Columbia Lake Foreshore Integrated Management Planning – 2021

Wood Project# VE52823-2021B

Prepared for:

Living Lakes Canada
Nelson, BC

31 March 2022

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Executive Summary

Columbia Lake, the headwaters of the Columbia River, is situated in the Columbia Valley within the southern Rocky Mountain Trench. The lake has a surface area of approximately 25 km^2 with productive wetland complexes at the south and north ends of the lake that provide habitat for various aquatic, herptile and avian species. Columbia Lake is located in the traditional territories of the Shuswap Band (member of the Secwepemc Nation) and Ktunaxa nations. As with many lakes in the East Kootenay, Columbia Lake is a popular recreation destination. As residential and recreational pressures on Columbia Lake escalate, questions have been raised about what measures need to be taken to balance the social, cultural, ecological, and economic values of any given area.

In response to concerns over the fast pace of development and potential for important fish and wildlife habitat to be lost, Foreshore Inventory and Mapping (FIM) was conducted in 2009 and included FIM field surveys, the development of an Aquatic Habitat Index (AHI) and corresponding Shoreline Management Guidelines (SMG). Twelve years had passed since the original FIM was conducted and there was an interest in updating the previous field surveys and corresponding analyses to evaluate rates of change (e.g., development), observe whether integrated policies have been working, identify additional important habitat and species at risk and update the Columbia Lake FIM dataset using standard Foreshore Integrated Management Planning (FIMP) methods that were updated in 2020. The following includes all three phases of FIMP for Columbia Lake: FIM survey; development of the Foreshore Habitat Sensitivity Index (FHSI, formerly called AHI) to rank the relative value of shoreline habitats; and the Foreshore Guidance Document (FDG, formerly called SMG).

In 2021, a FIM survey was completed along 39,563 m of the Columbia Lake shoreline, the majority of which was observed in relatively natural condition (23,372 m; 59%) while the remainder was classified as disturbed (16,191 m; 41%). The lakes' shoreline was classified as having a low level of impact (16,462 m; 42%), followed by high (14,643 m; 37%) or medium (8,458 m; 21%) impact. The most prevalent land use was conservation (23,043 m; 58%) followed by transportation (13,520 m; 35%), rural (1,877 m; 5%) and urban park (164 m; 2%). Shore type classifications observed included gravel (18,849 m; 47%), cliff/bluff (12,952 m; 33%) and wetland (7,763 m; 20%).

Aquatic vegetation was observed along 33,399 m (84%) of the Columbia Lake shoreline primarily consisting of emergent vegetation. Foreshore and littoral substrates consisted primarily of fines and gravel with lesser amounts of cobble, boulder and bedrock. Large woody debris (LWD) was observed in foreshore areas of half of the segments and ranged from 1 to 15 pieces per segment while in littoral areas LWD was observed in only two of the segments and a maximum of two pieces per segment. The littoral area width of most segments (23,355 m; 59%) was classified as wide (>50 m) and the remainder (16,208 m; 41%) was classified as medium (10-50 m). Nearshore riparian vegetation in half of the shoreline segments was continuous and patchy in the other half and consisted primarily of low shrubs with lesser amounts of mature forest and grass/herb vegetation classes. Where a second vegetation type/band was observed, it mainly consisted of mature, coniferous forest with continuous or patchy distribution.

The most prevalent lineal modification was erosion protection, which occurred along 16,398 m (41%) of the shoreline, followed by railway (15,172 m; 38%), substrate modification (2,009 m; 5%), retaining walls (1,082 m; 3%) and roadway (375 m; 1%). Other shoreline modifications included docks (n=30), mooring buoys (n=26), stairs (n=19), pile supported structures (n=14), retaining walls (n=11), sheds (n=9), groynes (n=7), dock groynes (n=7), swim floats (n=4), boat lifts (n=3), concrete boat launches (n=2), gravel boat launches (n=2), a fence (n=1), a pumphouse (n=1) and a marina (n=1).

Comparison between the 2009 and 2021 FIM surveys indicated that the total length of disturbed shoreline increased slightly by 75 m (0.2% of the total shoreline) from 16,116 m (40.7%) to 16,191 m (40.9%), respectively, and the observed shoreline rate of change was approximately 0.02% per year. Increased disturbance was observed in one segment at the southeast corner of the lake where shoreline modifications associated with residential and urban park development were observed. Between 2009 and 2021, several types of shoreline modifications increased by approximately 100% including docks (from 14 to 30), retaining walls (from 5 to 11) and groynes (from 4 to 7), while boat launches increased by 30% (n=4) and marinas (n=1) remained the same. The amount of the shoreline modified by retaining walls increased by approximately 25% (224 m) while shoreline modified by railways and roadways was unchanged. Increased disturbance and more shoreline modifications, however, did not result in changes to riparian area characteristics (i.e., Vegetation Band 1) nor did this result in redefining Level of Impact for delineated segments which remained unchanged between 2009 and 2021. One large property (approximately 2 km of shoreline) on the northeast side of Columbia Lake was purchased by the Nature Conservancy of Canada in 2011 and the land use in this area has therefore changed from natural area to conservation. Detailed fish and wildlife surveys were conducted during the 2009 FIM and were not resurveyed in 2021. However, 10 bird species, one wildlife species and various habitats were recorded opportunistically during the 2021 FIM surveys. Two fish species of conservation concern have been documented in Columbia Lake: Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) are of conservation concern provincially (blue-listed) and federally (Species at Risk Act (SARA) Schedule 1; Of Special Concern) while Bull Trout (*Salvelinus confluentus*) are of conservation concern provincially (blue-listed).

Most of the shoreline of Columbia Lake was ranked as Moderate (39.8%) ecological value followed by High (38.6%), Very High (19.6%), and Very Low (1.9%) based on the FHSI analysis. Most shoreline areas with High and Very High ecological value remained in natural condition (0% and 13% disturbed, respectively) while most shoreline areas with Moderate and Very Low ecological value were disturbed (91.6% and 100% disturbed, respectively). Compared to the results of the 2009 AHI analysis, the ecological ranks of two segments changed during the 2021 FHSI. The two segments adjacent to the west side of the lake increased in value from Low to Moderate. This was due to additional criteria and adjusted weighting included in the 2021 FHSI that captured more aspects of shoreline habitat sensitivity than the 2009 AHI was able to detect. The 2021 data was also analyzed using the 2009 AHI and through this evaluation the ecological rank of one segment along the southwest side of the lake increased from Low to Moderate ecological value. However, this change was due to inventory and analysis errors identified in the 2009 data and not because habitat conditions have improved since the previous survey. Conservation zones are already established along a significant percentage of the Columbia Lake foreshore (58%) including all areas identified as having Very High and High ecological value. It is recommended that conservation of these areas is supported in perpetuity.

First Nations Traditional Ecological Knowledge (TEK) was incorporated into the Columbia Lake FIM, FHSI and FDG. Shuswap Band (SB) holds ancestral knowledge of landscape conditions and changes over time that have contributed to the current day understanding of the environment and landscape throughout their caretaker area, including and beyond Columbia Lake. TEK was incorporated into the Columbia Lake FIMP through participation in the FIM field survey, a SB TEK-specific desktop review, collaboration and review of the FHSI, and review of the FIMP and FDG reports.

The Columbia Lake FDG provides development and planning guidelines that are aimed at protecting ecologically sensitive areas. Guidance is provided for landowners, regulators and other stakeholders on the permitting and review process for shoreline development. The FDG also identifies areas where development should be avoided.

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List of Acronyms and Abbreviations

AHI	Aquatic Habitat Index (now referred to as FHSI)
DFO	Fisheries and Oceans Canada
CDC	Conservation Data Center
FIDQ	Fisheries Inventory Data Query
FDG	Foreshore Development Guidelines
FHSI	Foreshore Habitat Sensitivity Index
FIM	Foreshore Inventory and Mapping
FIMP	Foreshore Integrated Management Planning
GIS	Geographic Information Systems
GPS	Geographic Positioning Systems
HWM	High Water Mark
LiDAR	Light Detection and Ranging
LLC	Living Lakes Canada
LWD	Large Woody Debris
MFLNRORD	BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development
OCP	Official Community Plan
RDEK	Regional District of East Kootenay
SARA	Species-At-Risk-Act
SHIM	Sensitive Habitat Inventory and Mapping
SMG	Shoreline Management Guidelines (now referred to as FDG)
TRIM	Terrain Resource Information Management
UAV	Unpiloted Aerial Vehicle
UTM	Universal Transverse Mercator
WMA	Wildlife Management Area
WSC	Water Survey of Canada
ZOS	Zones of Sensitivity

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https://www.dfo-mpo.gc.ca/species-especes/sara-lep/cnfasar-fnceap/index-eng.html

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1.0 Introduction

Columbia Lake, the headwaters of the Columbia River, is situated in the Columbia Valley within the southern Rocky Mountain Trench. Columbia Lake is located in the traditional territories of the Shuswap Band and Ktunaxa nations. Columbia Lake has 47 km of shoreline, a surface area of approximately 25 km^2, and is situated at 812 m elevation (MOE 2021). The lake has a mean depth of 3 m and maximum depth of 5 m and is ice covered during the winter months (McPherson et al. 2010). In 2020, peak summer water temperature reached nearly 25°C in early August (Thompson 2021). The primary inflow to Columbia Lake is from Dutch Creek, though depending on the continuously shifting channel configuration at the confluence, the creek can sometimes enter the Columbia River downstream of the Columbia Lake outlet, as it does currently (Thompson 2021). Other inflow comes from smaller tributaries, precipitation and groundwater sources including subsurface transport from the nearby Kootenay River at the south end of the lake (Thompson 2021). The outflow from Columbia Lake is the Columbia River which flows north approximately 15 km into Windermere Lake. Evaporation/evapotranspiration also influences the water balance of the lake (Thompson 2021). Columbia Lake is the southern extend of the Columbia Wetlands that extend 180 km north and are one of the largest wetland complexes in British Columbia. The Columbia Wetlands provide year-round and seasonal habitat for numerous species including 29 at-risk bird species (Mahr 2020).

As with many lakes in the East Kootenay and due to its proximity to the resort community of Fairmont Hot Springs, Columbia Lake is a popular recreation destination. McPherson et al. (2010) noted that many private properties adjacent to Columbia Lake have experienced increased development pressure as demand for residential and recreational properties has increased. Columbia Lake is also home to many unique and sensitive aquatic habitats and species and McPherson et al. (2010) identified Very High and High ecological value areas were present along 27% and 35% of the shoreline, respectively. Productive wetlands at the south and north ends of the lake provide habitat for various aquatic, avian, herptile and wildlife species (McPherson et al. 2010). Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) have been documented in Columbia Lake and are of conservation concern federally (Species-at-Risk-Act (SARA) Schedule 1; Of Special Concern) and provincially (blue-listed). Rare observations of Burbot (*Lota lota*) spawning aggregations have been made in a shallow spring-fed tributary at the south end of the lake and juvenile Burbot have been documented in littoral areas along the western shoreline and north and south ends of the eastern shoreline (McPhail 2007; McPherson et al. 2010). Burbot have experienced significant population declines in the Columbia system and though Columbia Lake Burbot are not listed as a provincial species of concern, they are a species of concern regionally (McPhail 2007; McPherson et al. 2010). Grassland ecosystems on the west-facing slopes along the eastern shore of Columbia Lake includes winter range habitat for Bighorn Sheep (*Ovis canadensis*) and other ungulates and habitat adjacent to the east, north and south shorelines are within the East Side Columbia Lake Wildlife Management Area (WMA) (Phillips 2021; Figure 1). Wildlife Management Areas (WMAs) are areas of land designated under section 4(2) of the *Wildlife Act* for the benefit of regionally to internationally significant fish and wildlife species or their habitats and conservation and management of fish, wildlife and their habitats is the priority in managing WMAs. Columbia Lake also holds important cultural value to local First Nations.

As residential and recreational pressures on Columbia Lake escalate, questions have been raised about what measures need to be taken to balance the social, cultural, ecological, and economic values of any given area. The Columbia Lake Stewardship Society (CLSS) was formed in 2014 in response to these concerns. The CLSS is working to preserve the ecological health and water supply of Columbia Lake for present and future generations through scientific investigation, collaboration, and outreach. The CLSS initiated and supports annual water quantity and quality monitoring activities in Columbia Lake. Prior to formation of the CLSS, the East Kootenay Integrated Lake Management Partnership (EKILMP) initiated the first Foreshore Inventory and Mapping (FIM) survey on Columbia Lake.

The initial FIM survey on Columbia Lake occurred in late September 2007 at which time the lake was separated into eight shoreline segments (McPherson et al. 2010). Orthophotos were created during the summer of 2008 and used, in addition to a foot-based survey on the frozen lake in March 2009, to update and complete the FIM database. Fish and wildlife assessments and aquatic invertebrate sampling were also conducted in 2009 and included in the initial FIM and Aquatic Habitat Index (AHI) evaluation to identify sensitive habitats around the lake (McPherson et al. 2010). The majority (63%) of the shoreline was in natural condition. Emergent vegetation, primarily consisting of bulrush species, was present along 75% of the shoreline and covered an area of approximately 3 km^2 (McPherson et al. 2010). Most of the 37% of the shoreline that had been disturbed had been modified by railway infrastructure (33%) while the remaining disturbance (4%) was due to residential and urban park modifications (e.g., retaining walls (n=5), boat launches (n=3), groynes (n=4), docks (n=14) and a marina; McPherson et al. 2010). Mooring buoys were not inventoried during the initial FIM, however, significant scouring of the substrates around mooring anchors/chain was observed and it was noted that overnight mooring within the Upper Columbia Valley Zoning area of the lake is illegal (McPherson et al. 2010). Shoreline Management Guidelines (SMG) were produced that incorporated the results of the FIM and AHI (EKILMP and Interior Reforestation 2010).

Twelve years has passed since the original FIM surveys were concluded and there is an interest in updating the previous field surveys and corresponding analyses (e.g., FIM, AHI and the SMG). It is important to determine whether any changes have occurred since the original FIM program to evaluate rates of change (e.g., development), observe whether integrated policies have been working (i.e., current OCP guidelines) and identify additional important habitat and species at risk.

The following summarizes the outcomes of each step of the process:

1. Foreshore Inventory and Mapping (FIM) – is a process that uses GIS, GPS and field observation to inventory and describe the land uses (e.g., residential and industrial development, etc.), shoreline modifications (e.g., docks, retaining walls, etc.), and biophysical attributes (e.g., wetlands, riparian vegetation, substrate, etc.) along the lake or reservoir shoreline. Information collected can be incorporated into a variety of land use planning documents including Official Community Plans, Shoreline Management Plans and Land and Resource Management Plans.
2. Foreshore Habitat Sensitivity Index (FHSI) – is the core technical analysis completed using FIM and non-FIM data to determine the relative habitat value of a shoreline. The FHSI uses data collected during the FIM survey, additional field reviews (e.g., fish and wildlife surveys) and data from other sources to determine the relative habitat value of a shoreline segment (one of five Ecological Ranks are assigned) and identify zones of sensitivity. The FHSI rankings are a relative measure of habitat value or sensitivity that are waterbody-specific.
3. Foreshore Development Guide (FDG) – is a report that used the FHSI results to recommend development guidelines that aim to protect sensitive foreshore habitats. The FDG is intended to provide background information to land managers, homeowners, developers and stakeholders when land use changes or activities are proposed that could alter the shoreline thereby affecting fish and wildlife habitat. The guidelines include the Ecological Rankings for all shoreline areas, an activity risk table and a decision-making flow chart for proposed works along the shoreline. The FDG also contains fish and wildlife habitat conservation areas and/or strategies.

The following report includes all phases of FIMP, which includes reporting on the FIM survey, FHSI and FDG. In this case it is a redoing of the FIM survey (herein referred to as re-FIM) that was previously completed between 2007 and 2009 (herein referred to as the 2009 FIM survey) but using the recently updated 2020 standards (Schleppe et al. 2021). Comparisons were made between 2009 and 2021, where appropriate.

