of the 20 potential fish species suspected to be found in the lake were observed during the survey. Cyprinids observed or recorded in the FISS database (2010) for Slocan Lake, were not identified as to species. The species breakdown for each of these groups is as follows:

- Sport fish species:
  - Fish observed: kokanee, rainbow trout, mountain whitefish and burbot
  - Fish not observed: westslope cutthroat trout, bull trout and Eastern brook trout
- Non-sport fish species:
  - Fish observed: redside shiner, northern pikeminnow, largescale sucker, slimy and torrent sculpins and fish not identified as to species were recorded as Cyprinids (spp) and Sculpins (spp)
  - Fish not observed: lake chub and peamouth chub

A total of 4,141 fish representing 11 fish species were observed during the foreshore assessment. The survey confirmed that a variety of shore types are used by the different fish species. Significantly fish communities were more diversified in shore types associated with stream mouth or gravel. Redside shiners constituted 67.3% of the total fish community observed and were mostly found along cliff/bluff, gravel and rocky shore types. Mountain whitefish was the second most abundant species observed, representing 16.7% of the total and were found along rocky, stream mouth and cliff/bluff shore types. It was only along the modified shores that no fish were observed.

1. Sport Fish Species

Slocan Lake is known for its year-round fishing and for the sizeable rainbow trout that are often caught, but there is very little available data on the sport fish species in the lake. Sport fish in Slocan Lake are generally adfluvial species which migrate from the lake to spawn in tributaries or the Slocan River which is the lake's sole outlet. When compared with the documented kokanee shore-spawning requirements for Kootenay Lake, Slocan Lake contains ample shore-spawning sites (upwelling on gravel beaches) which would make lake spawning possible but there is, as yet, no record of this occurring. More details on habitat conditions are provided below.

Stream resident species, such as the westslope cutthroat trout and rainbow trout, which spend their lives in the lake watershed tributaries, were outside the scope of the present study. Of the seven sport fish species likely to be present in Slocan Lake, brook trout is the only non-native one. There are two families of sport fish suspected to be found in Slocan Lake:

- Salmonidae Family:
  - Native salmonidae species: bull trout, kokanee, mountain whitefish, rainbow trout, and westslope cutthroat trout
  - Non-native salmonidae species: brook trout
- Gadidae (cod) Family: burbot

During the 2008 field survey, four of the seven sport fish species were observed: kokanee, rainbow trout, mountain whitefish and burbot. Sport fish abundance in the lake was found to be low (Appendix C). No brook trout were observed. Rainbow trout observations represent 0.27% of the total fish community observed. One burbot was observed. Low burbot representation is understandable since the species is not commonly seen along the foreshore. Kokanee observations represented 0.56 % of all the fish communities observed. Mountain whitefish recorded represent 16.7 % of the total fish community observed.

Sport Fish Species Observations:

Kokanee (Oncorhynchus nerka):

Twenty-three adult kokanee carcasses were found in five different segments. Two of the five segments were located within the alluvial fan of a creek. Skin color and carcass size suggest that these fish were all recent spawners. This survey was conducted in October, just after the kokanee spawning period, so it is likely that these carcasses were flushed down the creeks after spawning. Though one carcass was found on Segment 25, far from any creek outlet, the survey did not detect any evidence of lake-spawning activity for this species.

Slocan Lake was stocked with kokanee seven times between 1930 and 1948, and once more in 1985. Earlier stockings consisted of anywhere between 10,000 and 200,000 fish and eggs. In 1985, 7,500 kokanee fry were released. Very little is known about kokanee in Slocan Lake and there is virtually no information available in any of the literature. Like Okanagan and Kootenay lakes, Slocan Lake is suspected to have two distinct ecotypes of kokanee within its watershed, categorized as stream spawners and lakeshore spawners (Andrusak *et al.* 2002). The quality and quantity of spawning habitat in Slocan Lake is mostly unknown (Andrusak & Wilson 2003). There is no indication in the literature of kokanee lakeshore spawning in Slocan Lake. Andrusak suggests that, based on observed spawner production of 5 % to 7% of total in-lake abundance for Arrow Lake and Kootenay Lake, a first cut estimate of spawner numbers required to support the Slocan Lake kokanee population would be 50,000 to 100,000. Total stream spawner numbers are estimated at less than 50,000. Thus, there is a strong possibility of an undetected spawning stock contributing to lake production. Andursak also speculates that it is likely that Slocan Lake contains good spawning, rearing and overwintering habitats, cover and food sources given its size and pristine condition. The main creeks draining into the lake which have been documented as providing spawning habitat for kokanee include Enterprise, Silverton, Carpenter, Wilson, Bonanza, Wragge and Shannon Creeks. Wilson and Bonanza Creeks were found to contain particularly good spawning habitat for kokanee.

Rainbow trout (Oncorhynchus mykiss):

Eleven rainbow trout were observed during this survey. Most rainbow trout were observed at the lake outlet (Segment 1) and in the outflow of a creek. Rainbow trout is suspected to use the lake and its foreshore for rearing, feeding, migrating and overwintering. These fish seem to prefer sand and cliff/bluff shore types and stream mouths. The cliff/bluff shore type provides an ideal

environment for the species to prey on smaller fish which can be trapped up against the rock face. The alluvial fans provide opportunities for foraging and staging.

Since 1915, rainbow trout (Gerrard and Pennack strains) have been released into Slocan Lake and the lake was stocked annually from 1992 to 2002 (except for 1993). This stocking program was a government-sponsored effort to establish a spawning adult population within the Slocan Lake watershed. The Ministry of Environment, Lands, and Parks (MELP) also stocked Bonanza, Carpenter, Silverton and Wilson Creeks in the hope of establishing a solid rainbow trout population in the streams feeding Slocan Lake. Gerrard trout yearlings were stocked annually into these streams (Kokanee 1997). As many as 20,000 fish were stocked annually during the MELP program.

Little is known about the life history of the lake rainbow trout population. Habitat for the rainbow trout populations in the Slocan Lake watershed is extensive but in the tributaries suitable habitat is available only in the lower reaches (Timberland 2000 & 2003). Young fish are known to migrate to the lake habitat, to feed and find refuge. With the rise in water temperatures during the summer, the fish migrate to the colder waters in the water column (thermocline or hypolimnion layers). Upper reaches of the tributaries are usually too steep or encumbered with obstacles for rainbow trout to reach there. According to Baxter and Roome (1998), rainbow trout are expected to use Slocan Lake for overwintering and as a migratory corridor to gain access to their tributary spawning grounds. These fish can travel a considerable distance: a rainbow trout, tagged in the Slocan River, was angled at the mouth of Wilson Creek.

Stocked Gerrard strain rainbow trout can reach considerable size in Slocan Lake, making the fish highly prized by anglers.

Burbot (Lota lota):

The carcass of a burbot was found along the shore at Segment 19. The fish weighed approximately 4 kg. No live burbot were observed during the survey. Although burbot was not registered in the Slocan Lake FISS database, the species is often caught by anglers. Due to its decline in nearby lakes, protection of this species' habitat in Slocan Lake is critical. Evans Creek, at the south-west corner of the lake, was the only Slocan Lake tributary in which burbot presence was documented (FISS 2010).

According to Taylor (2001), habitat requirements for burbot include good cover, gravel and cobble substrate for young-of-the-year (YOY) and larger substrates of cobble and boulder to provide shelter for juveniles. The species is also attracted to areas of profusely branching aquatic vegetation such as pondweed. Taylor (2002) reported that predators of juvenile burbot could include fish species such as torrent sculpins and trout. Birds could also affect juvenile survival along the shoreline of Slocan Lake.

Little information is available on what may constitute an adequate food supply for successful rearing of burbot YOY (Bonnar *et al*, 2000). Telemetry studies indicate that burbot are often located near the mouth of large creeks (Bonnar 2000, Redfish 1998, McPhail & Paragamian 2000). This was confirmed in the Arndt & Baxter study(2006) of Arrow Lakes. General habitat information from other studies suggests that rearing, staging, and spawning habitats are abundant in Slocan Lake. The Wilson Creek alluvial fan, for example, is known by local anglers to contain burbots.

Mountain Whitefish (Prosopium williamsoni:

In total, 585 mountain whitefish were recorded during the survey at 15 segments including several creek mouths. Some of the fish observed within an alluvial fan appeared to be in staging mode. The species was often seen feeding along the shoreline in shallow turbid water agitated by wave action or feeding in deep waters at the edge of the littoral zone in the outflow of a creek. Most of the fish observed were adults. The juveniles observed generally appeared to be using the edge of the littoral zone. As recorded in Okanagan Lake, adult mountain whitefish were typically associated with deeper habitats, such as cliff/bluff, rocky and gravel shore types. According to the literature, during the spring and after spawning, adult mountain whitefish prefer shallow waters where they feed until water temperatures become too high. In Okanagan Lake, the species was found to spawn along the waterfront where the substrates were composed of boulders, a large percentage of cobbles (60%) and gravel (25%) (EBA 2006). This type of habitat is abundant in Slocan Lake and thus makes it very probable that mountain whitefish are spawning in the lake.

Mountain whitefish is known to use some of the lake's main tributaries, such as Enterprise, Bonanza, Wilson, Evans, Shannon and Wragge creeks and the Slocan River (FISS 2010). There is no information available on mountain whitefish lakeshore spawning in Slocan Lake but the deep pools and fast water of many of its tributaries offer good spawning habitat for the species (Northcote & Ennis 1989). The literature and data suggest that the adfluvial forms of these native sport fish species use the lake as a migration corridor to gain access to their spawning beds, located in other parts of the Slocan Lake system (Mirkwood 1996). The main creeks which have been documented as providing spawning habitat and a source of sport fish recruitment include: the lake outlet (Slocan River), and Enterprise, Silverton, Carpenter, Wilson, Bonanza, Wragge, Nemo and Shannon Creeks (Kokanee 1997 & 2001, Timberland 1999, 2000 & 2003). Wilson and Bonanza Creeks, were found to be particularly important creeks for spawning, along with the Slocan Lake outlet (Timberland 2003, Gebhart 2000). Fisheries production in some of the smaller tributaries is likely limited by excessively steep slopes and swift water flows.