Legend

- Columbia Lake - Lot 48
- Wildlife Management Areas
- Populated Place
- Railway
- Highway
- Road
- Watercourse
- Waterbody
- Parks & Protected Areas

0 1 2
Kilometers

References:
DataBC Data Distribution Service
Open Government License
(http://www.data.gov.bc.ca/)
Geogratis/Geobase
Open Government License - Canada
(http://data.gc.ca/eng/about-datagcca)

CLIENT: LivingLakes

PROJECT: Columbia Lake FIMP

TITLE: Columbia Lake Overview Map

DATE:	SCALE:	
February 24, 2022	1:110,000	**Figure 1**

GIS FILE: 02-01-020_columbia_lake_overview.mxd

COORDINATE SYSTEM:	JOB No:	ANALYST:	QA/QC:
NAD 1983 UTM Zone 11N	VE52823	PK	CL

wood.

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2.0 Methods

Methods presented herein provide a summary of the three phases of FIMP pertaining to Columbia Lake. FIMP methods (including re-FIM comparisons) are outlined in Schleppe et al. (2021), unless otherwise specified below.

2.1 Foreshore Inventory Mapping (FIM)

2.1.1 Pre-Field Assessment

Background information was compiled and baseline field maps prepared during the pre-field assessment to help guide field data collection activities and ensure all required information was acquired.

GIS map file layers including Regional District of East Kootenay (RDEK) legal boundaries/jurisdiction/ cadastral/zoning land uses, provincial data layers (e.g., Freshwater Atlas, TRIM, etc.), and Conservation Data Centre (CDC) BC Species and Ecosystems Explorer plants, animals and ecosystem mapping were obtained from online platforms. FIM segment breaks/points/polygons collected during the 2009 Columbia Lake survey were obtained from Living Lakes Canada; additional points/polygons (shapefiles) from fish and wildlife surveys and aquatic vegetation mapping were not available in digital form. The most recent and complete set of orthophotos are from 2009 for Columbia Lake (Map Sheet #82J.031, 82J.021, 82J.011) they are compiled at 1:20,000 grids, are in colour and have a pixel size of 0.5 m (BC Government Online Store). These are the same orthophotos used during the original 2009 Columbia Lake FIM. Therefore, World & Bing Imagery (2018-2022 satellite imagery, colour, 0.5 m pixels) were used to prepare the base maps as they are more representative of current conditions.

Baseline maps were prepared in ArcGIS using imagery and overlay of GIS layers from the 2009 FIM analysis (e.g., segment breaks, high water mark, aquatic vegetation polygons and wetlands). The high-water mark (HWM) delineated during the 2009 FIM analysis was reviewed by using a combination of orthophotos and satellite imagery interpretation (0.5 m pixels; interpretation to within ±5 m). Small changes were made to a few areas and this was incorporated into an updated shoreline layer for Columbia Lake. However for the north (Segment 4) and south (Segment 8) ends of the lake, changes to the HWM were more significant to specifically delineate the lake HWM and not the river outlets, tributary inlets and wetland areas; wetlands mapped in the BC Freshwater Atlas at the extent of these areas were included as wetland polygons and the entire shoreline of the realigned segment HWMs were included as an aquatic vegetation ZOS (see Section 3.2.2). Columbia Lake does not have an active hydrometric data station maintained by Environment and Climate Change Canada, so the HWM (i.e., shoreline layer) cannot be determined using staff gauge measurements (MOE 2009 as cited in Schleppe et al. 2021). In addition, there was no LIDAR available to use for HWM determination (RDEK 2020). The CLSS has conducted extensive water quantity monitoring in the Columbia Lake watershed, including monitoring lake water levels, since 2014, and have found the lake level fluctuates by approximately 0.9 m annually (Thompson 2022). Water level data collected by the CLSS was not incorporated into the HWM determination in 2021 but it could be consulted for finer scale determinations of HWM in the future. Average littoral width was calculated during the pre-assessment by taking an average of, at minimum, three measurements from the shoreline out to the area where there was an obvious colour change on the satellite imagery that identified deeper water; these areas were also confirmed during the 2021 FIM field survey.

The 2009 FIM segment breaks were reviewed against the more recent orthophoto imagery. Any changes in land use, riparian vegetation, wetlands and aquatic vegetation between the 2009 (original FIM) and current imagery (re-FIM) were identified for field verification as were any locations that may also warrant additional segment breaks. Significant changes (i.e., changes in shoreline characteristics over an area greater than 50 m) were not observed and therefore additional segment breaks were not required.

A literature review was conducted to obtain any more recent studies for Columbia Lake including previous FIM, AHI and SMG documents (McPherson et al. 2010). This was done to ensure necessary information was collected during the FIM field survey. Resources reviewed for fish, wildlife and ecological values included EcoCat: The Ecological Reports Catalogue, Conservation Data Centre (CDC) iMap, BC Species & Ecosystem Explorer and other web-based searches were consulted.

All digital datasets and mapping layers were loaded onto a tablet (e.g., iPad) prior to conducting the field portion of the FIM survey (Section 2.1.2). A health and safety plan was prepared and reviewed with team members prior to conducting field surveys.

2.1.2 Field Data Collection Platform

The primary method for field data collection was a tablet (e.g., iPad) loaded with the *ArcGIS Collector*™ application. Collector for ArcGIS is a map-driven, mobile data collection application that allows for easy and accurate field data capture. This application uses the device's GPS location services to identify your position and data can be captured in both a connected and disconnected (i.e., without Wi-Fi/cellular data) environment. Collector for ArcGIS is fully integrated with the ArcGIS platform so it can be seamlessly incorporated with other ArcGIS apps to maximize efficiency in workflows. This platform was successfully implemented and used during the Moyie and Whitetail lakes FIMP (Wood 2020a, 2020b).

Base maps developed during the pre-field assessment (Section 2.1) were loaded into the ArcGIS Collector application. The Columbia Lake data dictionary with the 2009 FIM dataset was also loaded onto the tablet for use in the ArcGIS Collector. This data dictionary included all segment line features as outlined in Schleppe et al. (2021; specifically Appendix B) which generates a layer within a file geodatabase that was then published and used by field assessors to populate. Other geometry type (e.g., point and polygon) feature layers that needed to be included in the re-FIM were created for any additional data collection that was outside of the segment break data dictionary (e.g., photographs and aquatic vegetation polygons). Photographs were directly embedded as a point location for each segment along with metadata including location (e.g., UTM), timestamp, segment number, photograph number and caption.

Field data were collected using the Columbia Lake ArcGIS Collector data dictionary in a disconnected environment. Data was exported and backed up to a laptop, cloud-based storage and Wood's internal server daily. Data were also reviewed for completeness at this time.

Additional data collection tools and back ups also included bringing the following into the field daily:

- Digital and hard copies of Excel spreadsheets with a copy of the updated data dictionary.
- Avenza Maps, an alternative application for georeferenced photo collection, was also loaded onto the tablet, with baseline maps imported.
- Hard copy printouts of base maps were available for field assessors to mark up polygons and other feature information. And,
- Waterproof field notebooks and hand counters were also available for field assessors to take additional notes and tally counts.

2.1.3 Foreshore Inventory and Mapping Field Surveys

The re-FIM field survey was conducted over a 3-day period on 15-17 September 2021. Columbia Lake was accessed via the boat launch at Tilley Park near Canal Flats, BC. As outlined in Schleppe et al. (2021), the field survey was conducted by navigating a boat along the shoreline of the lake, slowly and within a safe distance from shore to minimize wave action and avoid nearshore hazards. A three-person field crew was stationed on the deck of the boat and each crew member was responsible for ensuring specific data fields

were collected. On 15 September, high winds and wave action limited boat access on the lake and foot-accessible segments were surveyed from shore (Segment 4, 5, and 8); results were confirmed during boat surveys on subsequent days. Data collection was accomplished via tablet using the ArcGIS Collector data dictionary (Section 2.1.2). On 16 September the survey began at a segment break close to the boat launch and proceeded along the shoreline; all remaining segments were inventoried by the end of the day. Within each segment, all lake characteristics (i.e., data fields) outlined by Schleppe et al. (2021) were inventoried following standard methods. On 17 September, a representative of the Shuswap Band joined the crew and reviewed shoreline segments and FIM survey information collected at the south end of Columbia Lake.

The Columbia Lake ArcGIS data dictionary contained the 2009 FIM dataset that was used to verify and update the data collection fields during the re-FIM. Those data fields that remained similar between the 2009 and 2021 surveys were left as documented by the original observers to avoid documenting changes that were solely due to observer differences and potential changes/interpretation of the definitions from the updated methodology. Two crew members, Peter Holmes and Louise Porto, were present during both the 2009 and 2021 field surveys and provided consistency and background information on how original values were determined, when necessary. Potentially erroneous data in the 2009 FIM dataset was highlighted for further office review. Digital and hard copies of Schleppe et al. (2021) were available in the field and used as reference during inventory of all data entry fields. At least one photograph of each single-family residential lot, each shoreline modification as well as representative photographs of each segment were taken.

2.1.3.1 Fish Survey

Fish surveys were not conducted as part of the Columbia Lake re-FIM survey. Information on fish and other aquatic resources was compiled during the background literature review. The conservation status of all fish species identified in the lake was reviewed against the federal (e.g., SARA and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC)) and provincial (e.g., CDC) listings (Government of Canada 2021, CDC 2021). The information was summarized and presented in Section 3.1.6.

2.1.3.2 Wildlife Survey

Wildlife surveys, outside of observational data collected during the standard FIM procedure, were not conducted as part of the re-FIM survey as detailed wildlife surveys were conducted during the 2009 FIM survey (McPherson et al. 2010). Information on wildlife and other terrestrial resources in Columbia Lake was compiled during the background literature review. The conservation status of all wildlife species identified in the lake was reviewed against the federal (e.g., SARA and COSEWIC) and provincial (e.g., CDC) species listings (Government of Canada 2021, CDC 2021). The information was summarized and presented in Section 3.1.7.

2.1.3.3 Unpiloted Aerial Vehicle (UAV) Survey

Videography and still image photography via an Unpiloted Aerial Vehicle (UAV) (drone) survey was also conducted during early morning on 16 September 2021. The UAV survey was conducted to collect video and still images with a focus on areas with development, extensive aquatic vegetation/wetlands and any areas suspected to have changed since the 2009 FIM. The UAV survey was conducted up to a maximum height of 122 m (operator's permitted use) to capture these foreshore features as well as any areas that were not visible from the boat (e.g., vegetation bands in steeper areas). The UAV survey could not be conducted over the Columbia Lake Provincial Park area as this required a permit that was not acquired prior to conducting the survey; the permit review may not have been completed in time and it was deemed unnecessary since changes along the shoreline area of the park were not observed.

2.1.4 Post-Processing and QA/QC

Post-processing included extracting photos, converting data, modifying feature layers, shoreline mapping to match orthophoto representation of high-water mark, and another QA/QC of entire dataset. Shape files for each lake segment by section breaks were created. Aquatic vegetation GIS polygons delineated by McPherson et al. (2010) were manually digitized and added to map templates because digital versions (e.g., shapefiles) were not available. Where necessary, the 2009 aquatic vegetation polygons trimmed from terrestrial areas and clipped to the updated high-water mark. After post-processing, data were imported into map templates for report map production.

QA/QC of the 2009 FIM dataset was initially conducted during field surveys (Section 2.1.3) and completed during post-processing prior to comparing 2009 and 2021 datasets. No revisions to the 2009 dataset were required. The 2009 FIM dataset was not updated to include counts/evaluation of new variables that were included in the 2021 FIM dataset (e.g., sheds and boat racks) that had not been included in 2009 as outlined by Schleppe et al. (2021). Historic orthophotos and photographs taken during the 2009 surveys were reviewed, however, the imagery was not detailed and comprehensive enough to accurately update the 2009 dataset for these new parameters.

2.1.5 Data Analyses and Management

The following shoreline characteristics were summarized by evaluating the proportions of each category within a segment and summing each category for Columbia Lake:

- Natural versus disturbed shoreline.
- Shore type segment class including the proportion of natural versus disturbed shoreline within each shore type.
- Land use segment class including the proportion of natural versus disturbed shoreline within each land use type.
- Foreshore, littoral and riparian (i.e., vegetation bands) characteristics.
- Aquatic vegetation.
- Shoreline modifications. And,
- Level of impact.

Note that the segment classification for shore type and land use, not the proportion within each segment, were evaluated against the proportion of the segment that was disturbed versus natural. Riparian characteristics were summarized qualitatively, where possible. Fish and wildlife observations/attributes were described based on background literature review and field observations.

All fish and wildlife-related datasets collected during the desktop review were exported digitally (e.g., shapefiles, file geodatabase, Excel) and provided to Living Lakes Canada as supporting documentation to this report.

2.1.6 Comparison of 2009 FIM and 2021 re-FIM Datasets

The 2009 and 2021 datasets were scrutinized on a segment-by-segment basis to determine which categories were comparable between years. Segment length data measured in 2021 was used for all comparisons to remove bias in the data from GIS mapping differences between years. Shoreline categories that typically remain static through time (e.g., land use, shore type, substrate type, littoral zone width, and some riparian characteristics) were not formally compared between years since no change was expected

(Schleppe et al. 2021). Each dataset was reviewed to confirm that no change had been documented. One change in land use was documented that is discussed below but detailed analysis was not required.

The following shoreline categories were compared between the 2009 and 2021 Columbia Lake datasets:

- Natural versus disturbed shoreline.
- Level of Impact.
- Shoreline modifications including boat launches, docks, groynes, marinas and retaining walls. And,
- Lineal shoreline modifications including railway, retaining walls and roadway.

A rate of change analysis was conducted by comparing the percent natural shoreline for the entire lake in 2009 versus 2021 (Schleppe et al. 2021). Rate of change was also calculated for individual segments where a percentage of the segment in natural condition changed between 2009 and 2021. Orthophoto and still images available from the original FIM were reviewed against orthophoto, still images, and UAV to compare survey outputs, where possible.

2.2 Foreshore Habitat Sensitivity Index (FHSI)

A FHSI is a framework for assessing the relative aquatic and terrestrial habitat values along a lake's shoreline. The FHSI uses inventory information collected during the FIM survey, additional field surveys (e.g., fish and wildlife surveys), background literature reviews and/or data from other sources to develop a points-based index that assigns positive values to important and sensitive habitat features and negative values to modifications that have impaired habitat value. Non-FIM categories in the FHSI can include fish, wildlife, herptile, waterfowl, ecosystem, rare or endangered species or ecosystems, and/or other criteria. For Columbia Lake, numerous non-FIM categories and criteria were considered that were ultimately not included in the FHSI because habitats were not limited on the lake/foreshore, habitat was outside the foreshore and associated habitat of the lake, and/or the criterion was too general and could not be associated with a specific location. For example, Columbia Lake has been identified as providing important stopover habitat for SARA-listed bird species observed to use open water and littoral habitats throughout the lake. Therefore, all segments would receive value for the criterion if it was included (see Section 3.1.7) which would have had no influence on the ranking of ecological value. Ungulate winter range and badger habitat are examples of other criteria that were considered but ultimately not included because mapped habitat occurs nearly everywhere around the foreshore.

Once the FHSI categories are developed, it is then applied to each FIM-delineated shoreline segment, resulting in a collection of habitat segment scores. A numerical range is used to define each Ecological Rank (e.g., Very Low, Low, Medium, High, and Very High), allowing each segment to be labelled accordingly. Methods outlined by Schleppe et al. (2021) were followed during development and calibration of the Columbia Lake FHSI, calculation of segment FHSI scoring and determination of FHSI Ecological Ranks. Additional details are also provided below.

2.2.1 FHSI Weighting and Calibration

FIM and non-FIM categories were assigned an initial weighting following the standardized procedure outlined by Schleppe et al. (2021). This included assigning each category value an equal weighting, except for shoreline modifications, and adjusting these weightings based on the expected influence of the criterion. At the same time, the influence of each criterion was determined by adjusting the Percent Within Category to reflect its influence on foreshore habitat (see Section 3.2). The FHSI score was then calculated by summing the score of all index criteria for each segment. Note that Band 1 data was used for both Band 1 and Band 2

calculations when Riparian Band 1 extended the entire 50 m assessment zone and no Riparian Band 2 was observed.

Five FHSI versions were developed, each with different category and/or criteria weightings, and scrutinized by the study team; the version that best reflected Columbia Lake's habitat values was selected. The FHSI segment scoring was then used to develop FHSI Ecological Ranks, a five-class ranking system, ranging from Very Low to Very High ecological value, by reviewing the minimum, maximum, median and distribution of FHSI scores for the lake and creating appropriate boundaries for each ranking. Several iterations of the FHSI Ecological Rank breaks were conducted to determine if the ranks were reflective of values along the shoreline. Iterations were reviewed, mapped (Section 2.2.3) and updated using procedures outlined by Schleppe et al. (2021).

The FHSI was calibrated by reviewing the influences of each of the different FIM and non-FIM FHSI categories and criteria and associated weightings to ensure that the index was appropriately scored. Three versions of the FHSI were selected to represent the most reflective of shoreline habitat value for review/calibration by the LLC Technical Committee, including the version selected by the study team. Feedback was received from one committee member and was used to finalize FHSI criteria, FHSI Ecological Rank breaks and segment rankings.

2.2.2 Zones of Sensitivity

Zones of Sensitivity (ZOS) are specific areas identified as important habitats for either species or general ecosystem function. ZOS are a way of displaying sensitive habitat areas that may or may not have been included in the FHSI rank calculation, as point, line or polygon features graphically on maps and using GIS mapping tools. ZOS often include wetlands, creek mouths, native grasslands, wildlife habitat and corridors, gravel/cobble habitat, biologically productive areas and other unique unimpacted/natural areas because of their value to fish and wildlife (Schleppe et al. 2021, Caskenette et al. 2020, NRC 2002).

2.2.3 FHSI Mapping, Analysis and Reporting

Mapping is the best framework for viewing results of the FHSI. Mapping products initially developed during the FIM were updated to include the FHSI Ecological Rank of each segment using the prescriptive colour and mapping requirements as specified in Schleppe et al. (2021). ZOS were also added to the maps as polygons and a 20 m buffer was added to each polygon to account for unknowns in the mapping of the ZOS and protect the core ZOS from potential impacts from adjacent activities. The buffer size was kept relatively narrow due to inherent buffering already included in the ZOS polygons during digitization for tributary mouths.

Standard analysis of FHSI Ecological Rank was completed. These included a summary of the total shoreline length and percentage of the total shoreline of each FHSI Ecological Rank with an additional summary of FHSI Ecological Rank by shore type and a plot of total length of natural and disturbed shoreline by rank (Schleppe et al. 2021).

Areas with unique, high value habitats were highlighted for designation as conservation zones. Potential conservation zones included areas with Very High or High FHSI Ecological Rank that also contain one or more ZOS.

2.2.4 Evaluation of 2021 Data Using the 2009 AHI

Data collected in 2021 was also evaluated using the original AHI (now called FHSI) created for Columbia Lake in 2009. The 2009 AHI was used as a basis for development of the 2021 FHSI though adjustments were made to reflect current FHSI methodology (i.e., criteria added, value categories adjusted, and weighting changed) and though the outcomes of the 2021 FHSI and 2009 AHI could be compared, it was unclear if

differences observed were due to actual shoreline changes or variation in the FHSI itself. Therefore, data for 2021 was also evaluated using the 2009 AHI created by McPherson et al. (2010). FHSI rank categories defined in McPherson et al. (2010) were used to determine the segment rank based on values calculated using the 2009 AHI.

The results were reviewed on a segment-by-segment basis and summarized by tabulating the total shoreline length of each AHI rank. Results were presented in tabular form with a comparison to the 2009 AHI results.

2.3 First Nations Traditional Ecological Knowledge (TEK)

FIMP recognizes the importance of including First Nation's Traditional Ecological Knowledge, which can be included as non-FIM criteria and/or as points, polygons or lines on FHSI mapping and GIS products (Schleppe et al. 2021). The Columbia Lake FIMP program was developed to include the direct involvement of Shuswap Band (SB) members during the FIM field survey as well as in the review of FHSI criteria and the FDG document. However, due to capacity issues cited by SB, field participation was limited to the final day of the FIM survey. Additional contact occurred with SB band members in early November 2021, which resulted in the execution of the *Shuswap Band Traditional Knowledge Data-Sharing Agreement* (20 November 2021). In January 2022, SB conducted a TEK and cultural knowledge desktop review related to Columbia Lake, which was directly incorporated herein. TEK, as shared by SB, has been incorporated into the FHSI to include potential changes to the landscape and impacts to areas where important ecological and cultural values have been noted. Through this, SB aims to protect, restore, and maintain a strong, healthy, and diverse environmental landscape within *Secwépemcu'l'ecw*. Note that the information provided is not an exhaustive summary of SB's occupation or activities in the area in question. Shuswap Band is currently in the relearning phase of their history, due to a lack of consideration put into understanding rights and title due to forces outside their control. More information will become available as SB continues to gain a better understanding of their historical cultural context in these areas.

Ktunaxa Nation Council (KNC) did not respond to invitations to participate in the Columbia Lake FIMP during initial correspondence in 2021.

2.4 Foreshore Development Guide (FDG)

The FDG provides development planning guidelines, aimed at protecting sensitive fish and wildlife species and their habitats identified through the previous FIM and FHSI analyses. The template FDG provided by Schleppe et al. (2021) was populated with Columbia Lake specific information including the FHSI Ecological Rank of each shoreline segment and ZOS. This information was also provided on FDG mapping products which were a streamlined version of the FHSI maps revised to only include FHSI Ecological Rank and ZOS using predetermined colour coding (Schleppe et al. 2021). The FDG is provided in Appendix F.

3.0 Results

3.1 FIM

Biophysical characteristics of Columbia Lake are summarized below. Segment maps are provided in Appendix A and segment summaries are provided in Appendix B.

3.1.1 Natural versus Disturbed Shoreline

The re-FIM was completed along the entire 39,563 m of the Columbia Lake shoreline. The shoreline was divided into 8 segments ranging in length from 764 to 12,952 m. The total length of disturbed shoreline was 16,191 m (41%) while the total length of shoreline that remained in natural condition was 23,372 m (59%); (Figure 2).

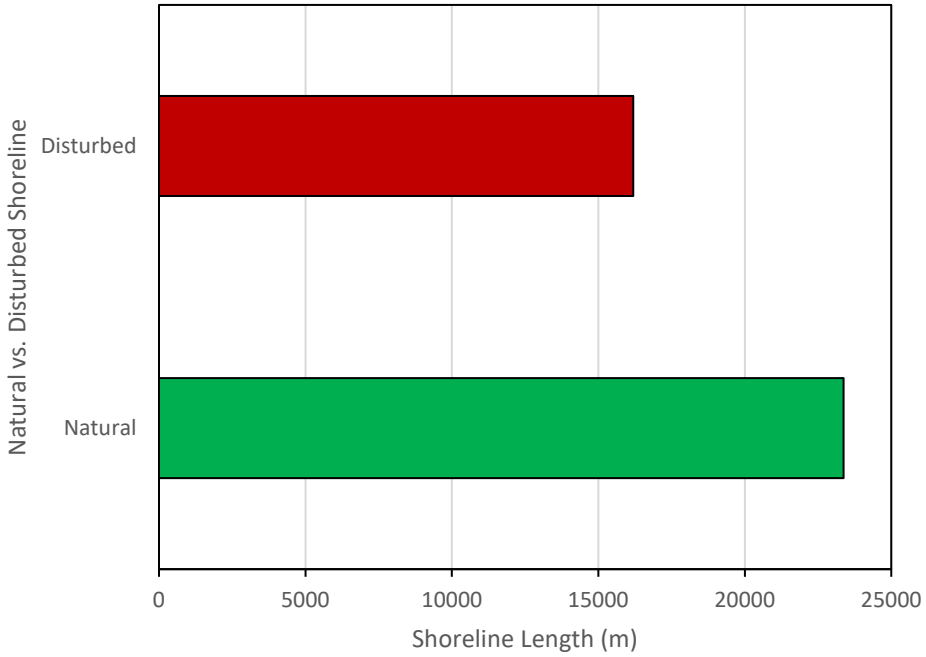

Figure 2: Total shoreline length (m) that is disturbed or natural for Columbia Lake.

3.1.2 Shore Type

The predominant shore type was gravel which was observed along 18,849 m (47%) of Columbia Lake (Figure 3). Other shore types observed included cliff/bluff (12,952 m; 33%) and wetland (7,763 m; 20%). No segments were classified overall as stream mouth though small areas of stream mouth were observed within segments classified as other shore types; rocky and sand shore types were not observed. In areas with gravel shore type, 19% of the shoreline remained in natural condition while in areas with wetland and cliff/bluff and the shoreline remained in 87% and 100% natural condition, respectively (Figure 3).

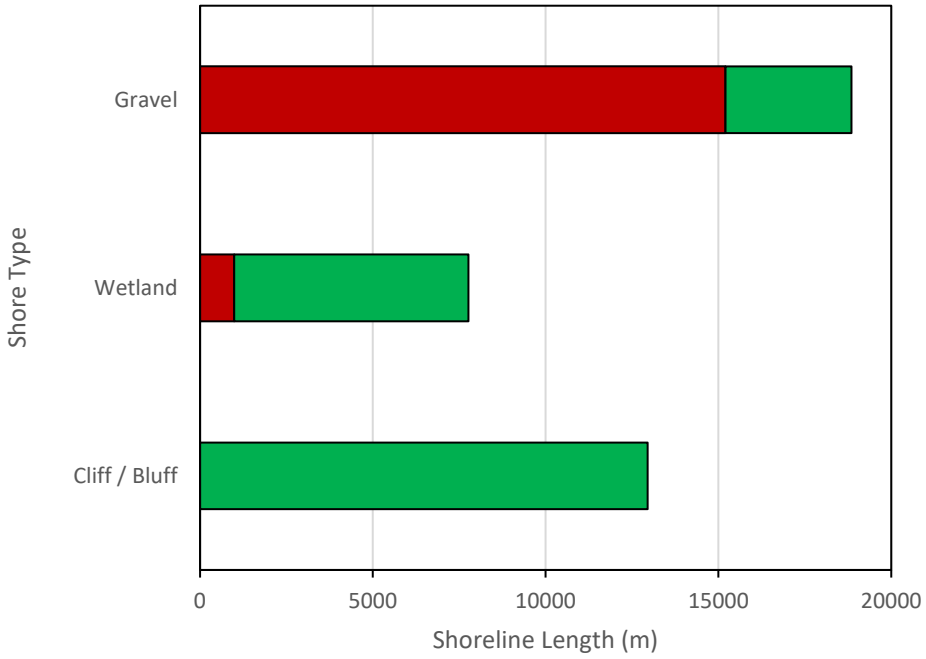

Figure 3: Shore types and length of natural (green) versus disturbed (red) shoreline for Columbia Lake.

3.1.3 Land Use

The predominant land use along the Columbia Lake shoreline was conservation (23,043 m; 58%) followed by transportation (13,520 m; 35%), rural (1,877 m; 5%) and urban park (164 m; 2%) (Figure 4). Small areas also had land uses including single-family residential (Segment 1 = 282 m; Segment 6 = 359 m), natural area (Segment 2 = 233 m; Segment 6 = 359 m) and park (Segment 3 = 1,943 m; Segment 4 = 414 m) though the overall classification of these segments were conservation (Segments 2, 3 and 4), rural (Segment 1) or transportation (Segment 6).

Most of the shoreline in segments classified as conservation were in a natural state (4% disturbed) (Figure 4). The only disturbance in a segment categorized primarily as conservation was observed at the southwest end of Columbia Lake in Segment 8 where transportation (railway and highway) and associated erosion protection modifications were located adjacent to approximately 1 km of the shoreline; a rustic boat launch is also located in this area. More disturbance was observed in the one segment classified as rural land use (Segment 1; 49% disturbed) where shoreline modifications were associated with residential developments (e.g., retaining walls, groynes, docks, stairs, boat racks, sheds, etc.) and an urban park. Highest disturbance levels were associated with segments classified as urban park and transportation (100% and 97%, respectively). Disturbance in the urban park (Segment 5) was primarily due to retaining walls, erosion

protection and a marina. Disturbed shorelines observed in areas with transportation land use were primarily due to railway lines and associated erosion protection as well as docks and mooring buoys. Scour around mooring buoy anchor weights and chains resulting in substrate disturbance, erosion and removal of aquatic vegetation was observed.

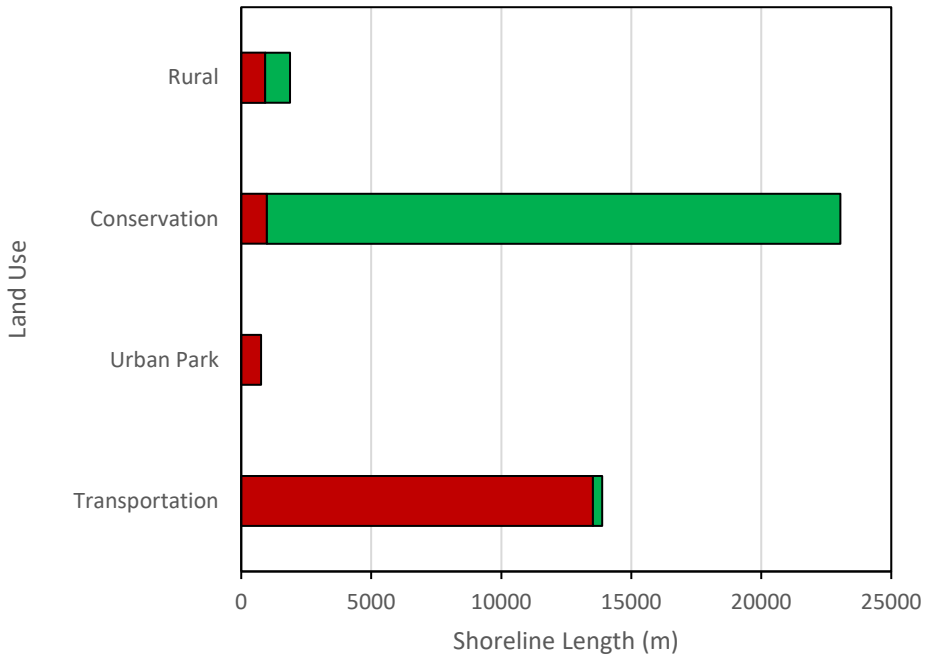

Figure 4: Land use types and length of natural (green) versus disturbed (red) shoreline for Columbia Lake.

3.1.4 Aquatic Vegetation

Aquatic vegetation was observed along 33,399 m (84%) of the Columbia Lake shoreline (Figure 5). Aquatic vegetation was observed in all shoreline segments. Emergent vegetation was the dominant aquatic vegetation type observed (30,707 m; 78%) followed by submergent (22,194 m; 56%). Segments with the highest density of aquatic vegetation (≥80% of the segment) had either wetland (Segments 4 and 8), cliff/bluff (Segment 3) or gravel (Segment 1) shore types.

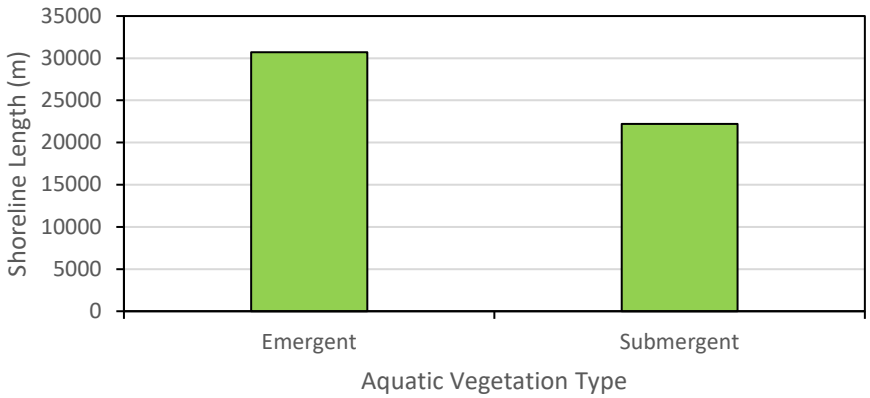

Figure 5: Aquatic vegetation types observed along the shoreline of Columbia Lake.

3.1.5 Shoreline Characteristics

Characteristics of foreshore, littoral, riparian, and wetland areas are described below.

3.1.5.1 Foreshore Areas

Large Woody Debris (LWD) was observed along the foreshore in half of the Columbia Lake shoreline segments and the number of LWD pieces ranged from 1 to 15 per segment when observed (Appendix B). The highest abundances of foreshore LWD were observed along the east side of the lake in Segments 2 and 3 that had 15 and 12 pieces, respectively.