Non-Observed Sport Fish Species

Eastern Brook Trout (Salvelinus fontinalis):

Though this non-native sport fish species was not observed during the survey, brook trout is recorded in the FISS database as inhabiting Slocan Lake and the Slocan River. Other than the FISS, which documents observations of the species in the 1980s, there is no other record of brook trout

presence in the lake. In addition, there has been no report of a brook trout capture by anglers in years. All fish sampling initiatives conducted in the Slocan River in the last thirty years have come up empty. The evidence seems to indicate that brook trout is no longer present in the Slocan Lake watershed.

Summit Lake, unlike Slocan Lake, has been regularly stocked with this non-native species since 1967. Summit Lake is the headwater lake of Bonanza Creek, one of Slocan Lake's largest tributaries but a screened gate, located at the far upstream section of the creek, was installed in the nineties to prevent the introduced fish from migrating to Slocan Lake. It may be that the introduced brook trout made its way to Slocan Lake before the installation of the screened gate and have disappeared since then.

As is the case in many lakes in southern BC, little is know about the life history of the introduced brook trout. The species competes with the bull trout for habitat and food. According to Riemen and McIntyre (1993), introduced brook trout have been associated with the decline and the displacement of bull trout populations. Hybridization appears to be a common problem where isolated or remnant bull trout populations overlap with brook trout. Hybrids are likely to be sterile and experience developmental problems (Rieman & McIntyre 1993). Both species are likely to spawn at about the same time and in the same places and require similar optimum temperatures for egg incubation. Brook trout likely have a reproductive advantage over resident bull trout because they mature earlier.

2. Non-Sport Fish Species

The non-sport fish species are often viewed as competitors of the more desirable fish species. Of the nine species suspected to be found in the lake, seven were observed during the survey. The species observed were cyprinids spp., redside shiner, northern pikeminnow, largescale sucker, sculpins spp., torrent sculpin and slimy sculpin. The non-sport fish species in Slocan Lake are all native to the Kootenays (Region 4-MOE) and are members of three different families:

- Cyprinidae (minnows and carps): redside shiners, dace (general), northern pikeminnow, lake chub, and peamouth chub;
- Catastomidae (suckers): largescale sucker; and
- Cottidae (sculpins): torrent sculpin, slimy sculpin, sculpin (general).

The Cyprinidae is the largest family of freshwater fish, commonly known as the carp and minnow family. They are recognized by the typically ventral mouth, which is well adapted for bottom feeding, and by their large head, stocky body and flat skull.

Non-Sport Fish Species Observations

Redside shiners were the most numerous cyprinids sampled during the 2008 snorkeling survey, representing 67.3 % (2,003 fish) of the total fish communities observed. Sculpins came next, representing 9.2 % of the total fish communities. The largescale sucker was the only member of the Catastomidae family observed with 122 fish observations representing 2.9 % of the total fish communities. Ninety one unidentified cyprinids (2.5%) and 127 northern pikeminnows (0.53%) were observed.

Redside Shiner (Richardsonius balteatus):

Redside shiners represented the highest percentage of the fish communities observed during this study. These fish were found to use every shore type habitat along the lake except the stream outlets. Northern pikeminnows and mountain whitefish were also observed feeding on shiners. During the snorkeling survey, redside shiners were found around gravel beaches and most of the rock clusters at the base of cliff walls or using dock structures as shelter. The evidence indicates that spawning and rearing habitats for this species are abundant in Slocan Lake.

Redside shiners are native to Slocan Lake but were introduced to many interior lakes as a food fish for rainbow trout. Redside shiners are an important component of Slocan Lake since they form the diet of many fish and aquatic species. According to the literature review, the species has been found in only one of the lake tributaries, Evans Creek. Since lakes, ponds and slow rivers are the species preferential habitat, shiners found in creeks will often be within the lower reaches of the creek. Shiners like shallow water during the day, and retreat to deep water at night. They are social fish and are often observed in schools.

Slimy sculpin (Cottus cognatus) & Torrent sculpin (Cottus rhotheus):

Sculpins were present in all shore types except for the modified shore type. Of the 1179 sculpins observed, 229 were not identified to species, 935 were slimy and 15 torrent sculpins. Most of the unidentified sculpins were observed along the gravel and the rocky shore types.

Although these two species are distinct, they will be discussed together because both species have similar life histories, occupy similar habitats and have overlapping ranges. Studies conducted in Montana lakes indicate that the slimy sculpin is the only other sculpin species that has been found to cohabit with the torrent sculpin (Lindstrom 2005). Whereas, interbreeding between the two species is possible, the limited genetic work that has been conducted has not shown any evidence of hybridization (Hendricks 1997). In British Columbia, the slimy sculpin occurs in the southeastern and northern parts of the province (McPhail 2007, Scott & Crossman 1990). According to Hendricks (1997), the species inhabit cold, clear streams but are also found along gravel beaches and in lake inlets. In lakes, the fish will be usually found in shallow water. Slimy sculpins are a common prey item of burbot and of trout species.

The torrent sculpin is a unique western North American species endemic to the Columbia Basin occurring within the Columbia system from its estuary to its headwaters (Scott & Crossman 1990). The species prefers a fluvial environment but can also be found along lake foreshores. It is most abundant when stable cobble or gravel substrate is available. The species likely uses the interstices in coarse substrate as cover and as a place to find food (Lindstrom 2005). Torrent sculpins are particularly fond of redside shiners and northern pikeminnow (McPhail 2007, Scott & Crossman 1990).

According to the literature, it is obvious that both species eat much the same food as other salmonid sportfish. However, sculpins feed almost exclusively along the lake bottom and may therefore not be in direct competition with the salmonids which are not primarily bottom feeders. The sculpin species were not considered to be species of significance for the Slocan Lake.

4.1.3 Rare & Endangered Species

Wildlife Species:

According to the CDC (2011), there are nine mammal, eight bird, one amphibian and three reptile species provincially or federally listed as 'at risk' within the region. Sensitive wildlife species potentially inhabiting the Slocan Lake foreshore are outlined in Appendix D. None of the animals appearing on that list were seen during the field survey. Only species associated with the terrestrial, lacustrine and palustrine habitat types were considered in this assessment.

Mammals: Nine mammal species are listed under the CDC list. Of these species, none was observed during the field survey. These species are; the Townsend's big-eared bat, the badger, the wolverine, the fisher, the fringed myotis, the caribou, the bighorn sheep, the grizzly bear and the red-tailed chipmunk. The lake foreshore may offer suitable habitat for the Townsend's big-eared bat, the wolverine and the fisher. The wolverine and the fisher were previously observed along the lake foreshore. The grizzly bear is rarely observed along the Slocan Lake shore zone. Due to the lack of feeding grounds associated with lower altitude, it is extremely unlikely that caribou will occur within the area.

Amphibians/Reptiles: One amphibian and two reptile species are listed as species of concern under the BC status (blue-listed) for the study area. The Coeur d"Alene salamander, the western painted turtle and the western skink are the species members listed for the Slocan Lake area. None of these species were encountered during the survey. The lake foreshore and the Bonanza Marsh offer possible habitats for the Coeur d'Alene salamander and for the western painted turtle. The western skink is extremely unlikely to occur within interior rainforest climate of the Slocan Lake area.

Two western toads were observed during the field assessment. The western toad is not on the Rare and Endangered species list but is a species of conservation concern in British Columbia

(Environmental Stewardship Division 2011). The western toad is the only "true" toad in British Columbia. The toad is relatively common in most of the province, though population declines are suspected in the south-western region (MOE 2011). The cause for such declines is still uncertain, but a combination of threats is suspected. One of the greatest impacts on western toad populations in B.C. is habitat destruction. Development in and around wetlands can destroy or isolate populations. The western toad is protected under the British Columbia Wildlife Act.

Avian Species: The CDC listing indicates that there are possibly eight bird species that could use the aquatic environment provided along the foreshore for breeding (i.e. particularly wetlands and creek mouths). These species include great blue heron, short-eared owl, bobolink, American bittern, barn swallow, western screech-owl, Lewis's woodpecker and the yellow-breasted chat. None of these species were identified during the 2008 survey. Potential nesting areas for the great blue heron and for the American bittern may occur within the Bonanza Marsh area. Suitable habitats for the barn swallow, the western screech-owl and the Lewis's woodpecker can be found along the lake foreshore. Due to non-existent preferential habitat in the area, it is extremely unlikely that short-eared owl, the bobolink and the yellow-breasted chat would be found along the lake foreshore.

Fish Species:

There are six rare and endangered fish species recorded in the British Columbia Conservation Data Centre (CDC 2010) for the region and three are suspected to be found in Slocan Lake. One is the red-listed white sturgeon and the other two are the blue-listed bull trout and westslope cutthroat trout. None of these species were observed during the survey. Information on these species at risk can be found in Appendix D.

4.2 FORESHORE INVENTORY & MAPPING

4.2.1 Segments Assessment

Foreshore Inventory and Mapping was completed on 87,937m (87.9km) of shoreline on Slocan Lake divided into 28 segments. Only an overview assessment for wildlife habitat was conducted on the wetland portion adjacent to the lake. Specific details on fish, wildlife, and rare and endangered species results are provided in other sections of this report. A detailed description and a photo documentation of all the segments can be found in Appendix B.

1. ***Level of Impact (LoI):*** Compared to other large lakes in the Kootenays, the Slocan Lake foreshore has experienced relatively little disturbance (Figure 3). The low development pressure on the lake is exemplified by the fact that 44.92% (39,500m) of the shoreline is designated as having a low level of impact. Also, 41.52% (36,509m) of the foreshore is still intact, showing no signs of disturbance. 4.73% (4,158m) of the shoreline is considered to have a moderate LoI, while segments classified as exhibiting a high level of impact represent 8.84% (7,770m) of the foreshore.

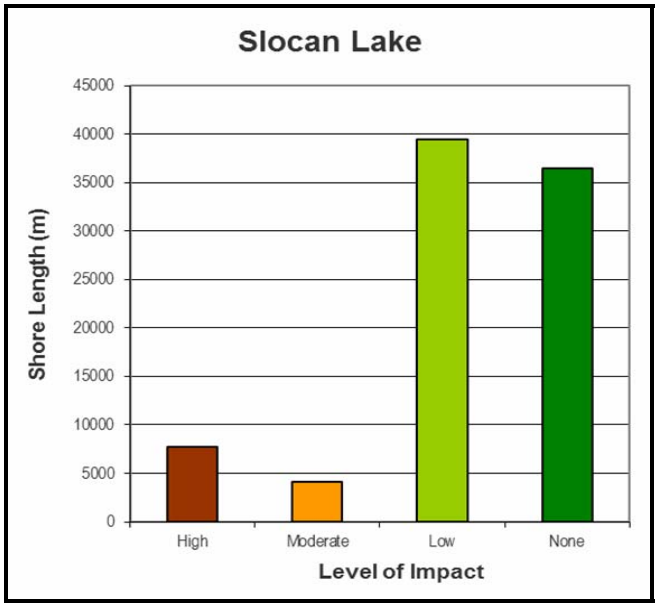

Figure 3: Level of Impact

2. ***Land Use:*** Most of the Slocan Lake shoreline, 89.4% (78,654m), is designated as a Natural Area (Figure 4). The Single Family designation accounts for 7.8% (6,846m) of the Slocan Lake shore. The vast majority of Single Family developments were concentrated within village boundaries. The Park designation covers 2% (1,772m) of the entire shoreline. Valhalla Park lies on the west shore of the lake, and the Rosebery Parklands, under the Regional District jurisdication, are located within the community of Rosebery. The Industrial designation covers 0.9% of the shoreline (788m). Most of this component is located in the town of Slocan and in Rosebery (log dump). The Recreational area represents 0.7% (590m) and includes two Forestry campsites: Bannock Point,

located on the east shore and south of Silverton, and Wragge Beach, located on the northwest corner of the lake.

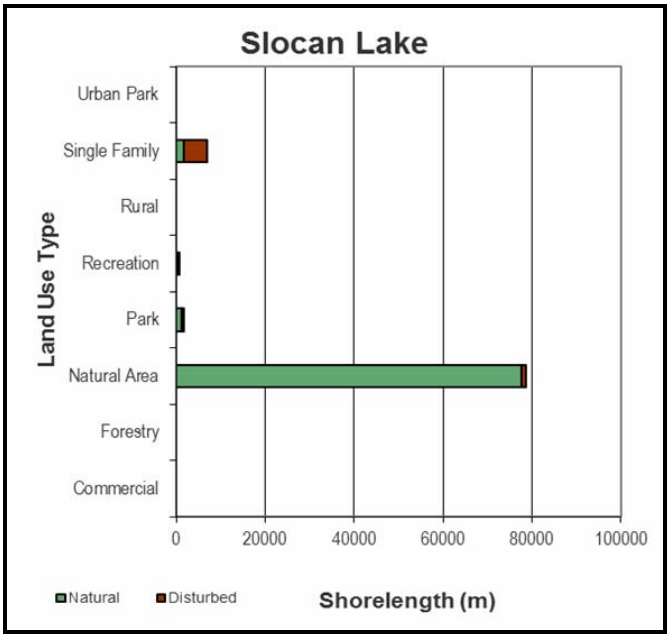

Figure 4: Land Use types

3. ***Slope:*** The slope analysis indicates the slope as a percentage in the upland areas above the high water mark. Figure 5 outlines the different slope categories, the length of shoreline characterized by each category and the state of the foreshore (Natural or Disturbed). Since they are easier to access, areas with a Low or Moderate gradient tends to have a higher level of disturbance. Most low gradient foreshores were found within village boundaries and communities within the RDCK land base. Table 9 provides a detailed description of shoreline slope.

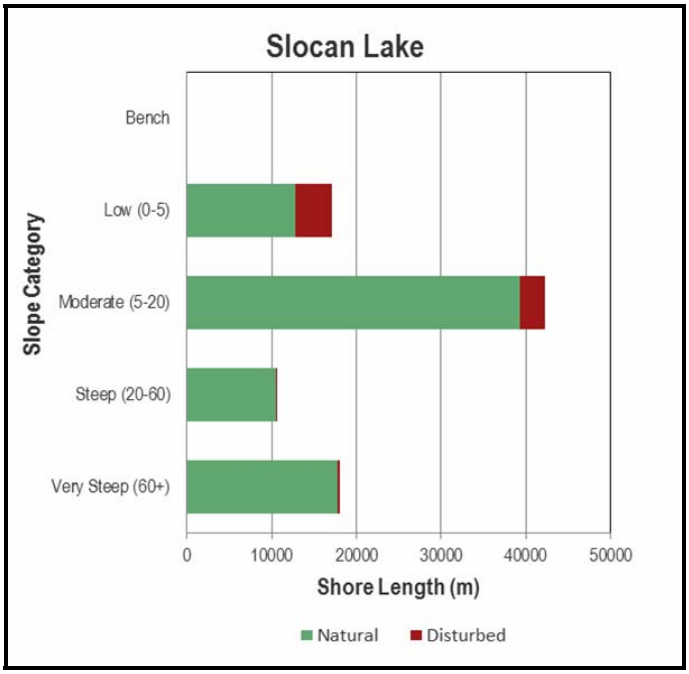

Figure 5: Slope categories

Table 9: Percentage of natural and disturbed shore lengths within each of the different slope categories

Slope	Total Shore Length (%)	Total Shore Length (m)	Shore Length Natural (m)	Shore Length Disturbed (m)	Natural (%)	Disturbed (%)
Very Steep (60+)	20.5	18030	17794	236	0.0	0.0
Steep (20-60)	12.0	10533	10518	15	99.9	0.1
Moderate (5-20)	48.1	42286	39257	3029	92.8	7.2
Low (0-5)	19.4	17087	12747	4340	74.6	25.4
Bench	0.0	0	0	0	0.0	0.0
Total	100.0	87937	80316	7621	91.3	8.7

4.3 AQUATIC HABITAT INDEX (AHI)

4.3.1 Biophysical Characteristics Results

Eight biophysical characteristics were used to calculate the Slocan Lake AHI; Shore type, Substrate, Percentage Natural, Aquatic Vegetation, Shoreline Vegetation, Foreshore Modifications and Modifiers.

1. Shore Type

The most predominant shore type observed around Slocan Lake was rocky shores, which accounted for 41.4% or 36,441 m of the total shoreline. Cliff/bluff areas are the next most predominant shore and occur along 37.5% or 32,963 m of the shore. Gravel beach accounts for 17.4% (15,274m), stream mouth for 2.5% (2,212m) and sand beach for 1.2% (1,048m). Figure 6 presents the length of natural and disturbed shoreline along each of the different shore types on Slocan Lake.

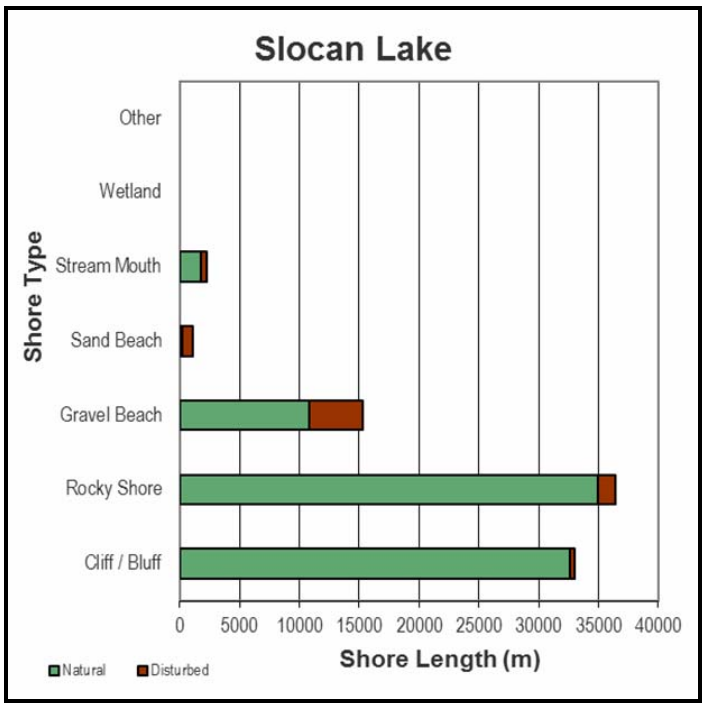

Figure 6: Shore type on Slocan Lake

***Stream Mouths/ Lake Outlet*:**

Together with descriptions of the segments, the stream assessments can be found in Appendix B. Stream mouths and the lake outlet are identified as light blue zones on the maps. With the segments description, Appendix B outlines a description of the assessments conducted on eight streams. Although all stream mouths and the lake outlet were designated as zones of sensitivity, only eight stream mouths, plus the lake outlet, were assessed during this survey (Table 10). They have been designated zones of sensitivity. The creek riparian zones were found to be high use areas for birds and ungulates. These streams are influenced by urbanization and development to varying degrees.