Fines (22,701 m; 57%) and gravel (14,077 m; 36%) were the predominant substrate type observed along the foreshore of Columbia Lake (Figure 6). Lesser amounts of cobble (1,935 m; 5%), boulder (733 m; 2%) and bedrock (116 m; <1%) were also observed.

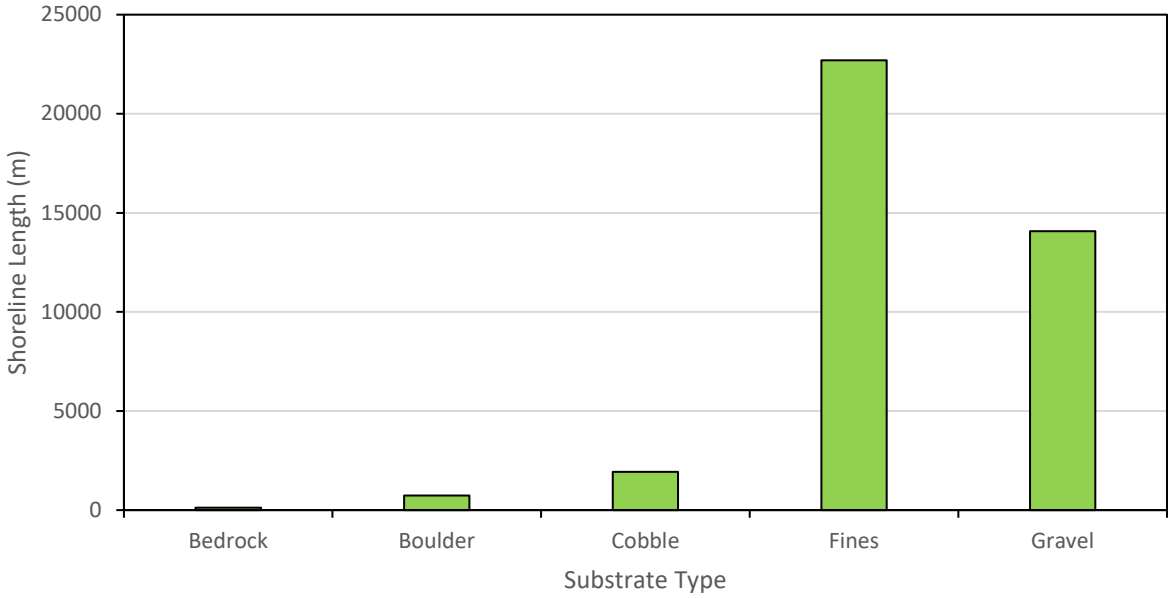

Figure 6: Substrate types observed along the foreshore of Columbia Lake.

3.1.5.2 Littoral Areas

The littoral area was classified as wide (>50 m) or medium width (10 – 50 m) along 23,355 m (59%) and 16,208 m (41%) of the shoreline, respectively. Littoral width ranged between 22 and 1,500 m. The widest littoral areas (≥1,000 m) were observed adjacent to a wetland at the south (Segment 8) and southeast (Segment 1) ends of the lake (Appendix A). Littoral LWD was observed in only two segments with 2 pieces in Segment 3 and 1 piece in Segment 6.

Marl (39,410 m; >99%) was the predominant substrate type observed along the foreshore of Columbia Lake. Trace amounts of cobble (76 m; <1%) and gravel (76 m; <1%) were also observed.

3.1.5.3 Riparian Areas (Vegetation Bands 1 and 2)

Overhanging vegetation was observed in seven of the eight segments and covered between 5 and 60% of the segment when present (Appendix B). The only segment with substantial amounts of overhanging vegetation (≥50%) was the southeast corner of the lake in the East Side Columbia Lake Wildlife Management Area (Segment 2; 60% overhanging vegetation).

The width of the nearshore riparian vegetation band (Vegetation Band 1) ranged between 5 and 50 m and half of the segments had continuous riparian vegetation within this band while the riparian areas in the other half were patchy. Low shrubs (21,641 m; 55%) and mature forest (17,157 m; 43%) were the predominant vegetation stages observed in Vegetation Band 1 (Figure 7). Lesser amounts of grass/herb (764 m; 2%) were also observed. The most modified shoreline area had landscape/lawns with sparse shrub and tree cover within Vegetation Band 1 (Segment 5). A transition in riparian vegetation to a second type (i.e., Vegetation Band 2) within 50 m of the shoreline occurred along 31,800 m (80%) of Columbia Lake, the remaining 20% of the shoreline only had Vegetation Band 1. Most of the vegetation observed in Vegetation Band 2, where present, was mature, coniferous forest with continuous or patchy distribution (approximately 70%). However, in Segments 1 and 5, Vegetation Band 2 was modified by landscaped/lawns and exposed soils, respectively, both having sparse tree cover with patchy distribution.

Approximately half the shoreline segments had >25 veteran trees (n=4 segments) and >5 snags (n=4 segments; Appendix B). Segments that had no or very few veterans and snags were in areas where shorelines were heavily modified by an urban park (Segment 5) or had low slope areas with younger stage riparian vegetation adjacent to wetlands (Segments 4 and 8).

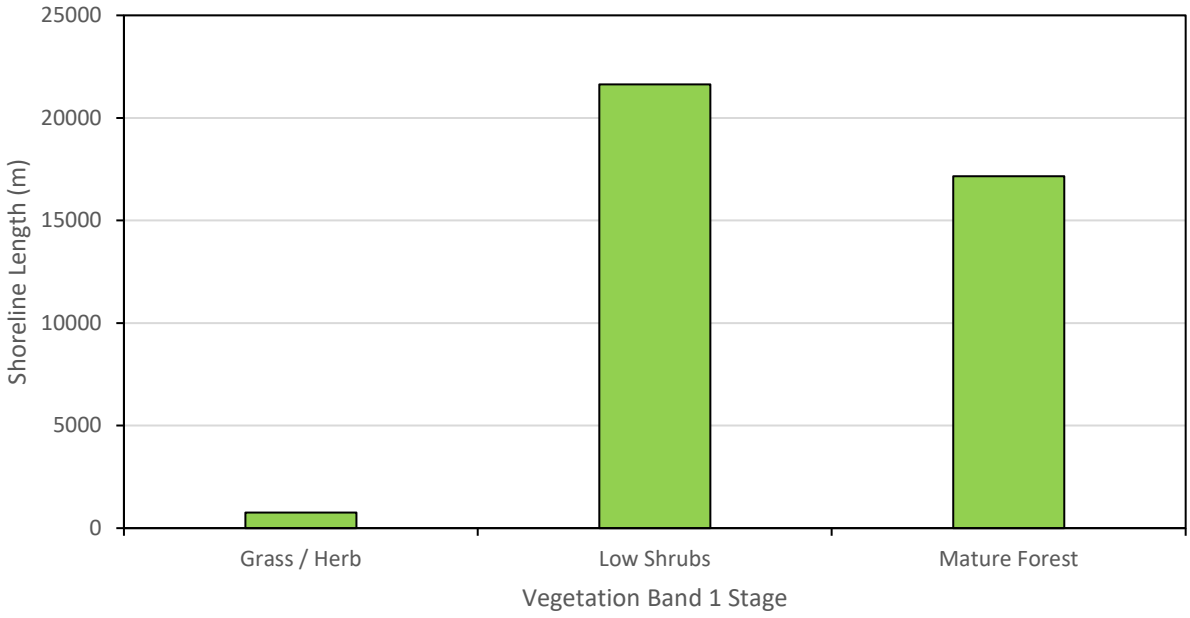

Figure 7: Vegetation stages observed in Vegetation Band 1 for Columbia Lake.

3.1.6 Fish Species Information

McPherson et al. (2010) provides a summary of fish species information for Columbia Lake as well as the results of fish and fish habitat sampling conducted during the 2009 FIM. Fish species occurrence information provided by McPherson et al. (2010) updated with information from the Fisheries Information Data Query (FIDQ 2021) is provided in Table 1.

Table 1: Fish species known to occur or have occurred in Columbia Lake including current provincial conservation status and federal Species-At-Risk (SARA) Listing.

Common Name	Species Name	BC Provincial Conservation Status	Federal Species-At-Risk-Act (SARA) Status
Bull Trout	*Salvelinus confluentus*	Blue	-
Burbot	*Lota lota*	Red	-
Kokanee	*Oncorhynchus nerka*	Yellow	-
Largemouth Bass	*Micropterus salmoides*	Exotic	-
Largescale Sucker	*Catostomus macrocheilus*	Yellow	-
Longnose Dace	*Rhinichthys cataractae*	Yellow	-
Longnose Sucker	*Catostomus catostomus*	Yellow	-
Mountain Whitefish	*Prosopium williamsoni*	Yellow	-
Northern Pikeminnow	*Ptychocheilus oregonensis*	Yellow	-
Peamouth	*Mylocheilus caurinus*	Yellow	-
Prickly Sculpin	*Cottus asper*	Yellow	-
Pumpkinseed	*Lepomis gibbosus*	Exotic	-
Rainbow Trout	*Oncorhynchus mykiss*	Yellow	-
Redside Shiner	*Richardsonius balteatus*	Yellow	-
Sculpin	*Cottus sp.*	Yellow	-
Torrent Sculpin	*Cottus rhotheus*	Yellow	-
Westslope Cutthroat Trout	*Oncorhynchus clarkii lewisi*	Blue	Special Concern
Winged Floater Mussel	*Anodonta californiensis/ nuttalliana*	Yellow	-

Two species of conservation concern have been documented in Columbia Lake: Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) are of conservation concern provincially (blue-listed) and federally (SARA Schedule 1; Of Special Concern) while Bull Trout (*Salvelinus confluentus*) are of conservation concern provincially (blue-listed; Table 1). Hatchery-reared Westslope Cutthroat Trout were released to Columbia Lake in 1977 (FIDQ 2021). Historical records document Westslope Cutthroat Trout up to 12 lbs. were captured from Columbia Lake to Spillimacheen, suggesting a native population was present prior to hatchery introductions (Lees and Clutterbuck 1889 as cited by Prince 2001).

Hatchery-reared Rainbow Trout (*Oncorhynchus mykiss*) were also released to Columbia Lake between 1915 and 2001 and Kokanee (*Oncorhynchus nerka*) in 1930 (FIDQ 2021). Kokanee spawning is well documented in Dutch Creek, the inflow at the north end of Columbia Lake. Though not listed in FIDQ (2021), McPherson et al. (2010) captured Largemouth Bass (*Micropterus salmoides*) in Columbia Lake during FIM fish inventory surveys in 2009. R.L.&L. (1992) cite an alleged stocking of Smallmouth Bass (*Micropterus dolomeiui*) sometime in the past though they found no confirmation of this.

Burbot are considered a species of regional conservation concern in the Columbia River system (McPhail 2007). Burbot are present in Columbia Lake and spawning has been documented during the winter under the ice at the north end of the lake (Segment 4) and at the southwest corner of the lake in an unnamed tributary near the lake shoreline (Segment 8) (Arndt 2001, Arndt and Hutchinson 2000, Arndt 2002). Population sampling was undertaken in 2001, 2006 and 2016. A population estimate could not be generated with the data obtained, however, catch-per-unit effort (CPUE) collected during October sampling periods was compared. In 2016 (CPUE = 0.15 fish/trap-day), catch rates had dropped to approximately half of what had been observed in 2001 and 2006 (CPUE = 0.31 and 0.29 fish/trap-day, respectively) (Cope 2016). The Burbot fishery on Columbia Lake had been closed to anglers for over a decade prior to 2016 sampling suggesting the closure has had no apparent effect on the population (Cope 2016). In 2017, the East Kootenay Burbot Scientific Working Group (EKBSWG) identified the urgent need for the recovery of Burbot populations in the East Kootenay, including Columbia Lake (EKBSWG 2019). A conservation strategy for the upper Columbia River Burbot population (Golden to Columbia Lake) is anticipated to be completed after a strategy for the upper Kootenay River population is completed (EKBSWG 2019). Burbot hold importance to Indigenous peoples and are considered a winter food staple (Shuswap Band, pers. comm., 2022).

Freshwater mussel beds have been documented in various areas of Columbia Lake (McPherson et al. 2010). In 2007, one survey conducted near Tilley Memorial Park (Segment 1) identified the species as Winged Floater Mussels (*Anodonta californiensis/nuttalliana*) and documented approximately 40 individuals near the riprap breakwater by the boat launch (Moore and Machial 2007). McPherson et al. (2010) also identified mussels along the west side of the lake in Segments 6 and 7. Poor underwater visibility has caused challenges identifying the extent of mussel beds in Columbia Lake (e.g., Moore and Machial 2007; personal observations). Due to their limited dispersal abilities as adults, freshwater mollusks are particularly sensitive to foreshore and littoral zone disturbances.

Historically, White Sturgeon (*Acipenser transmontanus*) in the Columbia River watershed could access the entire length of the river from Columbia Lake to the Pacific Ocean (DFO 2014). Populations in the upper reaches of the Columbia River were likely resident and benefited from seasonally available anadromous salmon. Following the construction of various dams, populations became isolated from one another and currently the northern extent of the Columbia River White Sturgeon population is Revelstoke Dam (DFO 2014). It is possible that remnant populations or individuals are present at very low numbers upstream of Revelstoke Dam, possibly including Columbia Lake, however, none have been observed despite considerable sampling effort (DFO 2014).

Anadromous salmon were an important part of life and identity of Secwépemc (SB) and other first peoples in the Columbia valley including Columbia Lake. Shuswap Band ancestors fished salmon in the lake prior to construction of Grand Coulee Dam (constructed in 1942) on the Columbia River in Washington that blocks their passage into Canadian waters. Restoration of salmon to the Columbia River including its headwaters, Columbia Lake, are of utmost importance to SB (see Section 3.3).

In August 2021, the CLSS partnered with the Lake Windermere Ambassadors to conduct fish surveys in Columbia and Windermere lakes (CLSS 2021). The objective of the project was to provide a baseline of fish species present as well as population estimates. The results of the study are expected in 2022 (CLSS 2021).

3.1.7 Wildlife and Wildlife Habitat Observations

McPherson et al. (2010) provides a summary of wildlife and wildlife habitat observations for Columbia Lake as well as the results of wildlife habitat assessments conducted during the 2009 FIM. Shuswap Band Knowledge Keepers note that wildlife species including grizzly bear, gray owl, grouse, white tail deer, moose, and eagle inhabit the lands and waters surrounding Columbia Lake (see Section 3.3).

Wildlife observations recorded during the 2021 re-FIM are included in the segment summaries in Appendix B and summarized by segment below:

- Segment 1 – Common Merganser (*Mergus merganser*) and gulls observed.
- Segment 2 – Common Merganser, Osprey (*Pandion haliaetus*), American Crow (*Corvus brachyrhynchos*), gulls, one stick nest and wildlife trails observed.
- Segment 3 – Bald Eagle (*Haliaeetus leucocephalus*), Turkey Vulture (*Cathartes aura*), Western Grebe (*Aechmophorus occidentalis*), gulls and swallow bank nests observed.
- Segment 5 – Common Merganser, loon (*Gavia* sp.) gulls, and Bald Eagle nest at north end of the segment observed.
- Segment 6 – Mallard (*Anas platyrhynchos*), Canada Goose (*Branta canadensis*), deer (*Odocoileus* sp.), Common Merganser, American Crow, Bald Eagle, grebes, an American Beaver (*Castor canadensis*) lodge and swallow bank nests observed.
- Segment 7 – Common Merganser, American Crow, loons, gulls and swallow bank nests observed.