In mountainous regions such as the Slocan Valley, creek channels can provide important wildlife corridors connecting the lake foreshore to the upland areas. The stream mouths and lake outlet are also crucial areas in the life history of many fish and wildlife species and are considered to be highly sensitive to alterations because they meet so many fish and wildlife habitat requirements. They contain the majority of critical habitat for most fish species that require fluvial environments at some time in their life cycle (e.g. rainbow trout, bull trout, kokanee, mountain whitefish, westslope cutthroat trout). For these reasons, all streams were considered to be zones of sensitivity. This zone of sensitivity often extends beyond the immediate confluence at the lake. The influence of water flow, nutrient introduction, sediment deposition, and fish feed delivery can extend beyond the area which is visible on an air photograph.

The stream mouths are indicated on the Mapsheets as a light blue arch extending out from the centre of the stream mouth. The stream mouth and adjacent areas to it are considered as areas of sensitivity and for this reason, their boundary was extended 50m upstream of the creek. Due to the ecological importance of these areas, a buffer zone (or setback distance) was added to the width of each creek outlet. Not all the stream mouths around Slocan Lake were given a detailed assessment. In total, eight streams and the lake outlet were assessed. The assessment of these stream mouths and of the lake outlet followed the segment assessment methodology in Section 2.2 of this report. Large creeks that tend to support multiple fish species, or have been identified by the Stakeholder Group as having sensitive alluvial fan areas, were provided with a 250m arch buffer zone. These creeks include Enterprise, Hasty, Silverton, Carpenter, Wilson, Bonanza, Shannon, Wragge, Wee Sandy, Sharp, Nemo and Evans. A 250m buffer zone was also added to the lake's outlet. All other creeks, with or without recorded fish presence and without an alluvial fan, were accorded a 100m buffer zone each side of the stream mouth. Recorded fish use in each stream was gathered from the FISS database (2011) and from local expertise.

Table 10: Stream mouths and lake outlet assessed during the survey

OUTLET & STREAM MOUTHS	LAT/LON INFORMATION		WATERSHED CODE
Segment 1a Lake outlet	117º 28' 29W	49◦ 46' 09N	340-047200
Segment 4 Enterprise Creek	117º 25' 31W	49◦ 52' 02N	340-047200-72000
Segment 4 Vevey (Aylwin) Creek	117º 23' 45W	49◦ 53' 14N	340-047200-75800
Segment 6 Silverton Creek	117º 23' 44W	49◦ 57' 10N	340-047200-82200
Segment 8 Carpenter Creek	117º 22' 48W	49◦ 59' 20N	340-047200-86300
Segment 10d Wilson Creek	117º 24' 58W	50◦ 01' 49N	340-047200-91700
Segment 12a Bonanza Creek	117º 28' 05W	50◦ 05' 20N	340-047200-99600
Segment 13 Shannon Creek	117º 27' 52W	50◦ 04' 17N	340-047200-97700
Segment 13 Wragge Creek	117º 27' 32W	50◦ 03' 22N	340-047200-96100

2. Substrate

Of the 7 different types of substrate associated with Slocan Lake, Boulder was the most commonly encountered and was found on 26 of the 28 segments. Areas with Gravel (Gravel-Cobble & Gravel-Fines) substrate was spread over 19 segments. Areas with Cobble and Bedrock substrate are represented in equal number, being found on 16 segments. Sand and Fine substrates were the least commonly encountered along the Slocan Lake foreshore where Sand was found on 8 segments and Fine on 7 segments.

Substrate mapping was conducted to determine where major changes in substrates occur. Lakebed substrates are extremely important for a variety of reasons. Fish species generally deposit eggs onto the lake or streambed substrates and certain species are extremely selective about the substrate types used for egg deposition. Substrates, in combination with wave energy and other factors, also act as rooting areas for aquatic vegetation which provides cover from predators, foraging opportunities for benthic macroinvertebrates, and three-dimensional structure (Randall *et al*. 1996). Substrate composition data was collected during the FIM and included an estimation of the percentage of boulders, cobbles, gravel, fines, and bedrock within a given segment. The importance of different substrate types was determined by reviewing the life history requirements of the different species. In general, most lake spawning fish species use cobble/gravel substrates, while areas of finer substrates tend to be used more for foraging because they contain more aquatic macrophytes and can be penetrated by rooting and foraging fish species (e.g., suckers and whitefish). Data collected during the fisheries assessment, coupled with published species life history data, was used to rank substrates from most to least important. Substrates used for reproduction were considered to be more critical than those used for foraging because spawning areas with suitable substrates are often a limiting factor to the productive capacity of habitats for several fish species in Slocan Lake.

Cobble substrates were ranked as the most valuable littoral zone areas in Slocan Lake because of the spawning habitat which they provide, and were accorded the maximum value of 12. Gravel shores can be used for spawning and therefore, were rated as a 10. Boulder, Organic, Mud, Marl and Fines shores offer feeding grounds for fish communities and were rated 8. Sand shores offer little fish habitat quality and therefore, were rated as a 4. Bedrock substrate is common along Slocan Lake and would not be expected to provide spawning habitat or very valuable forage habitat for fish or other wildlife species; it was provided with a habitat value of 2.

Gravel and rocky substrate are often associated with shallow shelves. Gravel is used by fish species at different stages of their lives (Scott & Crossman 1990, Andrusak 2006). Aquatic invertebrates and phytoplankton inhabit the interstices of the substrate in these warmer, shallow water zones. Young rainbow trout and redside shiners will often use these areas as feeding grounds and shelters. Gravel substrate is not common along the Slocan Lake foreshore but it is of high ecological value, providing potential rearing, staging, feeding and spawning habitats for fish species. Since information on typical species requirements is not available for Slocan Lake, the Stakeholder Group identified extended gravel areas as relatively rare habitats corresponding to potential rearing, staging, feeding and spawning habitats for fish species.

3. Percentage Natural

Most of the Slocan Lake shoreline is in a natural state. The total length of disturbed shoreline is 7.6 km, which represents 8.67% of the shoreline. The total length of natural shorelines is 80,316 m or 91.33% of the total (Table 11). Figure 7 presents the total shoreline length that is either natural or disturbed on Slocan Lake.

Table 11: Total shore length of natural and disturbed shorelines

Shore Type	% of Shoreline	Shore Length (m)
Natural	91.33	80316
Disturbed	8.67	7621
Total	100	87936.8

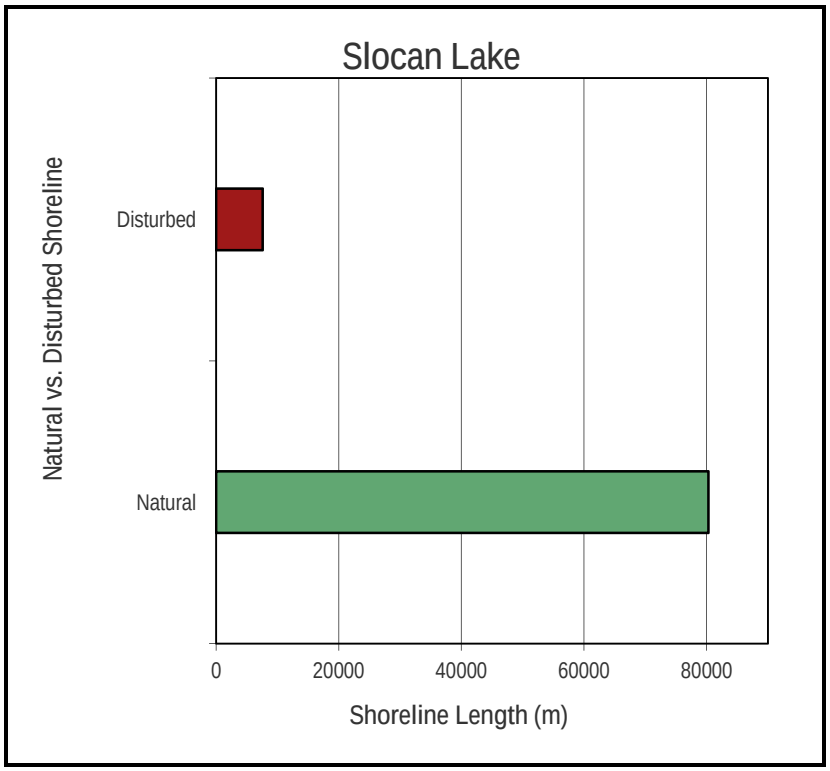

Figure 7: Natural and disturbed shoreline lengths on Slocan Lake

The following figure, Figure 8 presents the natural and disturbed shoreline length by the different types of land use. Around Slocan Lake, the largest land use type are the natural areas. These natural areas along the shore zone are approximately 98.7% natural. Park land use areas show 37.7% disturbance, caused

mainly by tree removal, pedestrian trails and beach grooming. Forty percent of the recreation land use areas was found to be disturbed. Single family land use segments were 75.9% affected by disturbance. This category represents a shoreline characterized by high occupation in the villages and clustered habitations within Regional District jurisdiction. Industrial land use areas are 100% disturbed.

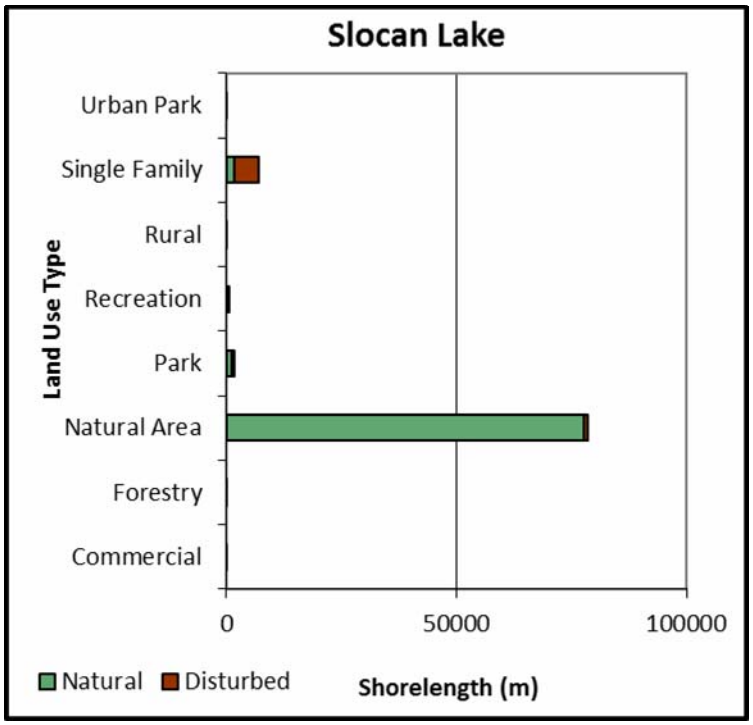

Figure 8: Natural and disturbed shoreline according to land use type

Figure 9 presents the length of natural and disturbed shoreline along each of the different shore types on Slocan Lake. Sand beaches represent the most disturbed shoreline with 82.9% disturbance (868.9m). This is reflective of the high use made of these zones by tourists and locals. Gravel beaches and stream mouths have the next highest incidence of disturbance at 29.1% and 20.9% respectively. Rocky shore and cliffs/bluffs were the least disturbed shore types, each at 4%. Difficulty of access protects these areas from being disturbed.

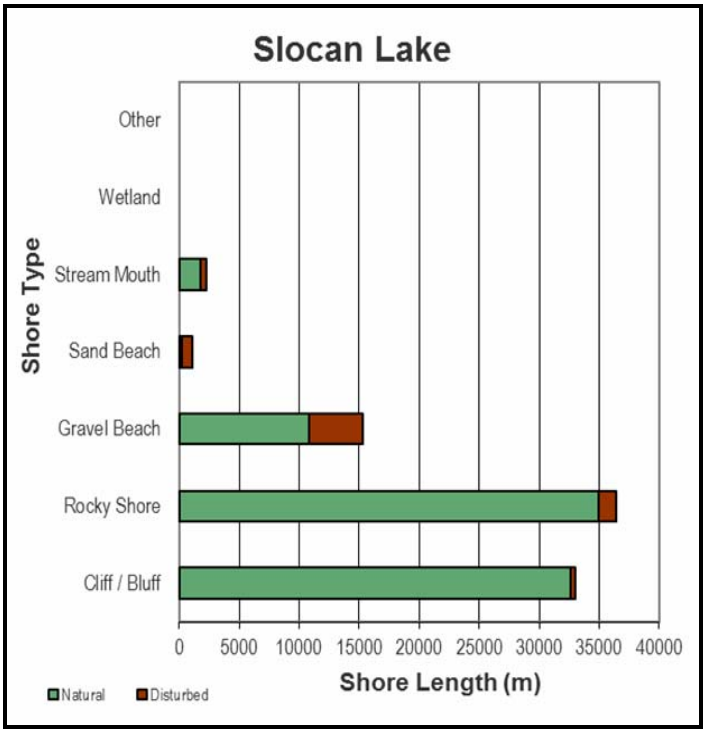

Figure 9: Natural/Disturbed according to shore type

5. Aquatic Vegetation

Aquatic vegetation is loosely defined as any type of emergent, submergent or floating vegetation that occurs 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 levels. Studies have shown that during periods of inundation even terrestrial vegetation provides important food for juvenile salmonids and other aquatic life and this is why it has been included. In total, there is approximately 7999 m of shoreline that has aquatic vegetation, spread over 18 segments and representing approximately 9.1% of the entire shoreline (Figure 10). Instead of being concentrated in specific areas, the presence of aquatic vegetation is spread all around the lake. Most vegetation that was observed was submergent, along 8.6% (7555 m) of the entire shoreline. Emergent vegetation was scarce and was only observed on 5 segments, covering 0.5% (409m) of the entire shoreline. Floating vegetation was not observed along the lake shore.

Although aquatic vegetation was not identified to species during this survey, no invasive Eurasien water milfoil (*Myriophyllum spicatum*) was observed along the Slocan Lake foreshore. Figure 10 presents the total shoreline length that has aquatic, submergent, emergent and floating vegetation along Slocan Lake.

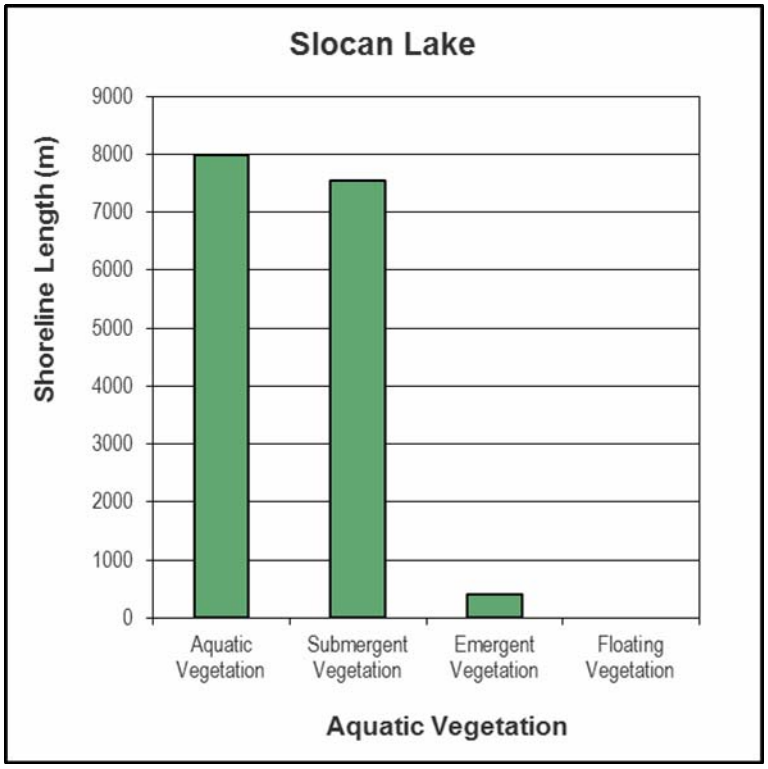

Figure 10: Aquatic Vegetation

Importance of Aquatic Vegetation: In oligotrophic lakes such as Slocan Lake, aquatic vegetation (macrophytes) patches are rare and are of high ecological value for fish habitat. The deep rocky shoreline and cold water offer limited possibilities for macrophyte growth. According to Horne and Goldman (1985), aquatic vegetation is likely to dominate warm sandy or muddy littoral zones in lakes. Young fish likely feed on the microscopic organisms attached to this aquatic vegetation. Macrophytes are so important that in some waterbodies, much of the food chain may be based on the existence of detritus produced by macrophytes. Fish vulnerable to predation use the vegetation cover and varying light levels in these patches to minimize their exposure to sight-feeding predators (Horne & Goldman 1985). In Slocan Lake, sandy or muddy zones are not common and macrophytes are usually present around stream mouths or in calm, shallow areas with fine substrates. During the summer, creek flows diminish considerably, reducing cold water input into the lake, facilitating macrophytes growth in the fine substrate of the alluvial fans.

Presence of macrophyte beds was recorded for the entire lake shoreline. Field assessments included visual observation from a boat and/or snorkelling and the use of an underwater camera. Macrophytes were not identified to species but only recorded for their presence.

6. Shoreline Vegetation

The riparian area (Band1) is the narrow strip of land that borders creeks, rivers and lakes. Due to the proximity to water, plant species of riparian zones differ considerably from those of adjacent uplands.

Although, riparian areas may occupy only a small percentage of the area of a watershed, they represent an extremely important component of the overall landscape.

Of the 28 segments, 23 were associated with the highest Band1 category; the coniferous forest, three with Herbs/Grasses and two with Landscaped type (Table 12).

Table 12: Band1 Classification Results

Segment	Class	Bandwidth	Score
1	Landscaped	50	2.4
2	Landscaped	50	2.4
3	Coniferous forest	50	6.4
4	Coniferous forest	50	6.4
5	Coniferous forest	50	6.4
6	Coniferous forest	50	6.4
7	Coniferous forest	50	6.4
8	Coniferous forest	50	6.4
9	Coniferous forest	50	6.4
10	Coniferous forest	50	6.4
11	Coniferous forest	50	6.4
12	Coniferous forest	50	6.4
13	Coniferous forest	50	6.4
14	Coniferous forest	50	6.4
15	Herbs/grasses	50	4.8
16	Herbs/grasses	50	4.8
17	Coniferous forest	50	6.4
18	Coniferous forest	50	6.4
19	Coniferous forest	50	6.4
20	Coniferous forest	50	6.4
21	Herbs/grasses	50	4.8
22	Coniferous forest	50	6.4
23	Coniferous forest	50	6.4
24	Coniferous forest	50	6.4
25	Coniferous forest	50	6.4
26	Coniferous forest	50	6.4
27	Coniferous forest	50	6.4
28	Coniferous forest	50	6.4

Band2, represents the upland area, most of which is rated very high (Table 13).

Table 13: Band2 Relative Value

Band2 Relative Value	
Segment #	Band2 Relative Value
1	0
2	0
3	0.8
4	0.8
5	0.8
6	0.8
7	0.8
8	0.8
9	0.8
10	0.8
11	0.8
12	0.8
13	0.8
14	0.8
15	0.6
16	0.6
17	0.8
18	0.8
19	0.8
20	0.8
21	0.6
22	0.8
23	0.8
24	0.8
25	0.8
26	0.8
27	0.8
28	0.8

A large portion (82%) of the foreshore vegetation (Band1 and Band2) of Slocan Lake was rated high. The results are demonstrative of a lake with crown lands and parks land uses. Results show that a highly rated Band1 is usually associated with a similarly rated Band2. And, conversely, where one of the vegetation zones is disturbed, the other vegetation zone appears similarly affected. Landscaped riparian zones are associated with landscape upland vegetation.