Observations of at-risk wildlife species and their habitat adjacent to the Columbia Lake shoreline include:

- Painted Turtle – Intermountain-Rocky Mountain Population (*Chrysemys picta* pop.2), provincially blue-listed and federally listed under SARA as Special Concern have been identified in Segment 3 near Armstrong Bay (Darvil 2021), Segment 5 (Incidental observation in the marina in Columere Park close to wetlands in 2019 (CDC 2021)) and Segment 8 (Habitat known in the small section of the lake in the southwest corner isolated by a railway berm (I. Adams pers. obs. cited by McPherson et al. (2010)).
- Bank Swallow (*Riparia riparia*; listed under SARA as Threatened), nest in burrows in banks, cliffs or bluffs with friable soils along Columbia Lake (Darvin 2021).
- Lewis's Woodpecker (*Melanerpes lewis*; listed under SARA as Threatened) habitat is limited to six geographic regions in southern BC of which the East Kootenay Trench is the most northerly breeding location (Darvil 2021). Critical Habitat is located near the southwest side of the lake (Segment 8) and in 2020 two nesting sites were documented there by Darvil (2021).
- Western Grebe, provincially red-listed and federally listed under SARA as Special Concern, were observed in Segment 3 during the re-FIM survey (Appendix B). Darvil (2017) found the middle sections of Columbia Lake were regularly utilized by Western Grebe as stopover habitat and that these lake sections (along with Windermere Lake) are the most important staging areas within the Columbia Wetlands for grebes and other birds. Western Grebe were observed adjacent to all shoreline segments during surveys conducted between 2015 and 2017 (Darvil 2017).
- Great Blue Heron, *Herodias* subspecies (*Ardea herodias herodias*) provincially blue-listed, colony nests were historically located in an established rookery along the Dutch Creek fan approximately 1 km from the lake in Segment 4 (CDC 2021; McPherson et al. 2010). The rookery moved to a residential area near the Columere subdivision from 2011-2016 and have most recently been observed in Columere Park which is not located near the shoreline (Machmer 2017, 2021). Rookery

abandonment has been the result of repeated attacks by predators and human encroachment (Machmer 2017). Great Blue Heron were observed adjacent to all shoreline segments during surveys conducted between 2015 and 2017 (Darvil 2017).

- Other at-risk bird species including Horned Grebe (*Podiceps auratus*; Special Concern under SARA), Tundra Swan (*Cygnus columbianus*; provincially blue-listed), California Gull (*Larus californicus*; provincially blue-listed), and American White Pelican (*Pelecanus erythrorhynchos*; provincially red-listed) were observed on Columbia Lake during surveys conducted between 2015 and 2017 (Darvil 2017).
- Flammulated Owl (*Psiloscops flammeolus*), provincially blue-listed and federally listed under SARA as Special Concern have been identified in Segments 1 and 2 (two individuals identified by call in 1993 (CDC 2021)). And,
- American Badger (*Taxidea taxus*), provincially red-listed and federally listed under SARA as endangered, occurs in the East Kootenay Trench and potential habitat is documented around the entirety of Columbia Lake (CDC 2021).

In 2017, an ecosystem restoration plan was developed for the Columbia Lake East treatment areas aimed at reducing forest cover (within the East Side Columbia Lake Wildlife Management Area adjacent to Segments 2 and 3; Figure 1). Grassland habitat that provides Bighorn Sheep (*Ovis canadensis*) and other ungulates winter range has been reduced by encroaching conifer growth in some areas. The Columbia Lake East treatment area is located on the west-facing slopes along the east side of Columbia Lake approximately 7.5 km north of Canal Flats, BC and covers a total treatment area of 21 hectares (ha). In the fall of 2018, the first phase of the program, thinning forest in-growth conifers, was completed by slashing and piling. The second phase, re-introducing fire to the landscape, had not yet been carried out as of fall 2020. Vegetation monitoring in 2020 documented positive results following the first treatment phase with lower stem densities and lower crown closure (Phillips 2021).

3.1.7.1 Other Observations of at-risk Species

Observations of other at-risk species have been documented adjacent to the Columbia Lake shoreline including:

- Limber Pine (*Pinus flexilis*) provincially blue-listed and federally listed under SARA as endangered, has been observed at various locations along the east shore of the lake in Segments 2 and 3 (CDC 2021).
- McCalla's Dwarf Braya (*Braya humilis* ssp. *maccallae*) provincially blue-listed has been observed in Armstrong Bay in Segment 3 (last observation in 2015 (CDC 2021)).
- Stiff-Leaved Pondweed (*Potamogeton strictifolius*) provincially blue-listed has been observed in wetland areas of Segment 4 (identified in 1978 and last documented in 2015 (CDC 2021)).

3.1.8 Shoreline Modifications

Docks were the most prevalent shoreline modification observed in Columbia Lake. Docks (n=30) were observed in three segments including Segment 1 (n=13), Segment 6 (n=16) and Segment 7 (n=1) (Figure 8). The next most common shoreline modifications were mooring buoys (n=26), stairs (n=19), pile supported structures (n=14) and retaining walls (n=11). Sheds (n=9), groynes (n=7), dock groynes (n=7), swim floats (n=4), boat lifts (n=3), concrete boat launches (n=2), gravel boat launches (n=2), a fence (n=1), a pumphouse (n=1) and a marina (n=1; Figure 9) were also observed (Figure 8).

The most prevalent lineal modification was erosion protection, which occurred along 16,398 m (41%) of the shoreline, followed by railway (15,172 m; 38%), substrate modification (2,009 m; 5%), retaining walls (1,082 m; 3%) and roadway (375 m; 1%; Figure 10). Erosion protection included retaining walls, groynes, and rip rap material along railways and roadways. A railway line is present along the entire west shoreline of the lake (Figure 9). Retaining walls were mainly associated with homes in Segment 1 and along an urban park in Segment 5. Substrate modification was mainly caused by beach grooming, imported sand and infilling along retaining walls. Roadways were associated with property and park access at the southeast end of the lake in Segment 1 (Appendix A).

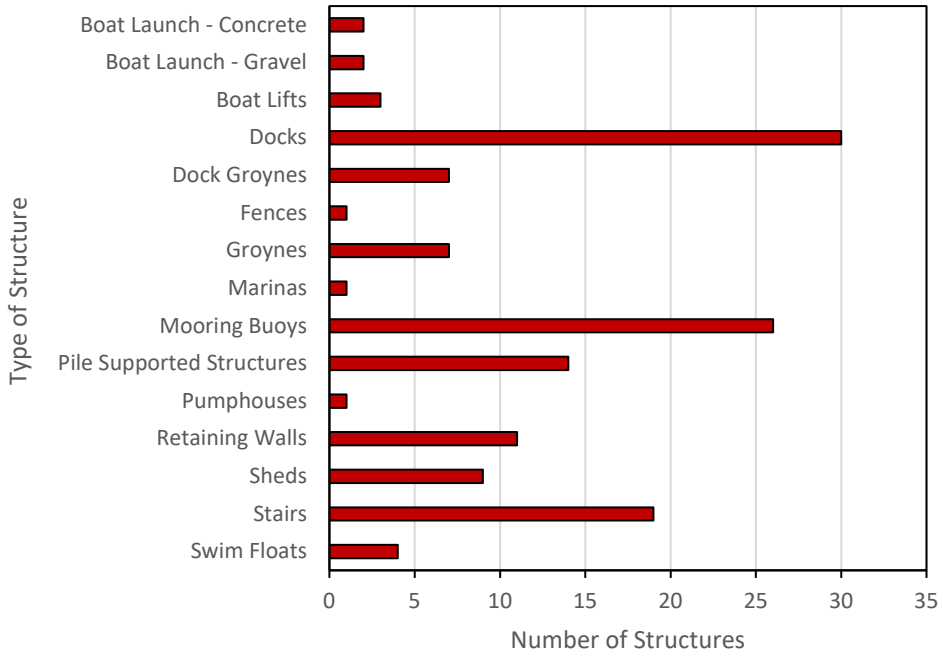

Figure 8: Total number of shoreline modifications observed along the foreshore of Columbia Lake.

Figure 9: Example of shoreline modifications observed on Columbia Lake including docks within a marina, retaining wall, groyne and substrate modification in Segment 5 (left) and the railway line along the west side of the lake in Segment 7 (right).

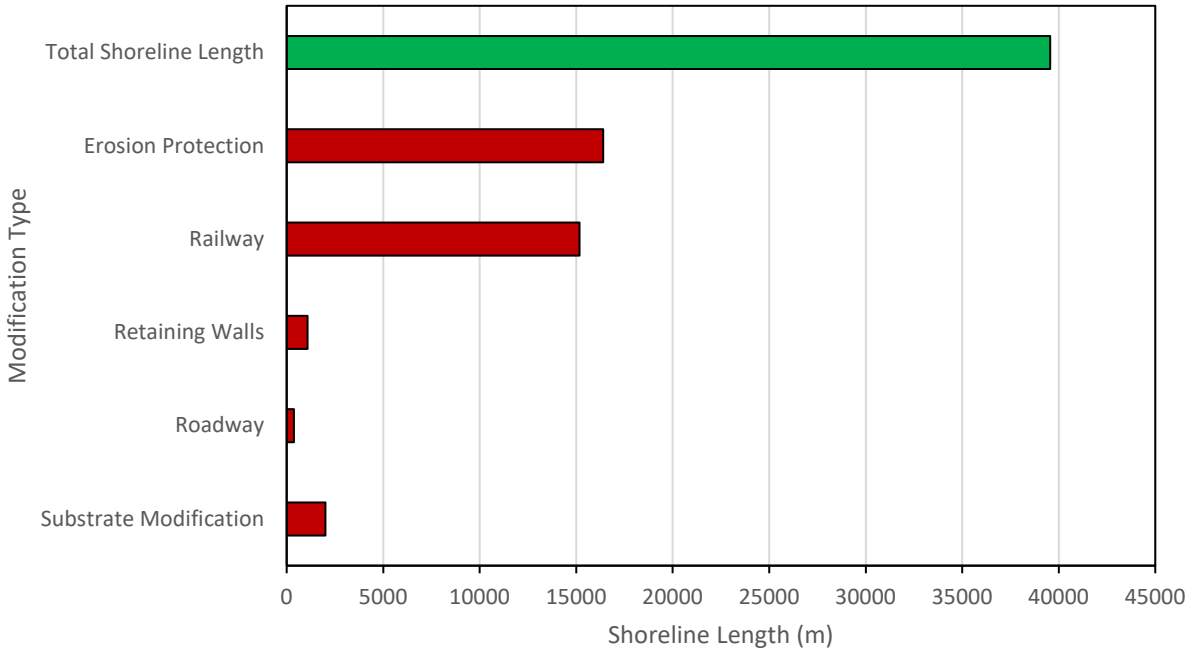

Figure 10: Total shoreline length that has been impacted by lineal modifications along the shoreline of Columbia Lake.

Disturbance of aquatic vegetation and littoral substrates was observed. Satellite and drone imagery suggested emergent aquatic vegetation had been removed to improve shoreline access at various locations. Aquatic vegetation was disturbed in lines caused by boat propeller drag through marl substate in shallow littoral areas (Figure 11). Mooring buoy anchor/chain drag and scour disturbed benthic sediments and impacted the growth of submergent aquatic vegetation (Figure 11).

Figure 11: Erosion and aquatic vegetation disturbance caused by mooring buoy anchor scour and boat propeller drag observed along the west shoreline of Columbia Lake in Segment 6.

3.1.9 Level of Impact

In total, 16,462 m (42%) of the Columbia Lake shoreline was considered to have a low level of impact (<10% disturbance; Figure 12). Areas with high level of impact (>50% disturbance) were observed along 14,643 m (37%) of the shoreline while medium level of impact (10-50% disturbance) was observed along the remaining 8,458 m (21%) of the shoreline (Figure 12). Examples of the different levels of impact assessed along the shoreline of Columbia Lake are illustrated in Figure 13.

The highest level of disturbance (≥95%) was observed in segments modified by the railway and associated erosion protection that also had modifications including docks and mooring buoys (Segments 6 and 7) and by an urban park with a large groyne, marina, retaining wall and modification of riparian habitat (Segment 5). Similar impacts were observed in segments with medium levels of impact (10-50%), however, sections of these segments remained in natural condition. For example, the wetland at the south end of the lake (Segment 8) was in natural condition except for along the west side of the segment where the railway and associated erosion control impacted the shoreline. Shoreline development associated with rural property residential development in Segment 1 also resulted in a medium level of disturbance (49% disturbed) because sections of the segment remained in natural condition though recent development within riparian Vegetation Band 1 and new shoreline modifications were observed (see Section 3.1.10).

Areas with low level of impact (<10%) were primarily in natural condition and were observed along the east shore of the lake that are protected as conservation or park lands.

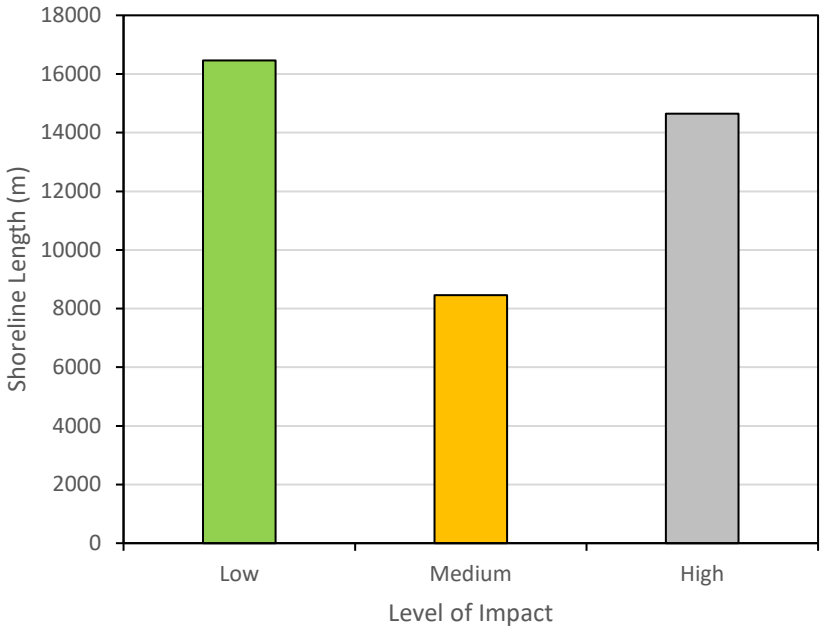

Figure 12: Level of Impact (None, Low, Medium or High) observed along the shoreline of Columbia Lake.

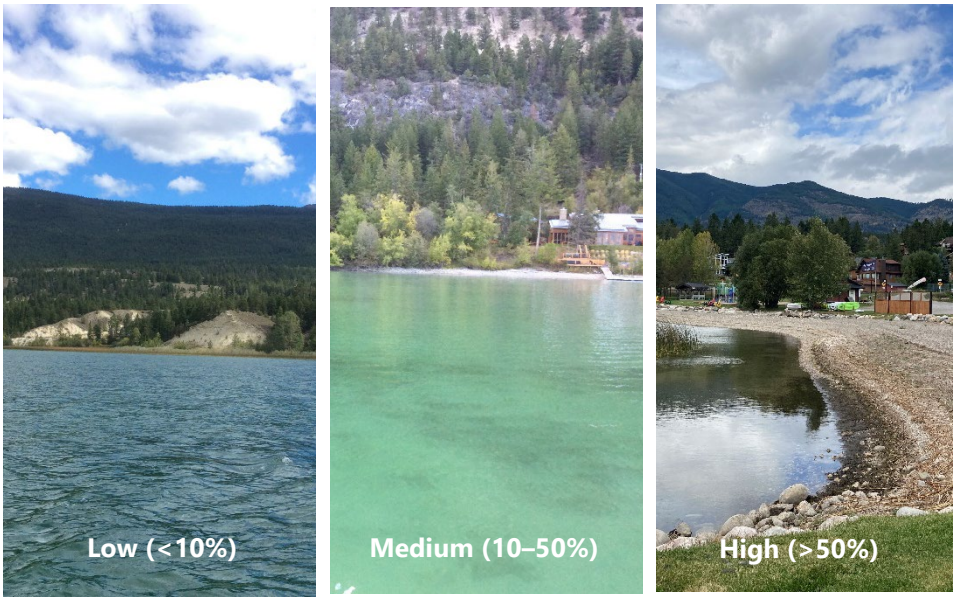

Figure 13: Examples of the different levels of impact assessed along the shoreline of Columbia Lake.

3.1.10 Comparison of 2009 FIM and 2021 re-FIM

The shoreline of Columbia Lake was divided into 8 segments in both 2009 and 2021. The total length of the mapped shoreline was less in 2021 (39,563 m) compared with 2009 (43,291 m) due to changes in HWM delineation methods (see Section 2.1.1).