7. Foreshore Modifications

Although very little of the foreshore length has been impacted by modifications, Slocan Lake has experienced varying degrees of impacts along its shoreline (Table 14). In general, steeper sloped areas (cliff/bluff shorelines) tend to be more natural whereas lower gradient shorelines tend to have a higher

level of impact. The following section summarizes foreshore modifications that were observed during the field surveys. Figure 11 outlines the level of impact around Slocan Lake.

Table 14: Type of Modifications

Type of Modifications	Total (#)	# Per km
Docks	38	0.43
Groynes	66	0.75
Boat Launch	4	0.08
Mooring Buoy	0	0.00
Retaining Walls	29	0.33
Marina	1	0.10
Marine Rails	0	0.00

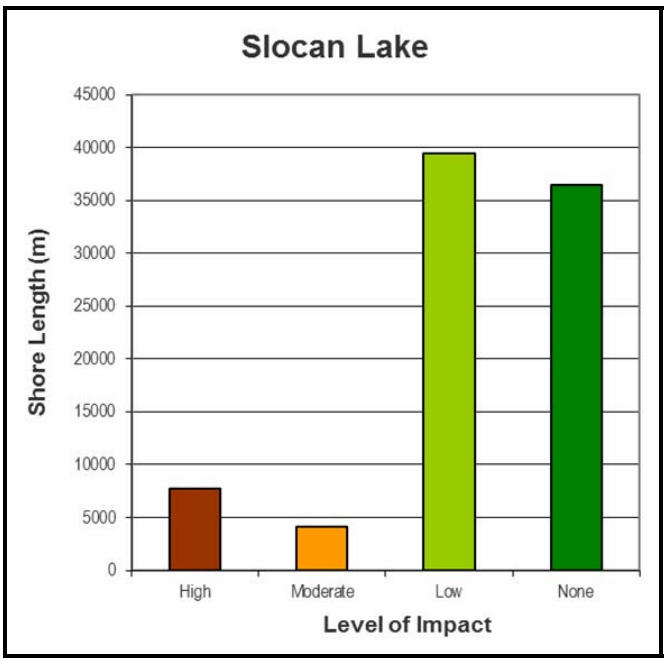

Figure 11: Levels of Impact

Groynes: Groynes, docks and retaining walls were the most common foreshore modifications encountered. A total of 66 groynes (0.75 per km) were observed mostly on the east shore of the lake. Most of the groynes observed were within urbanized land use areas and rural land use areas with a higher concentration of housing. Groynes were found on nine of the 28 segments.

Docks: Docks were the next common type of modification found along the lake, where 38 docks (0.48 per km), spread over 15 segments were counted during the surveys. Again, most docks were observed on the east shore of the lake.

A small dock was recorded at each of the public beaches located within the villages of Slocan, Silverton and New Denver. Small private docks were mostly observed along the shoreline of urbanized land use areas. About 90% of these docks were removable, i.e., not permanently attached to the lake bed or to the shore. Segment 8 has a newly constructed large commercial dock. The dock is permanently attached to the rocky shore and its footprint covered a portion of Enterprise Creek's alluvial fan. One private permanent dock can be found on Segment 18. The dock is fixed to the littoral bed with large concrete blocks. Both these docks do not comply completely with government best management practices.

Retaining Walls: Twenty nine retaining walls (0.33 per km) were recorded, mostly at the north end of the lake and along the east shore. Two of these walls were classified as industrial in Segment 2 and Segment 15 (Figure 12Figure 12) and small private retaining walls were spread over 13 segments. The retaining walls are constructed out of various materials. Some of these walls may have not been built to prevent shoreline erosion but purely for aesthetic purposes and could thus have been prevented.

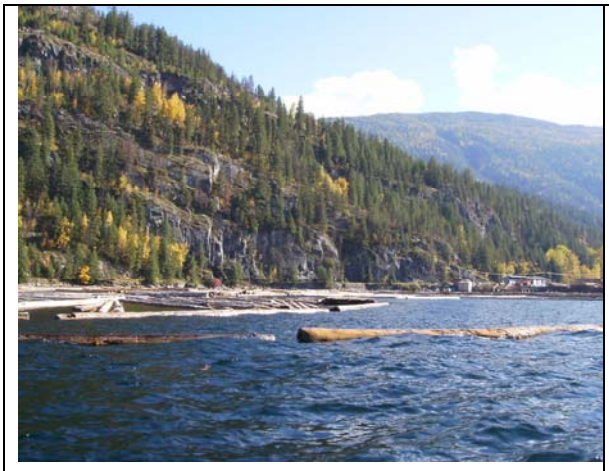

Photo 1: Industrial retaining wall on Segment 2

Photo 2: Industrial retaining wall on Segment 15

Photo 1: Private retaining wall

Photo 2: Private retaining wall

Figure 12: Industrial and private retaining walls along Slocan Lake foreshore

Marina/Boat Launches: Slocan Lake has a single public marina located in New Denver. The marina is a land-locked type connected to the lake by a man-made water way built within the foreshore.

Slocan Lake has four public boat launches that belong to the villages of Slocan (Segment 1), Silverton (Segment 10, Figure 13), New Denver (Segment 12) and the Regional District of Central Kootenay (Segment 16 in Rosebery). All boat launches are equipped with a concrete slab acting as a boat launch. Private boat launches were not observed during the field survey.

Boat launches and the marina cover a total shoreline length of approximately 1000m and their impact on fish and fish habitat is considered minimal. Marina and boat launches are often associated with vehicular access that impacts directly on the riparian vegetation. But the marina and boat launches on Slocan Lake were built in highly disturbed areas located within village or community boundaries and riparian vegetation removal was not required for their construction.

Figure 13: Silverton boat launch

Modifiers: The percentage of the shoreline that has been impacted by roads, retaining walls, and where substrate modification has occurred was recorded.

Railway construction has impacted 11% (9339 m) of the entire shoreline. A deactivated railway line runs slightly above the foreshore area along Segments 13, 14, 18 and 19. The railway was transformed into a pedestrian trail (Galena Trail) and its impacts on fish and wildlife is deemed minimal. There is still evidence of engineering structures to retain the railway bed along Segment 19. Riparian vegetation was removed in the past along the railway shoulders and was regularly cleared until the railway deactivation in the eighties. Since the deactivation, a layer of second growth coniferous species can be found on each side of the trail. This new vegetation is enhancing the riparian habitat and wildlife signs were abundant along the trail. The trail's right-of-way along the foreshore also serves to protect the riparian vegetation from the development of the private lands above it.

Substrate modifications were observed along 4% (3,120 m) of the entire foreshore. Most substrate modifications are associated with beach grooming (groynes) and were mostly found within areas with higher development concentrations.

Roadway modifiers represent 3% (2,764 m) of the Slocan Lake shoreline. Except for Segment 18 where the Highway 6 encroaches into the riparian, most roadway modifiers are associated with foreshore access. Most foreshore accesses can be found within the three villages and the communities of Rosebery and Hills.

Retaining walls represent 2% (1,607m) of the shoreline. Most retaining walls are found on the east shore of the lake, within Rosebery. Figure 14 presents the total shoreline length that has been impacted by substrate modification, road and railways, and retaining walls along Slocan Lake.

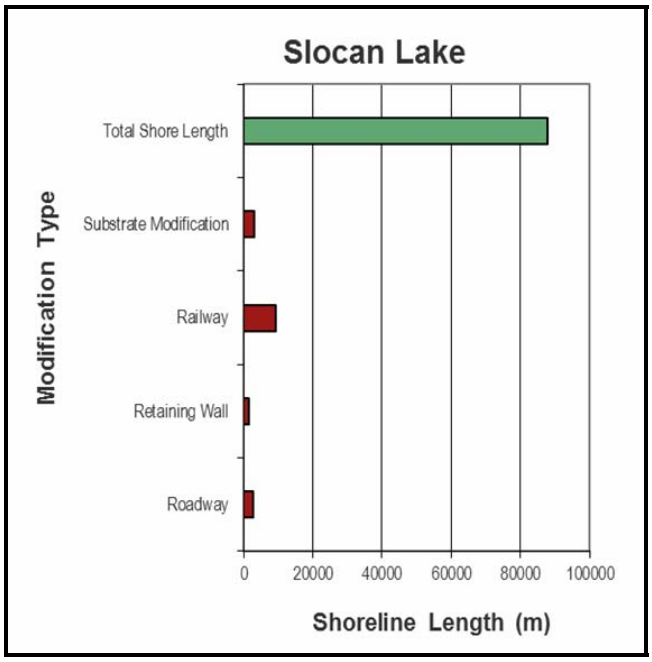

Figure 14: Modification type and shoreline length

4.3.2 AQUATIC HABITAT INDEX SUMMARY RESULTS

The results of the Aquatic Habitat Index are best viewed graphically. They can be found on the 23 maps of the Slocan Lake foreshore and in Appendix E. The habitat rankings accorded by the AHI are: Very Low, Low, Moderate, High, and Very High (Table 15 & 16, Figures 15 & 16).

The AHI is shown in two sets of two values; the Current Value and the Potential Value. The Current Value presents the value of the segment at the moment of the site assessment, while the Potential Value represents what the habitat value would be if the modifications were removed. This serves to identify areas where restoration efforts would be beneficial. Subsequent analysis may help better interpret where restoration may be more feasible and result in the most improvement.

The AHI indicates that 57.2% of the Slocan Lake shoreline ranks as High or very High and 34.3% as Moderate. Only 8.2% is ranked Low, with 0.3% considered Very Low. Current Value and Potential Value are identical for the Very High (11.5%), High (45.7%) and Moderate (34.3%) categories. Results for Low and Very Low categories demonstrated a slight difference between the Current and the Potential values.

The Low category is represented by a 8.2 % Current Value and a 8.5% of Potential Value. The Very Low category is represented by a 0.3% Current Value with a 0% Potential Value.

Very High Rankings: The habitat index determined that a total of 5 segments representing 10090.4 m, or 11.5% of the Slocan Lake total shoreline, were rated Very High. These are segments 9, 17, 20, 22 and 23. Areas of high value are typically located adjacent to undisturbed foreshore or near stream confluences and the wetland area and are associated with aquatic vegetation, gravel and rocky shorelines. Segments 9, 20, 22 and 23 are located away from any type of urban development. Segment 17, though located within Rosebery, was accorded a Very High ranking due to the ecological importance of the Wilson Creek alluvial fan.

High Rankings: Eight segments (10, 11, 12, 13, 18, 24, 26 and 28), comprising 45.7% of the total shoreline, were given a rating of High. These shoreline sites are mostly associated with gravel and rocky shores. Though they are located within the towns of Silverton and New Denver and within the community of Rosebery and associated with 'negative' features such as groynes, docks and scarce riparian vegetation, segments 10, 12 and 18 were rated High due to the proximity and the ecological importance of the Silverton, Carpenter and Wilson creeks alluvial fans.

Moderate Rankings: A Moderate value was assigned to 34.3% of the total shoreline representing 11 segments; segments 1, 2, 5, 7, 8, 14, 16, 19, 21, 25 and 27. Although, Segments 1, 2 and 14 had suitable potential as fish habitat, the Habitat Index rated these segments as Moderate due to their proximity to areas of industrial activity (proximity to the mill in Slocan and the log dump in Rosebery).

Low Rankings: Three segments, or 8.2% of the entire shoreline, were given a Low habitat rating. These segments are 3, 4 and 6 and are associated with Cliff/Bluff shore types. Steep shorelines associated with bedrock tend to bring the AHI lower because these shorelines are utilized to a lesser extent by fish (subsequently are given a lesser weighting in the AHI). Although located within an industrial setting (Slocan), the alluvial fan within Segment 3 boosted the ranking of this segment. Segments 4 and 6 are located in an uninhabited area but because of previous shoreline modifications, the segments ranked Low.

Very Low Rankings: Segment 15, representing 0.3% of the total shoreline was ranked Very Low because of the presence of the Rosebery log dump, a retaining wall and the highly disturbed condition of the riparian vegetation. The large number of submerged logs here has destroyed fish habitat.

Table 15: Aquatic Habitat Index rankings for Slocan Lake showing Current and Potential Values

Categories	Current Value			Potential Value		
	# of Segments	Shoreline Length (m)	% of Shoreline	# of Segments	Shoreline Length (m)	% of Shoreline
Very High	5	10090.4	11.5	5	10090.4	11.5
High	8	40221.9	45.7	8	40221.9	45.7
Moderate	11	30134.2	34.3	11	30134.2	34.3
Low	3	7244.2	8.2	4	7490.3	8.5
Very Low	1	246.2	0.3	0	0.0	0.0
Total	28	87936.8	100.0	28	87936.8	100

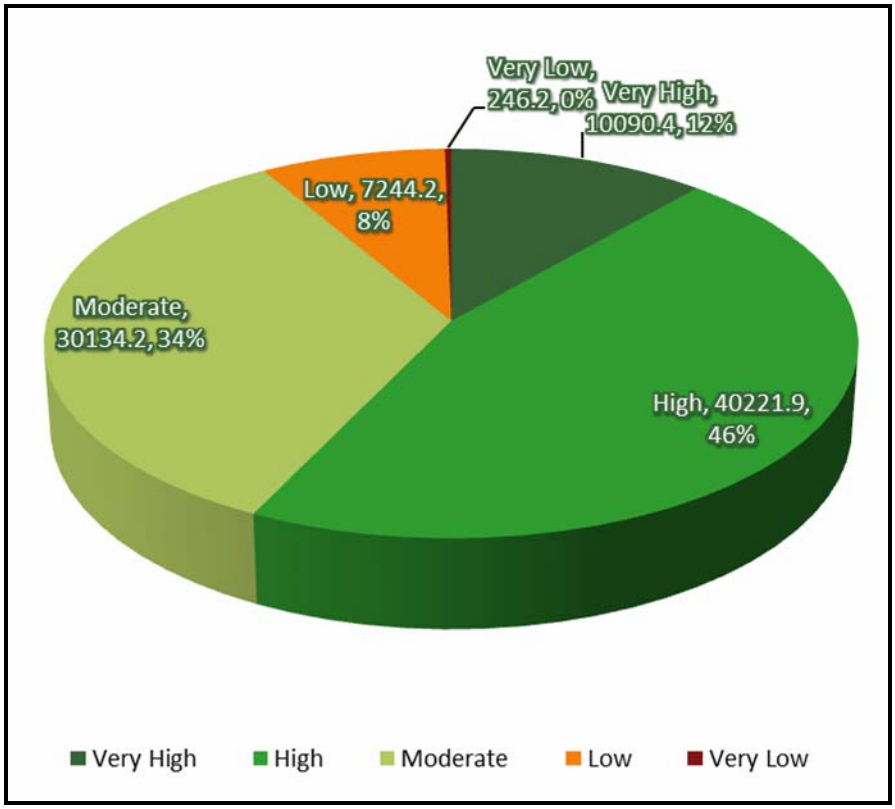

Figure 15: Aquatic Habitat Index rankings for Slocan Lake (Current Values in meters) indicating shoreline lengths in meters and as percentage of total shoreline length

Table 16: Summary of the Aquatic Habitat Index results for the different shore types for the Current Value of the shoreline

Categories	Current Value			Cliff_Bluf		Rocky		Gravel		Sand		Stream_mou		Wetland		Other	
	# of Segments	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline Length	Shoreline Length	% of Shoreline Length	Shoreline Length	% of Shoreline Length	Shoreline Length	% of Shoreline Length	Shoreline Length	% of Shoreline Length	Shoreline Length	% of Shoreline Length	Shoreline Length	% of Shoreline Length
Very High	5.0	10090.4	11.5	0.0	0.0	5224.1	51.8	3682.8	36.5	137.1	1.4	1046.4	10.4	0.0	0.0	0.0	0.0
High	8.0	40221.9	45.7	7341.5	18.3	21819.5	54.2	9777.3	24.3	0.0	0.0	1283.6	3.2	0.0	0.0	0.0	0.0
Moderate	11.0	30134.2	34.3	18436.4	61.2	8970.0	29.8	1619.6	5.4	545.7	1.8	562.4	1.9	0.0	0.0	0.0	0.0
Low	3.0	7244.2	8.2	7185.1	99.2	0.0	0.0	0.0	0.0	0.0	0.0	59.1	0.8	0.0	0.0	0.0	0.0
Very Low	1.0	246.2	0.3	0.0	0.0	0.0	0.0	246.2	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

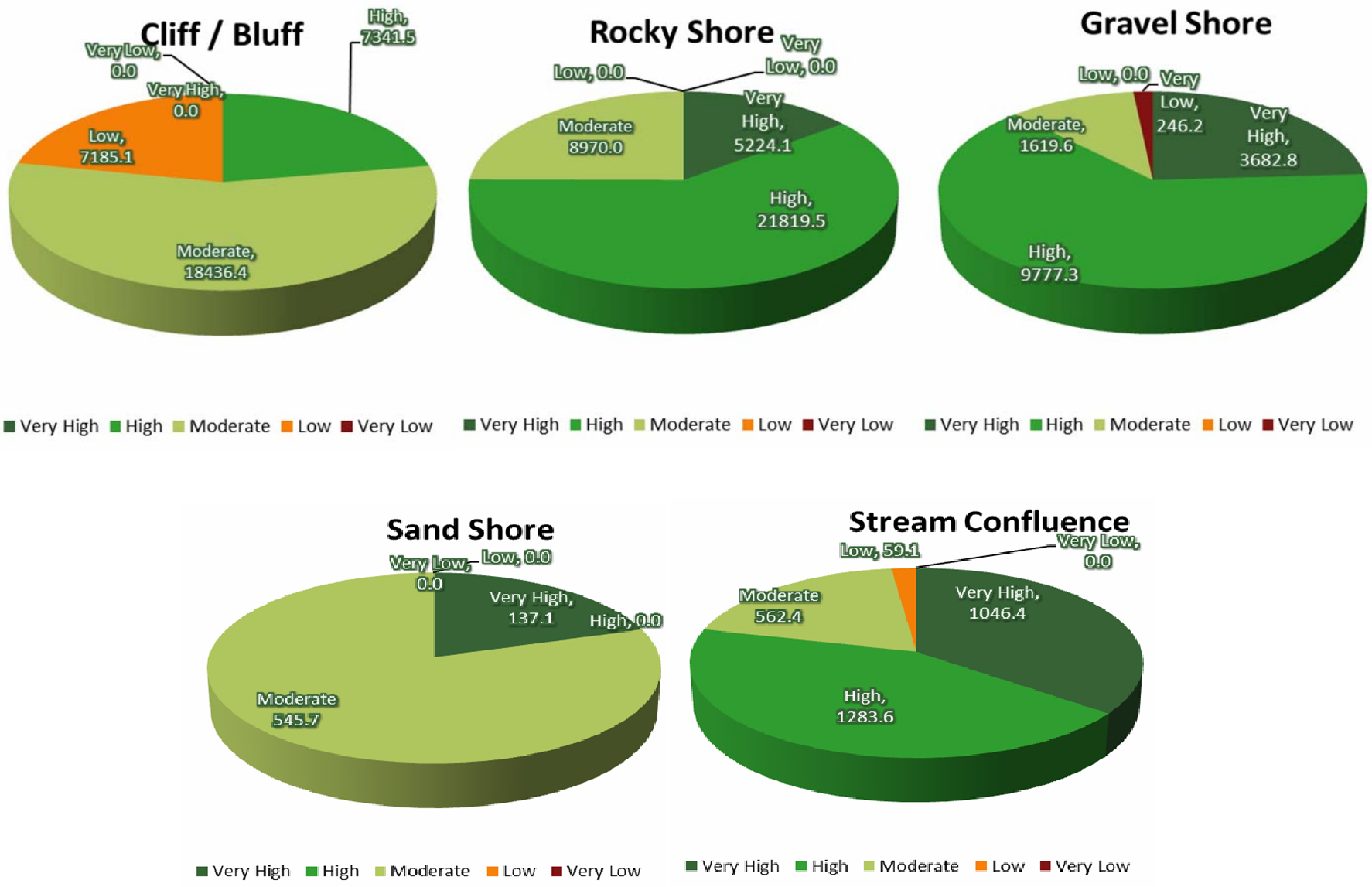

Figure 16: Aquatic Habitat Index rankings for the different shore types indicating shoreline lengths in meters

4.2.2.1 Fish Habitat Suitability

Fish habitat such as Juvenile Rearing, Migration Corridor and Staging Areas were among the fisheries parameters included in the AHI. Rearing habitat for juvenile fish species was ranked High for 11 segments (16,337 m), Moderate for eight segments (53,365 m) and Low for nine segments (18,233m). Table 17 presents the scoring system given to each category and the habitat suitability results.