3.1.10.1 Natural versus Disturbed Shoreline

The total length of disturbed shoreline increased slightly by 75 m (0.2% of the total shoreline) between 2009 and 2021 from 16,116 (40.7%) to 16,191 m (40.9%), respectively (Figure 14). Therefore, the total length of natural shoreline also slightly decreased between 2009 and 2021 from 23,447 m (59.3%) to 23,372 m (59.1%), respectively (Figure 14). This suggests the amount of disturbance along the Columbia Lake shoreline is increasing by approximately 6.8 m (0.02%) per year.

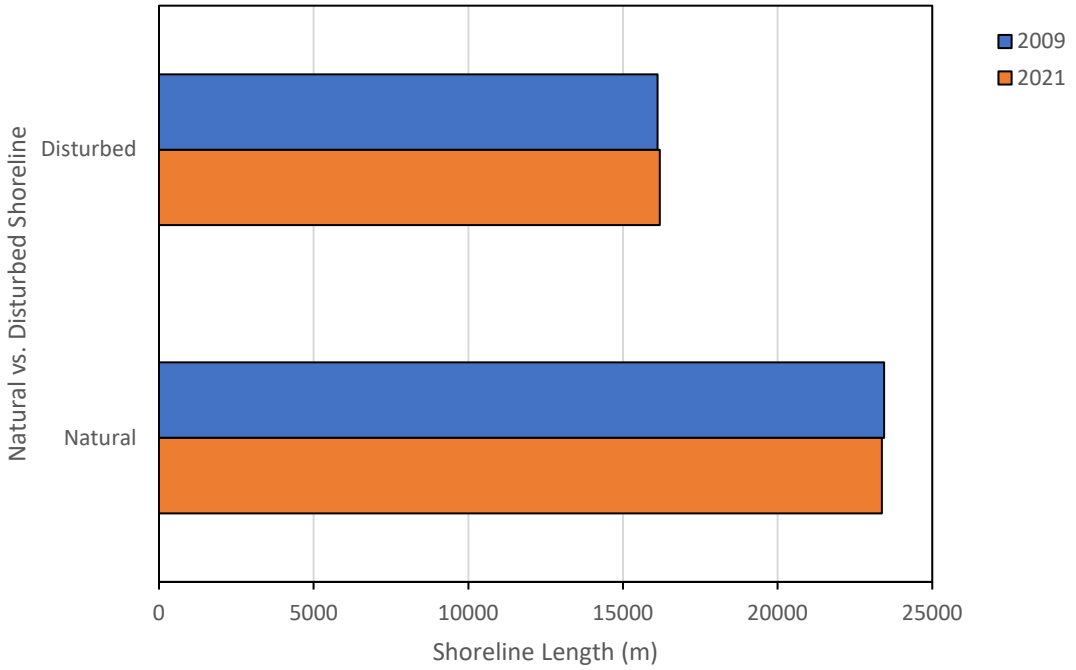

Figure 14: Comparison of the total shoreline length (m) classified as disturbed or natural for Columbia Lake, 2009 and 2021.

The level of disturbance increased between 2008 and 2021 at the following location:

- Southeast side of the lake north of Canal Flats (Segment 1) – New single-family homes have been constructed since the previous survey in the northern half of the segment. Shoreline modifications associated with new residences included removal of riparian vegetation, retaining walls and docks. Additional riparian clearing, retaining walls and docks were also observed near pre-existing residences (Figure 15). Additional infrastructure (e.g., washrooms, pumphouse, covered picnic tables) and docks were observed at Tilley Memorial Park, which was previously Canal Flats Provincial Park before being transferred to Canal Flats in 2010 and upgrades to park infrastructure were made in 2018. The land use in this section was defined as rural in both 2009 and 2021 though traits of the new properties being developed could warrant the reclassification of some or all areas of the segment to single-family residential. Overall, the level of disturbance increased by 4% (from 45% to 49%) between 2009 and 2021 resulting in approximately 75 m of recently disturbed shoreline.

This suggests the amount of disturbance in Segment 1 is increasing by approximately 6.8 m (0.4% of the segment) per year.

Figure 15: Photo of the southeast shoreline of Columbia Lake (Segment 1) in 2009 (left) and new retaining walls near the shoreline in 2021 (right).

Disturbance may have also increased in areas that were already disturbed in 2009 (e.g., Segments 5, 6 and 7) that did not change the percentage of the segment disturbed. Additional modifications were observed in some segments where the overall level of disturbance did not change (see Section 3.1.10.5). For example, upgrades to the Columere Park private marina (Segment 5) since the 2009 FIM survey were observed including expansion and resurfacing of the existing boat launch, new dock, new retaining wall adjacent to the boat launch, new boat slips and vegetation clearing (Figure 16). The shoreline of Segment 5 had already been classified as 100% disturbed in 2009, therefore, the additional modification observed in 2021 did not result in a change to this classification.

Figure 16: Photo of the Columere Park marina (Segment 5) in 2009 (left) and in 2021 (right).

3.1.10.2 Aquatic Vegetation Mapping

Overall, the 2009 aquatic vegetation mapping fit closely with what was observed in the field and in UAV images and no changes were made to the mapping at this time.

3.1.10.3 Land Use

Land use re-classification occurred in portions of segments where land use had changed since the 2009 survey. These locations included:

- Segment 1 – Most of the segment had been classified as rural (90% of the segment; 1689 m) in 2009. In 2021, this portion was reallocated to 75% rural (1407 m) and 15% single-family residential (282 m) because this classification better reflected additional shoreline development observed in some lots (e.g., Figure 15) and to capture the transition from rural to single-family residential style of development observed in the segment. Approximately 30% of parcels in Segment 1 are zoned as "SH - Small Holding" while the remaining 60% are "R-1A Residential" (Village of Canal Flats 2021), however, at this time most parcels were still only partially developed, a riparian buffer was retained and fit best under a rural land use definition.
- Segment 3 – One privately owned parcel that had been natural area in 2009 was converted to conservation in 2021 (15% of the segment; 1,943 m). The property, known as Columbia Lake - Lot 48, was acquired by the Nature Conservancy of Canada (NCC), with support from many partners and private donors, in 2011 (NCC 2021). The property had been the last remaining parcel not designated for conservation on the east side of the lake between Columbia Lake Park and the East Side Columbia Lake Wildlife Management Area (Figure 1).

Land use re-classification occurred in portions of segments where no land use changes had occurred, but updated definitions provided by Schleppe et al. (2021) required reassignment. These locations included:

- Segment 2 – An undeveloped privately held parcel at the south end of the segment that was assigned single-family residential in 2009 was reassigned as natural area in 2021 (10% of the segment; 233 m).
- Segment 8 – Three large private parcels at the northeast end of the segment were reassigned from conservation to rural land use (5% of the segment; 329 m).

3.1.10.4 Level of Impact

The level of impact classification for each segment did not change between the 2009 and 2021 surveys.

3.1.10.5 Shoreline Modifications

Counts of shoreline modifications that were comparable between survey years included the number of boat launches, docks, groynes, marinas, and retaining walls (Figure 17). Differences between 2009 and 2021 counts are as follows (Figure 17):

- Docks increased from 14 to 30.
- Retaining walls increased from 5 to 11.
- Groynes increased from 4 to 7. And,
- The number of boat launches and marinas remained the same.

Additional docks were observed since 2009 in Segment 6 (n=13) and Segment 1 (n=4), additional retaining walls were observed in Segment 1 (n=5) and Segment 6 (n=1), and groynes increased in Segment 7 (n=2) and Segment 6 (n=1).

The amount of the shoreline modified by retaining walls increased by approximately 25% (224 m) between years, while shoreline modified by railways and roadways was unchanged (Figure 18). Recently constructed retaining walls were observed in Segment 1 and the proportion of the segment containing retaining walls increased from 5% to 15% (see Section 3.1.10.1).

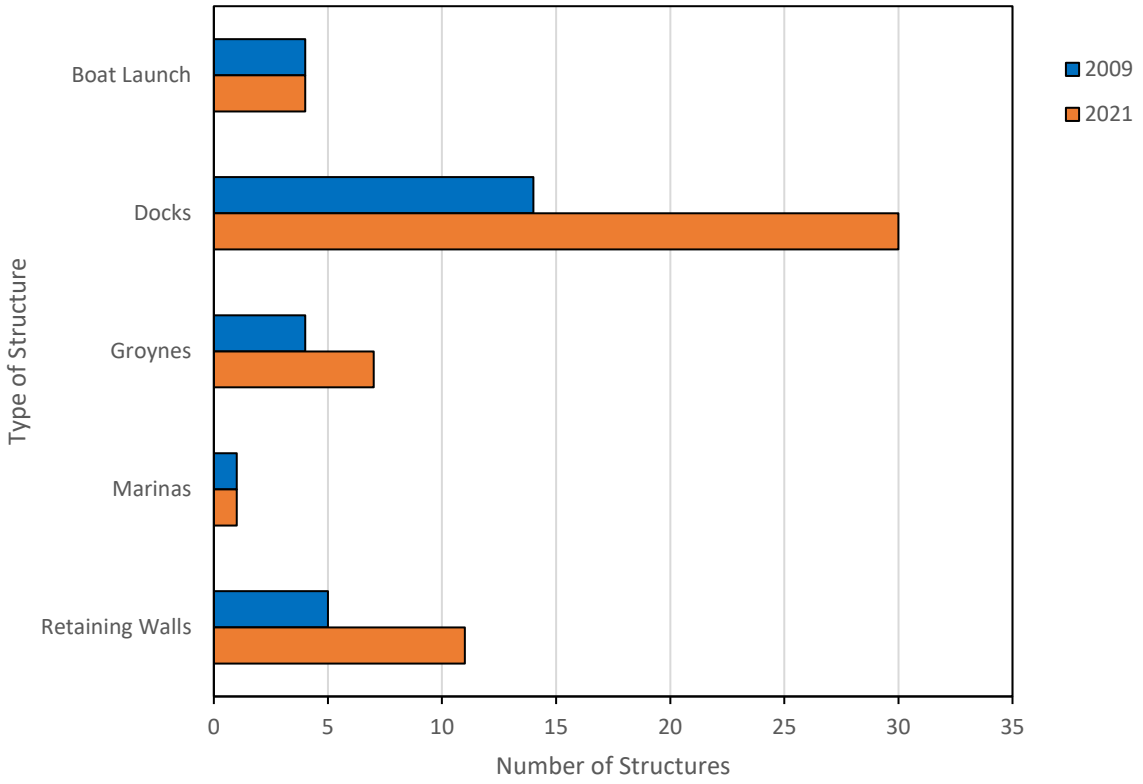

Figure 17: Comparison of the total number of selected modifications observed along the foreshore of Columbia Lake, 2009 and 2021.

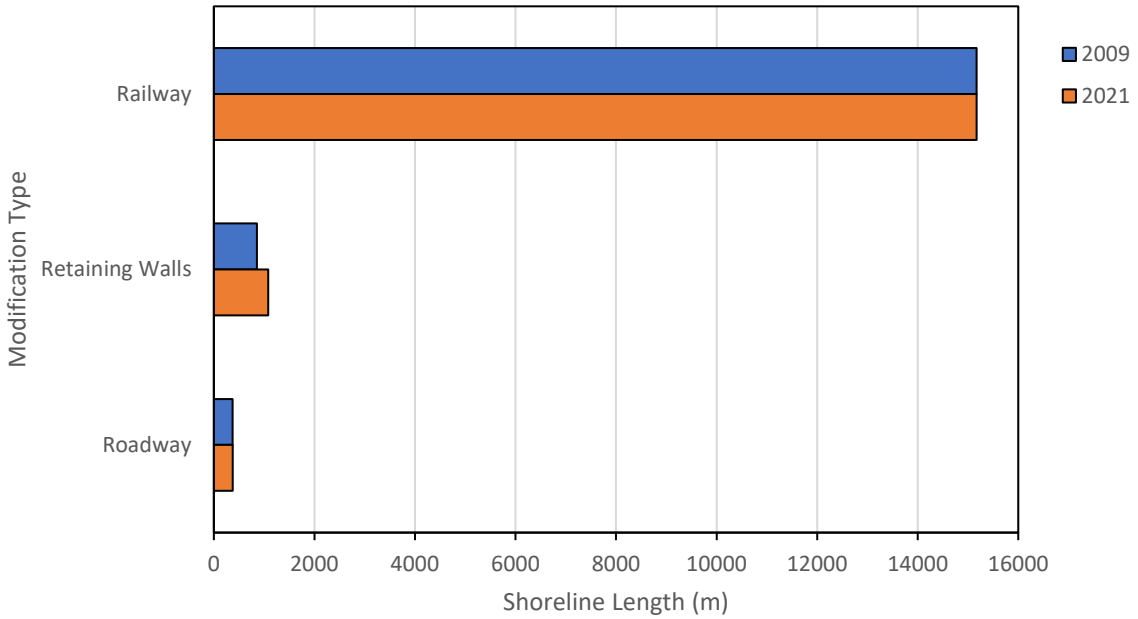

Figure 18: Comparison of total shoreline length that has been impacted by lineal modifications along the shoreline of Columbia Lake, 2009 and 2021.

Comparison of other modifications such as mooring buoys and substrate modification could not be made quantitatively because they had not been inventoried during the 2009 surveys. However, review of photo documentation taken in Segment 6 in 2009 suggests there were less mooring buoys in 2021 compared with 2009. Photographs depict at least 16 mooring buoys at a shoreline access point below Columbia Ridge in 2009 (Figure 19) while the 2021 survey inventoried only six in approximately the same location (see points identified on maps in Appendix A). Local residents suggest there are approximately 31 mooring buoys at Columbia Ridge in peak summer (CLSS, pers. comm., 2022). Similar observations were made in other areas of the lake including Timber Springs where five mooring buoys were documented in September 2021 whereas up to nine can be present during the summer season (CLSS, pers. comm., 2022). Based on these observations, it is likely some mooring buoys had been removed for the season when the 2021 re-FIM survey was conducted.

Figure 19: Photo of mooring buoys observed near the community of Columbia Ridge during the 2009 FIM survey.

3.2 FHSI

The FHSI developed for Columbia Lake followed the example provided by Schleppe et al. (2021) and used both FIM and non-FIM data. The Columbia Lake FHSI included four categories:

1. Biophysical (FIM).
2. Fisheries (non-FIM).
3. Ecosystem (non-FIM).
4. Rare Occurrences (non-FIM). And,
5. Modifications (FIM).

Biophysical and modification criteria used data collected during the 2021 re-FIM survey, fisheries criteria used information compiled during the 2009 fish survey and background literature review, and wildlife criteria used background literature review. Other non-FIM categories outlined in Schleppe et al. (2021) (e.g., herptile, waterfowl, and/or other criteria) were not included in the FHSI because data did not support the addition of these categories. Rationale for FIM criteria included in the Columbia Lake FHSI is provided in Table 2. The Columbia Lake FHSI is provided in Table 3.

Table 2: Ecological Rationale for Criteria Included in the Foreshore Habitat Sensitivity Index for Columbia Lake.