Table 17: Fish habitat suitability per segment

	Scoring points				
	10				
	6				
	2	3	3		
Segment	Juvenile Rearing	Migration Corridor	Staging Area	Suitability Area (m)	Suitability Category
1	10	3	3	27.2	High
2	10	3	3	24.16	High
3	2	3	3	14.8	Low
4	2	3	0	14.2	Low
5	2	0	0	16.8	Low
6	2	0	0	9.28	Low
7	2	0	0	14.35	Low
8	6	3	3	21.08	Moderate
9	10	3	0	24.06	High
10	10	3	3	25	High
11	6	3	0	19.31	Moderate
12	10	3	3	24.9	High
13	6	3	0	18.76	Moderate
14	2	0	0	14.22	Low
15	2	0	0	15.9	Low
16	6	3	0	19.5	Moderate
17	10	3	3	30.3	High
18	6	3	3	19.6	Moderate
19	2	0	0	14.85	Low
20	10	3	3	27.01	High
21	10	3	3	24	High
22	10	3	3	24.32	High
23	10	3	3	25.86	High
24	6	3	0	18.76	Moderate
25	2	3	3	14.7	Low
26	6	3	3	21.85	Moderate
27	6	3	3	20.72	Moderate
28	10	3	3	27.2	High

5 RECOMMENDATIONS

The results of this study are intended to assist in developing appropriate, effective and well-balanced shoreline management guidelines for Slocan Lake. It is hoped that the FIM and AHI results presented here will be integrated into future development guidelines. The following provides a list of recommendations for the protection of the Slocan Lake foreshore. Some of the recommendations are similar to those in other recent FIM reports and credit should be given to the original authors.

1. Fish and Wildlife Habitat Management: High ranking habitats tend to occur outside of the urbanized areas around the lake. Not only are these areas less impacted by development, but they also contain features and substrates that many species use for rearing, staging and reproduction. In order to maintain and improve the condition of native fish and wildlife populations, it is critical that natural habitat be preserved. The present diversity of habitats created by stream mouths, riparian vegetation and wetland needs to be maintained. Recommendations for fish and wildlife habitat are listed below:

- Wildlife movement corridors that connect the upland areas to the lake foreshore should be identified and developments or encroachments into these areas minimized;
- A wildlife tree survey (wildlife and veteran trees) within 30 m of the shoreline is recommended to identify trees of significance and nesting potential;
- More detailed assessments of the lake stream mouths would enhance our present knowledge of the habitat types they provide for different species;
- Obtain a better understanding of habitat use by kokanee, mountain whitefish, burbot, rainbow trout ;
- A rigorous fish sampling regime should be undertaken for the entire lake;
- A long term creel and angler survey would be beneficial for a better understanding of fish communities and would help in managing future fishing regulations on the lake;
- Conduct inventories of amphibians, reptiles, invertebrates, birds and vascular plants around the lake; and
- Compile a baseline database on the Bonanza Marsh.

2. Environmentally Sensitive Areas:

Environmentally sensitive areas should be identified because they are extremely important to maintain as habitat for fish and wildlife.

- Native aquatic vegetation should be mapped in detail. These macrophyte beds are not common on Slocan Lake and for this reason, an extensive inventory (species, abundance) should be mapped to protect these sensitive features; and
- Bonanza Marsh: The single wetland around Slocan Lake is located along the north foreshore of the lake (Figure 17). Wetland ecosystems should be protected and restoration encouraged.

Figure 17: Bonanza Marsh
Photo: DeRosa PhotoWorks

3. Water Quality:

The primary focus of water quality monitoring is the collection of information related to changes in lake biological productivity over time. Water quality data gathered by volunteers can be used to determine whether Slocan Lake is becoming more productive, less productive, or is stable. Many years of data are generally required to make these determinations with confidence. Recommendations for water quality are listed below:

- Repeat nearshore and offshore water quality assessments for the lake; and
- Gather data on water quality of the streams around the lake.

4. Lake Management Considerations: The results of this study provide a basis for identifying areas for conservation and restoration. According to Radomski and Goeman (2001), increasing development of a lake foreshore renders habitat protection based solely on site-specific or individual management practices biologically insufficient and administratively impractical. Management strategies must employ a more comprehensive approach to ensure the survival of a healthy, functioning ecosystem which includes littoral zones, wetlands, stream mouths, riparian areas and key features specific to each lake. One of the primary tools for municipalities and local governments is the Environmental Development Permit (EDP) which is required prior to the onset of construction along the foreshore of a lake. A specific shoreline guidance document should be developed for the foreshore to facilitate inter-agencies review and applications that may affect Very High, High and Moderate values areas. Recommendations for lake management are listed below:

- An environmental advisory committee should be created and be included in the development review process;
- Environmental information collected during this survey should be available to all stakeholders, relevant agencies, and the general public;
- An Environmental Assessment should be required for any development activities within the Very High, High and Moderate areas;
- Legal setbacks of 30m should be established by government agencies on each of the streams draining into Slocan Lake;
- Development and use of best practices for all type of construction along the foreshore should be mandatory;
- A lakeshore erosion hazard mapping system should be implemented for private lands to help identify areas at risk;
- Monitoring of approved works is required, with consequences for failure to construct following best practices standards or failure to apply for necessary permits;
- Conduct a continuing assessment of the lake foreshore and its modifications;
- Storm water management plans should be included in all development applications that alter the natural drainage pattern;
- To prevent fish habitat deterioration and to ensure riparian conservation, boat launches and marinas should remain concentrated within village boundaries (Taillon & Fox 2004);
- No new marinas or boat launches should be built in shallow areas requiring dredging;
- Designate Slocan Lake as a pesticide free zone;
- Protection of the lake outflow and its foreshore should be incorporated in the Village of Slocan OCP;
- The SLSS should develop a Lake Management strategy that incorporates a more regional approach to development of the foreshore;
- Put in place a regulatory system equipped with an enforcement officer to ensure foreshore protection and penalize bad management practices; and
- The SLSS should ensure that the guidelines resulting from this FIM study will be implemented by the villages of Slocan, Silverton and New Denver, the Regional District of Central Kootenay, the Integrated Land Management Bureau, the Ministry of Environment and Fisheries and Oceans Canada.

5. Habitat Restoration: Any and all initiatives to restore habitat in impacted areas should be ncouraged in highly populated areas. Examples include placement of large woody debris, live staking and re-vegetating shoreline regions, riparian restoration, etc.

Presently, the impact of retaining walls and groynes may not be very significant on Slocan Lake but to preserve fish habitat, future construction of these features should be prevented.

6 DISCUSSION

The present report has documented the current state of the Slocan Lake shoreline. The assessment provides substantial background information summarizing the current condition of the riparian areas, foreshore and littoral zones of the lake. Due to the lack of previous fish and wildlife information on Slocan Lake, the information collected during the 2007, 2008 and 2009 surveys should be used as the baseline database for guidelines and future lake management plans. This database will also serve as a starting point for future studies on the lake species and their respective habitat.

Quantifying previous shoreline impacts, fish assemblage and wildlife habitat status is very difficult since historical fisheries information and a baseline database do not exist for Slocan Lake. Moreover, the fish and wildlife sampling for the present study was conducted over a restricted period of time. It would thus be premature to assume that sufficient information has been gathered to date to accurately describe the fish and wildlife assemblage on Slocan Lake.

Historical disturbances on the Slocan Lake shoreline are mostly concentrated within the village boundaries and the community of Rosebery. Intensification of private shoreline development has occurred primarily within the past 10 to 15 years and most modifications occurred within the urbanized land use zones. No previous studies have been done on the effects of development on Slocan Lake. When compared to other large lakes in southern British Columbia, Slocan Lake shoreline development seems minimal. The large crown land and park tenures on Slocan Lake have undoubtedly played a role in preventing shoreline development. The natural components have been maintained because residential development has been concentrated within village boundaries and urbanized zones.

More inventory assessments of the foreshore will help to better understand the relative habitat value of the large expanse of natural areas around the lake. Further investigations into the shoreline area will also yield more accurate results (e.g., some of these areas may offer higher juvenile rearing capability; micro habitats may be discovered along cliff/bluff shorelines of higher value; and the assessment of smaller shoreline segments could offset the ranking dilution created by longer segments).

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8 APPENDICES

Appendix A: Mapsheet Binder
Appendix B: Segment, Creek & Wetland Assessments
Appendix C: Fish & Wildlife Results
Appendix D: Rare & Endangered Fish Species
Appendix E: Aquatic Habitat Index Results

APPENDIX A: MAPSHEET BINDER

Mapsheets 1 to 23