Category	Criteria	ZOS	Rationale
FIM	Shore Type	No	Shore type is related to many aspects of fish and wildlife habitat and inherent characteristics in each shore type (e.g., complexity, slope, substrate, etc.) can be an overarching determinant of habitat value. As a result, shore type received the highest weighting in the biophysical FIM category. Shore types with complexity that provide a variety of rearing, feeding and breeding habitats for both fish and wildlife (e.g., stream mouth, wetland, gravel beach and rocky shore) received higher value than less complex shore types (e.g., cliff/bluff and sand beach) (e.g., Kennedy and Mayer 2002; Rice et al. 2008).
	Foreshore Substrate	No	Substrates received a moderate weighting in the category because they provide important spawning and rearing habitat for fish. Cobble and gravel substrates received higher value than others because of their use as spawning and juvenile rearing habitat for salmonids and Burbot in Columbia Lake (McPhail 2007).
	Percentage Natural	No	Percent natural was weighted high in the biophysical FIM category to capture the habitat value of intact ecosystems found in natural areas.
	Aquatic Vegetation	Yes	Aquatic vegetation provides cover, food supply, primary production and filtration to aquatic ecosystems (Caskenette et al. 2020). The moderate weighting assigned reflects the wider extent of this criterion than others with smaller range of influence (e.g., overhanging vegetation, LWD). Aquatic vegetation was also included as a ZOS in Columbia Lake (see Section 3.2.2).
	Overhanging Vegetation	No	Overhanging vegetation provides a source of nutrients to aquatic ecosystems, foraging areas for wildlife and can shade nearshore habitat (Caskenette et al. 2020). This criterion along with LWD were weighted lowest of the biophysical FIM data because relative to other criteria the influence is quite low due to the class of riparian vegetation around Columbia Lake and relatively small bandwidth overhanging vegetation occupies.
	Large Woody Debris	No	LWD provides instream cover for fish of all age classes and is an especially important habitat for rearing juvenile salmonids. As with overhanging vegetation, the weighting of this criteria was lower than others due to the relatively small habitat contribution given the minor availability of LWD to Columbia Lake.
	Band 1	No	Riparian Band 1 received a higher value than Riparian Band 2 because it inherently has more influence on foreshore habitat than riparian areas set back from the shoreline. Wider riparian areas received more value as did vegetation types that contribute more to nutrient production than others (i.e., wetlands, broadleaf and shrubs) (Caskenette et al. 2020). Some riparian shrub species are also an important food source identified by SB thus receiving higher value (see Section 3.3).
	Band 2	No	

Category	Criteria	ZOS	Rationale
Fisheries	Burbot Spawning	Yes	Burbot are a species of regional conservation concern in the upper Columbia River system (McPhail 2007; EKBSWG 2019; Section 3.1.6). A Burbot spawning criterion was included in the initial Columbia Lake AHI (McPherson et al. 2010). The Burbot spawning criterion was assigned a higher value than other fisheries criteria due to the limited spawning areas documented, the population decline observed and the risk associated with loss of Burbot spawning habitat. Burbot are a historic food source for First Nations and the continued health of the species is a current priority (see Section 3.3). Documented spawning locations were also included as a point location ZOS (see Section 3.2.2).
	High Value Kokanee Area	No	A Kokanee staging/rearing criterion was included in the initial Columbia Lake AHI (McPherson et al. 2010). Dutch Creek, the inflow stream at the north end of Columbia Lake, is an important tributary for Kokanee spawning with the highest concentration of spawners occurring between the railway bridge and Highway 95 crossing (McPherson et al. 2010 and references cited therein). The north end of the lake provides important staging habitat for Kokanee spawners as well as important rearing habitat for juveniles as they out-migrate from Dutch Creek in the late spring.
	Juvenile Burbot Rearing	No	Juvenile Burbot in Columbia Lake have been observed in benthic habitats that provide cover, mainly from interstitial spaces in gravel, cobble and boulder substrates and infill (e.g., riprap) (Taylor 2001; McPherson et al. 2010). McPherson et al. (2010) evaluated lake foreshore substrates and juvenile Burbot observations to identify the presence of potential Burbot rearing habitat; they included this as a criterion in the initial AHI. This criterion was weighted lower than other fisheries criterion because of the relatively wide extent of possibly suitable habitats around the lake.
	Migration/Staging Habitat	Yes	Tributary mouth areas provide important habitat for fish rearing, migration and staging. Tributaries to Columbia Lake may provide spawning, egg incubation and juvenile rearing habitat for salmonids including Westslope Cutthroat Trout (Special Concern under SARA). Tributary mouth habitat was identified by reviewing watercourses that run to and/or from Columbia Lake as delineated in the BC Freshwater Atlas.
	Mussel Presence	No	The presence of mussel beds was included as a criterion in the initial Columbia Lake AHI (McPherson et al. 2010). Mussels are filter-feeders that help maintain/improve water quality and they also provide a food source for a variety of wildlife, birds and fish. Mussels have been identified during targeted and incidental observations though identifying the boundaries of mussel beds in Columbia Lake has proved challenging (see Section 3.1.6). Due to location uncertainties and limited data, mussel beds were not delineated as ZOS and weighted slightly lower than some fisheries criteria.
Wildlife	Avian Bank Nesting Locations	No	The steep bluffs with friable soils common to much of the Columbia Lake shoreline are ideal for supporting burrowing swallow nests. Some burrow sites belong to Bank Swallows, listed as Threatened under SARA. Human presence near nest sites can reduce species use by avoidance and through alteration/destruction of nesting sites. The presence of bank nesting sites was identified by McPherson et al. (2010) and during the 2021 FIM field survey. Darvil (2021) also provides additional information on swallow nesting sites along Columbia Lake. All bank nesting sites identified during the FIM surveys were weighted equally (i.e., SARA-listed species were not rated higher) to ensure all habitat available was captured in a meaningful way, and to protect sensitive information related to at-risk species.
Ecosystem	Grassland Ecosystem	No	Native grasslands cover less than 1% of the land base in B.C. while providing habitat for 30% of B.C.'s at-risk species (GCC 2022). Grassland ecosystems adjacent to Columbia Lake provide habitat for species that depend on grassland and open forest habitat types at low elevation including Bighorn Sheep and ungulates. Grasslands around Columbia Lake have been reduced by anthropogenic development and by encroaching conifer growth in some areas. Grasslands were mapped in the Fairmont Hot Springs & Columbia Lake Area OCP and include polygons adjacent to the foreshore. Intact grassland habitat is mainly located within the East Side Columbia Lake WMA with small areas also present on the west side of the lake. The criterion was included because grassland ecosystems are rare, at-risk of loss due to human encroachment and may be present near developing areas of Columbia Lake.

Category	Criteria	ZOS	Rationale
Rare Occurrences	SARA Listed Species	No	Location where species listed as Endangered, Threatened or Special Concern under SARA have been observed that were not already included in the categories above were identified under rare occurrences. Observations within the lake as well as the riparian area within 50 m of the HWM identified on CDC iMap were included. This included Painted Turtle - Intermountain-Rocky Mountain Population, Lewis's Woodpecker, Limber Pine, McCalla's Dwarf Braya and Stiff-Leaved Pondweed.
Modifications	Retaining Wall	No	Schleppe et al. (2021) provides detailed description of the impacts modifications can have on foreshore habitats. Similar weights were given to all modification criteria. Docks and marinas were weighted slightly higher than other modifications because they are often associated with various other foreshore modifications (e.g., riparian clearing, substrate modification) and provide habitat for non-native fish species. Groynes were weighted slightly lower because groyne density was fairly low relative to docks and retaining walls. Columbia Lake FIM data was reviewed as a histogram to develop lake-specific value categories (Low, Moderate, High).
	Docks		
	Groynes		
	Boat Launch		
	Marina		

Table 3: Foreshore Habitat Sensitivity Index for Columbia Lake

Category	Criteria	Percentage of FHSI	Percent Within Category	Logic	Uses Weighted FIM Data	Value Categories
FIM	Shore Type	17.7	26	Proportion of Segment * Percentage of FHSI * Value Category	Yes	Stream Mouth = Wetland (1) > Gravel Beach = Rocky Shore (0.8) > Sand Beach = Cliff /Bluff (0.5), Other (0.3)
	Foreshore Substrate	9.5	14	Proportion of Segment * Percentage of FHSI * Value Category	Yes	Cobble (1) > Gravel (1) > Boulder = Organic = Mud = Marl (0.8), Fines = Sands (0.5) > Bedrock (0.3)
	Percentage Natural	14.3	21	Proportion of Segment Natural * Percentage of the FHSI	No	
	Aquatic Vegetation	10.2	15	Proportion of Segment with Aquatic Vegetation * Percentage of the FHSI	No	
	Overhanging Vegetation	2.7	4	Proportion of Segment with Overhanging Vegetation * Percentage of the FHSI	No	
	Large Woody Debris	2.7	4	Percentage of the FHSI * Value Category	No	3 LWD/km (1) > 2 -3 LWD/km (0.8) > 1 - 2 LWD/km (0.6) > 0 - 1 LWD/km (0.4) > 0
	Band 1	8.2	12	Vegetation Bandwidth Category * Vegetation Quality * Percentage of the FHSI	Yes	**Vegetation Bandwidth Category** 1 to 5 m (0.2) < 6 to 10 m (0.4) < 11 to 15 m (0.6) < 16 to 20 m (0.8) < 21 m (1)
	Band 2	2.7	4	Vegetation Bandwidth Category * Vegetation Quality * Percentage of the FHSI	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)
Category Subtotal		68.0	100			

Category	Criteria	Percentage of FHSI	Percent Within Category	Logic	Uses Weighted FIM Data	Value Categories
Fisheries	Burbot Spawning	3.9	30	Present (Percentage of the FHSI), Absent (0)	No	
	Burbot Rearing	1.3	10	Present (Percentage of the FHSI), Absent (0)	No	
	High Value Kokanee Area	3.3	25	Present (Percentage of the FHSI), Absent (0)	No	
	Migration/Staging	3.3	25	Present (Percentage of the FHSI), Absent (0)	No	
	Mussel Presence	1.3	10	Present (Percentage of the FHSI), Absent (0)	No	
Category Subtotal		13.0	100			
Wildlife	Avian Bank Nesting Locations	3.0	100	Present (Percentage of the FHSI), Absent (0)	No	
Category Subtotal		3.0	100			
Ecosystem	Grassland Ecosystem	3.0	100	Present (Percentage of the FHSI), Absent (0)	No	
Category Subtotal		3.0	100			
Rare Occurrences	SARA Listed Species	3.0	100	Present (Percentage of the FHSI), Absent (0)	No	
Category Subtotal		3.0	100			

Category	Criteria	Percentage of FHSI	Percent Within Category	Logic	Uses Weighted FIM Data	Value Categories
Modifications	Retaining Wall	2.0	20	Proportion of Segment with Retaining Walls * (Percentage of the FHSI)	No	
	Docks	2.5	25	Dock Density is categorized as High, Moderate, Low or None using segment data. High = Percentage of the FHSI, Moderate (0.75*Percentage of the FHSI), Low (0.5*Percentage of the FHSI), None (0*Percentage of FHSI)	No	>0-1 docks/km (Low); >1-5 docks/km (Moderate); >5 docks/km (High)
	Groynes	1.0	10	Groyne Density is categorized as High, Moderate, Low or None using segment data. High = Percentage of the FHSI, Moderate (0.75*Percentage of the FHSI), Low (0.5*Percentage of the FHSI), None (0*Percentage of FHSI)	No	>0-1 groynes/km (Low); >1-5 groynes/km (Moderate); >5 groynes/km (High)
	Boat Launch	2.0	20	Boat Launch Density is categorized as High, Moderate, Low or None using segment data. High = Percentage of the FHSI, Moderate (0.75*Percentage of the FHSI), Low (0.5*Percentage of the FHSI), None (0*Percentage of FHSI)	No	>0-1 boat launch/km (Low); >1-2 boat launches/km (Moderate); >2 boat launches/km (High)
	Marina	2.5	25	Present (Percentage of the FHSI), Absent (0)	No	
Category Subtotal		10.0	100			
Total		**100.0**				

3.2.1 Summary of FHSI Values

A summary of the 2021 FHSI values for Columbia Lake is provided in Table 4. Maps of shoreline segments with FHSI Ecological Ranking are provided in Appendix C. Calculations for each criterion and category as well as Ecological Rank breaks are provided in Appendix D.

Most of the shoreline of Columbia Lake was ranked as Moderate (39.8%) ecological value followed by High (38.6%), Very High (19.6%), and Very Low (1.9%) (Table 4). Most shoreline areas with High and Very High ecological value remained in natural condition (0% and 13% disturbed, respectively) while most shoreline areas with Moderate and Very Low ecological value were disturbed (91.6% and 100% disturbed, respectively) (Figure 20).

Table 4: Columbia Lake FHSI Ecological Rankings.

FHSI Ecological Rank	# of Segments	Shoreline Length (m)	% of Shoreline
Very High	2	7,763	19.6
High	2	15,280	38.6
Moderate	3	15,755	39.8
Low	0	0	0.0
Very Low	1	764	1.9
Total	8	39,563	100

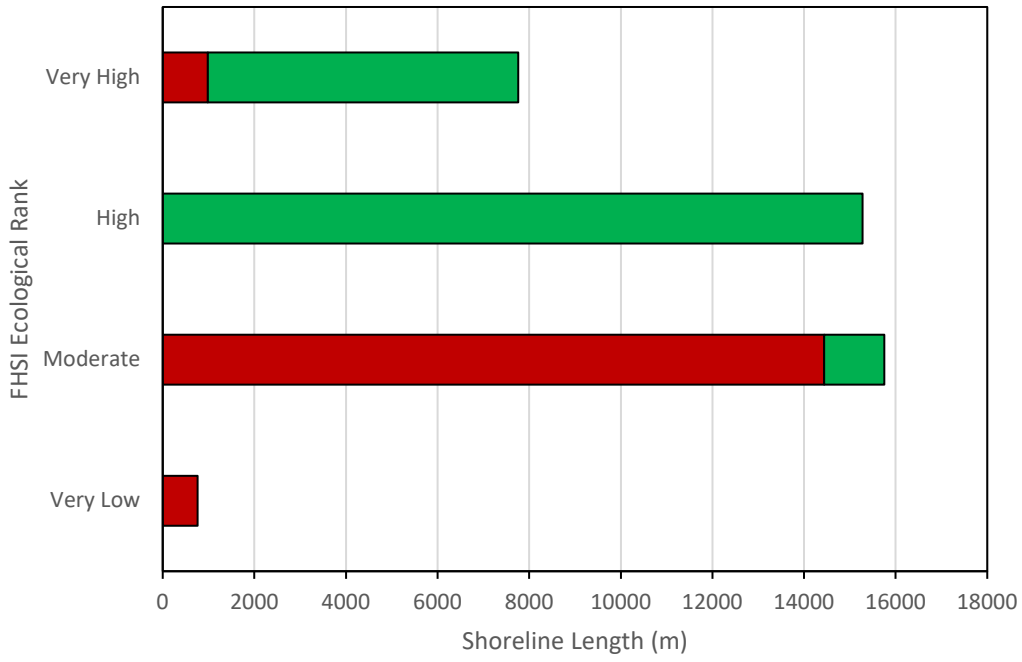

Figure 20: FHSI Ecological Rankings and length of natural (green) versus disturbed (red) shoreline for Columbia Lake.

All Very High ecological value segments had wetland shore types while High ecological value segments had gravel or cliff/bluff shore types (Table 5). Moderate and Very Low ecological value segments had gravel shore types (Table 5). Conservation land use was observed in all segments with Very High and High ecological value while rural and transportation were observed in segments with Moderate ecological value (Table 6). The one Very Low ecological value segment was entirely an urban park (Table 6).

Table 5: Columbia Lake FHSI Ecological Rankings by shore type.

FHSI Ecological Rank	Cliff/Bluff		Gravel		Wetland	
	Shoreline Length (m)	% of Shore Type Category	Shoreline Length (m)	% of Shore Type Category	Shoreline Length (m)	% of Shore Type Category
Very High	0	0	0	0	7,763	100
High	12,952	100	2,329	12	0	0
Moderate	0	0	15,755	84	0	0
Low	0	0	0	0	0	0
Very Low	0	0	764	4	0	0

Table 6: Columbia Lake FHSI Ecological Rankings by land use.

FHSI Ecological Rank	Conservation		Rural		Transportation		Urban Park	
	Shoreline Length (m)	% of Shore Type Category	Shoreline Length (m)	% of Shore Type Category	Shoreline Length (m)	% of Shore Type Category	Shoreline Length (m)	% of Shore Type Category
Very High	7,763	34	0	0	0	0	0	0
High	15,280	66	0	0	0	0	0	0
Moderate	0	0	1,877	100	13,879	100	0	0
Low	0	0	0	0	0	0	0	0
Very Low	0	0	0	0	0	0	764	100

In general, Very High ecological value was identified where the shoreline consisted of wetlands that were in natural condition with no/very little shoreline modification or disturbance observed. These shoreline areas also had wide littoral areas, abundant aquatic vegetation, important habitat for various species and life stages of fish as well as intact wildlife connectivity corridors. Conversely, Very Low ecological value areas were identified where the shoreline was heavily disturbed by transportation and residential related shoreline modifications.

Overall, two segments had different Ecological Rankings in 2021 compared to 2009 (McPherson et al. 2010). Segments 6 and 7 both increased in ecological value from Low to Moderate between the initial FIM and the re-FIM. This was due to additional criteria and adjusted weighting included in the 2021 FHSI that captured more aspects of shoreline habitat sensitivity than the 2009 AHI was able to detect.

3.2.2 Zones of Sensitivity

A list of ZOS identified during the FIM field assessment and during the background data review are described below.

- Aquatic Vegetation – Aquatic vegetation contributes to the overall health of an ecosystem by providing an important source of nutrients, oxygenation and habitat for aquatic, terrestrial and avian species (Kennedy and Mayer 2002). Aquatic vegetation is an important component of wetlands, which provide habitat, flood control, water filtration and food resources (Mitsch and Gosselink 1993). Emergent aquatic vegetation on Columbia Lake was originally mapped by McPherson et al. (2010). Darvil (2021) identified Bulrush and Cattail marsh ecological communities at various locations around Columbia Lake; these locations fell within areas delineated by McPherson et al. (2010). Note that aquatic vegetation polygons overlaid wetland polygons delineated in the BC Freshwater Atlas; wetlands were not included as a unique ZOS because detailed wetland inventory and mapping has not been conducted and the available polygons from the BC Freshwater Atlas did not incorporate the full extent of wetland areas observed during FIM surveys and orthophoto and UAV image review. Therefore, aquatic vegetation polygons were selected as the best way to represent this ZOS with the data that is currently available.
- Tributary Mouths – Tributary mouth areas provide important habitat for fish rearing, migration and staging. Tributaries to Columbia Lake may provide spawning, egg incubation and juvenile rearing habitat for Westslope Cutthroat Trout (SARA Schedule 1; Of Special Concern), Bull Trout and Rainbow Trout. Tributary mouths can also provide cool water refuge during summer when there are periods of higher water temperatures (Rice et al. 2008). In addition to fisheries values, water quality parameters such as temperature, dissolved oxygen, turbidity and nutrients of tributary inflows play an important role in the overall water quality of lake ecosystems (Rice et al. 2008). Therefore, the confluence areas of all tributaries to and from Columbia Lake delineated in the BC Freshwater Atlas dataset were identified as tributary mouth ZOS. Tributary mouth polygons were identified by a 100 m radius semicircle polygon at the confluence of tributaries and Columbia Lake. The outlet to the Columbia River and Dutch Creek was identified by a 250 m radium semicircle as it is the main outflow, backflooding source and Kokanee spawning stream in the lake.
- Burbot Spawning Areas – Burbot spawning has been documented in a tributary at the south end of the lake (Segment 8) and under the ice at the north end of the lake (Segment 4; Ardnt 2001). Burbot spawn during the winter and aggregations of up to 200 individuals (13 February 2002) have been observed at one time in the spawning tributary at the south end of the lake (Ardnt 2002). Known spawning locations were identified as a ZOS point location to provide an indication of the general area that spawning occurs.

3.2.3 Potential Conservation Zones

Columbia Lake is unique in that conservation zones are already established along a significant percentage (58%) of the foreshore and most of this area remains in natural condition (96%). Habitat adjacent to most of the north, east and south foreshore is protected by park, conservation areas and WMAs located in Segments 2, 3, 4 and 8. It is recommended that conservation of these areas is supported in perpetuity.

3.2.4 Comparison of 2009 and 2021 AHI Results

The AHI developed in 2009 by McPherson et al. (2010) was applied to the 2021 dataset to allow direct comparisons of shoreline sensitivity using the same index. Table 7 summarizes the amount of shoreline area designated as Very High, High, Moderate, Low and Very Low habitat index ranking in 2009 and 2021. Detailed results by segment are provided in McPherson et al. (2010) for the 2009 dataset and in Appendix E

for the 2021 dataset. The comparison suggested the shoreline ranking remained unchanged except for one segment that increase from a Low to Moderate rank (Segment 7; Table 7; Appendix E). The Segment 7 rank increase was due to data/analysis errors during the 2009 AHI evaluation and not because habitat conditions have improved since the previous survey. A boat launch from Segment 8 was included as a modification in Segment 7 and riparian characteristics were not given full scoring during the AHI calculation which resulted in a lower ranking than should have been assigned in 2009.

Table 7: Summary of the number of shoreline segments, shoreline length and percent of shoreline for the 2009 Aquatic Habitat Index categories for Columbia Lake. Data for 2009 is reproduced from McPherson et al. (2010).

Categories	2009			2021		
	# of Segments	Shoreline Length (m)*	% of Shoreline	# of Segments	Shoreline Length (m)*	% of Shoreline
Very High	2	7,763	19.6	2	7,763	19.6
High	2	15,280	38.6	2	15,280	38.6
Moderate	1	1,877	4.7	2	8,583	21.7
Low	2	13,879	35.1	1	7,173	18.1
Very Low	1	764	1.9	1	764	1.9
Total	8	39,563	100	8	39,563	100

Notes: * Shoreline segment lengths calculated in 2021 are used for both years to facilitate direct comparison.

3.3 TEK

Shuswap Band is a member of the Secwépemc Nation and caretaker over a vast area within Secwépemc traditional territory, or *Secwépemcu'l'ecw*. Effective habitat and resource management techniques were developed by SB ancestors over a span of 3,500 years, to preserve and maintain the land within the territory. Communities depended on accurate knowledge of environmental resources and the ability to adapt to changing environmental conditions to survive and grow. Ancestral knowledge of landscape conditions and changes over time has contributed to the current day understanding of the environment and landscape throughout Shuswap Band's caretaker area, including and beyond Columbia Lake.

In the areas surrounding both Windermere and Columbia Lakes, fishing camps as evidenced by kekuli, or underground pit-houses, were established to allow families to harvest salmon which once existed here in abundance. Salmon are an inseparable facet of Secwépemc life and identity, as teachings, stories, spirituality, and culture have been intertwined with salmon fishing and food preparation for thousands of years. Columbia Lake was also of spiritual importance to SB ancestors, and culturally significant as a place of living, teaching, travelling, and resource-gathering, as evidenced by the existence of trails, kekulis, and oral histories which have been passed down through the Shuswap community for generations. As Shuswap Band ancestors traveled throughout the Columbia Valley for millennia making use of waterways as transportation networks and using established trail networks to connect to meeting sites, resource collection-areas, and habitation grounds, Columbia Lake became an important part of Secwépemc life and knowledge of the territory and landscape.

Shuswap Band Knowledge Keepers note that species including trout, burbot, grizzly bear, gray owl, grouse, white tail deer, moose, and eagle inhabit the lands and waters surrounding Columbia Lake[1]. Shuswap Band ancestors also fished salmon in the lake before Settler-built dams were constructed and led to the degradation of the species. As salmon is so deeply intertwined with Secwépemc culture, spirituality, teachings, and livelihood, the restoration of salmon habitat to the Columbia River and its connected waterways is of the utmost importance to SB members. The sustained health of existing species such as burbot, trout, and ungulates, and plants which are found in this area such as huckleberries, soapberries, and chokecherries, are of the utmost importance as independent yet connected parts of the same ecosystem.

3.4 FDG

The FDG for Columbia Lake is provided in Appendix F. The FDG is also provided under separate cover for distribution to landowners, regulators and other stakeholders.

[1] Information provided by Knowledge Keepers (KK) is stored on Shuswap Band's internal database, the "Community Knowledge Keeper" (CKK). KK's are not identified by name for reasons of confidentiality.

4.0 Discussion

The foreshore of Columbia Lake remained in a relatively similar state between the 2021 re-FIM and the initial 2009 FIM. Overall, 59.1% of the Columbia Lake shoreline remains undisturbed. The total length of disturbed shoreline increased slightly between 2009 and 2021 (75 m; 0.2% of the total shoreline) and this change was documented in one segment at the southeast corner of the lake to the north of Canal Flats (Segment 1; 4% of segment shoreline). Columbia Lake stands out from other lakes in the East Kootenay where re-FIM surveys were recently conducted in that a higher percentage of the shoreline remains in natural condition and less shoreline area has been modified since the initial FIM. For example, a re-FIM survey of Windermere Lake conducted in 2020 observed that 43% of the shoreline remained in natural condition and approximately 1% (369 m) of the shoreline had been disturbed since the initial FIM in 2006 (Schleppe and McPherson 2021). Similar results were also observed during the re-FIM survey of Moyie Lake in 2020 where 55% of the shoreline remained in natural condition and approximately 1.3% (471 m) of shoreline had been disturbed since the initial FIM in 2008 (Wood 2021a).

Land uses around Columbia Lake limit the areas available for further modification and development. The primary shoreline disturbance is the railway along the west shoreline of the lake and erosion protection features (e.g., riprap) associated with it and the majority of other shoreline areas are protected. Although the west side of the lake is mainly a transportation corridor, small pockets of crown and private land occur adjacent to the lake beside the railway. In Segment 6, the number of docks increased over 5-fold from only three in 2009 to 16 in 2021. Docks and mooring buoys are the primary non-lineal shoreline modifications observed in this segment and they are usually concentrated in small areas near privately held land. Although the total number of modifications remains low on Columbia Lake compared to other East Kootenay lakes (e.g., 30 docks total compared to 275 docks enumerated on Windermere Lake in 2020 (Schleppe and McPherson 2021)), counts of docks, retaining walls and groynes have at least doubled in Columbia Lake since the initial FIM.

Shoreline disturbance increased in one segment in the southeast corner of the lake near Canal Flats (Segment 1). New single family residential developments had been constructed or were in construction during the 2021 re-FIM survey and new docks and retaining walls were also documented. Undeveloped shoreline properties in Segment 1 are mainly zoned for residential use and it is likely more development will occur in the future. However, some residential lots have been developed in a way that limits shoreline impacts by maintaining riparian areas and minimizing the number of shoreline modifications. McPherson et al. (2010) showcased a property in Segment 1 as an example of how future planning could be undertaken (Figure 21). This same property in 2021 was observed to retain these features (i.e., intact emergent and riparian vegetation and a lack of shoreline modifications) (Figure 21). However, in 2021 it was noted that modifications have increased at other properties in Segment 1 (e.g., Figure 15).

Figure 21: Photo of a residence in Segment 1 in 2009 (left) presented as an example of development that minimized foreshore disturbance by McPherson et al. (2010). An updated photo of the residence was taken in 2021 with the roofline now mostly hidden by coniferous trees at the middle of the photo (right).

There are two Official Community Plans (OCPs) applicable to Columbia Lake: Fairmont Hot Springs & Columbia Lake Area OCP (Bylaw No. 2779, 2017) and the Village of Canal Flats OCP. The Village of Canal Flats OCP includes Shoreline Development Permit Area (DPA) requirements that apply to all properties with all or a portion of the property located adjacent to Columbia Lake (Village of Canal Flats 2019). This includes all properties in Segment 1. The Shoreline DPA includes, among other requirements, a direction to landowners/developers to utilize the Columbia Lake FIM and SMG (now FDG) documents to identify sensitive habitats. Also included in the DPA is a requirement that "*The shoreline area, understood to be any land within 30 metres of the natural boundary of Columbia Lake or the Kootenay River, shall remain free of development and in its natural condition*" though there is a caveat that a lesser setback is permissible provided a Qualified Environmental Professional (QEP) details how the development will minimize shoreline impact and provide habitat restoration (Village of Canal Flats 2019). Development was observed within this 30 m setback between the 2009 and 2021 FIM surveys; it is unknown if DPAs were obtained prior to development. Enforcement of OCP policies is recommended.

Columbia Lake was the first lake on which the RDEK introduced surface water zoning to restrict where mooring buoys or other in-water structures were permissible (RDEK 2022). The RDEK conducted on-lake inventories of mooring buoys in 2010 (n=53) and 2020 (n=58) to maintain a record of use and to determine the level of compliance with the zoning bylaw (RDEK 2022). They noted that in the past there has been limited enforcement of mooring buoy regulations on the lake. The number of mooring buoys observed during the 2021 re-FIM survey was lower (n=26) suggesting some mooring buoys have been removed since the 2020 RDEK survey, though it is unknown if this reflects permanent or seasonal removal. The Columbia Lake Management Strategy is currently being revised and includes recommendations around "Moorage and Lake Access" including requirements specific to mooring buoys, marinas and docks as well as a statement that new mooring buoys are generally not supported (RDEK 2022).

Conservation areas adjacent to Columbia Lake have successfully preserved a large proportion (58%) of the shoreline. Habitat along nearly the entire north, east and south shores of the lake, except for Segment 1 and a small section of Segment 8 in the southeast corner near Canal Flats, is protected as provincial park, WMAs and conservation properties (Figure 1). In segments with primarily conservation land uses, shoreline disturbance was not observed to have increased during the re-FIM survey. Since the initial FIM, nearly 2 km of shoreline on the east shore has changed from a privately held property parcel to a conservation property after purchase by NCC in 2011 (NCC 2021). The actions of stewardship groups, private landowners, regulators and First Nations have resulted in protection of a significant portion of the Columbia Lake foreshore.

5.0 Recommendations

The following are recommendations to protect sensitive habitats around Columbia Lake and improve the FIMP if additional data becomes available in the future:

1. **Update existing ZOS to reflect any new information.**

   Additional sensitive habitat features can be added as polygons, points or lines to the FIMP dataset and maps. A field-based tributary assessment should be conducted to update the current dataset of tributary mouth ZOS. Potential swallow habitat around the lake could be inventoried, mapped and FIMP updated to include as ZOS.

2. **Conduct an inventory of freshwater mussel bed locations in Columbia Lake.**

   Previous mussel surveys have identified water clarity issues as a limiting factor to identifying mussel bed locations in Columbia Lake. In addition, targeted surveys have been limited to one half day in 2007. An inventory conducted during periods of good underwater visibility is required to better identify the current distribution of mussel beds in the lake.

3. **Conduct an assessment of overnight moorage on Columbia Lake.**

   Overnight moorage on Columbia Lake is only permitted in the marina at Columere Park in areas of the lake included in the Fairmont Hot Springs & Columbia Lake Area OCP. Overnight moorage was observed at various locations during the 2021 FIM survey. Enforcement of this bylaw is required.

4. **Remove private mooring buoys in areas not zoned for their placement.**

   The Fairmont Hot Springs & Columbia Lake Area OCP states that private mooring buoys are only allowed in the three areas of the lake zoned for their placement. A desktop review could be conducted to review the locations of mooring buoys identified on FIM mapping products against current zoning and bylaws to identify locations where buoy removal may be necessary.

5. **Remove private mooring buoys and docks from ZOS.**

   Mooring buoys and docks were observed within emergent vegetation and tributary mouth ZOS in Columbia Lake. Disturbance of littoral substrates and aquatic vegetation was observed to facilitate placement of shoreline modifications in some locations. For example, mooring buoy anchor/chain drag and scour was observed to disturb benthic sediments and impact the growth of aquatic vegetation. It is recommended that non-tenured mooring buoys and docks be removed from sensitive habitat areas identified as ZOS.

6. **Consider downstream impacts of hydrological changes in tributaries to Columbia Lake.**

   Upstream alterations to streamflow to control future flooding (e.g., dykes) or for anthropogenic water withdrawals have the potential to change the flow regime through wetlands identified as Very High and High ecological value to the lake. Hydrological impacts of channel alterations to tributaries and groundwater sources that contribute to the water balance of Columbia Lake should be evaluated with consideration of downstream impacts that may occur.

7. **Consider conservation actions and priorities when considering or reviewing applications for future shoreline development.**

   For example, the Columbia Wetlands Conservation Action Framework (2020-2025) includes actions that will contribute to sustaining the biological diversity and ecological integrity of the Columbia Wetlands. Some actions are specific to Columbia Lake. For example, "*Action 4.20 - Ensure*

developments along the shorelines of Lake Windermere and Columbia Lake follow best practices to maintain high quality lake ecosystems in the two lakes" (Mahr 2020).

8. **Consider potential impacts of climate change during foreshore and lake planning.**

   The effects of climate change have the potential to alter riparian and aquatic habitats in various ways such as altering hydrological patterns, increasing wildfire intensity and increasing water temperatures. Lake planning, such as FIMP, can help mitigate climate-related impacts by identifying sensitive habitats, directing development applications in a manner that conserves high value habitat, communicating to the public how these habitats provide resilience to climate impacts such as mitigating flood impacts and identifying opportunities for habitat restoration.

9. **Conduct a compliance audit of recent shoreline modification.**

   Determine if permits were obtained for new works documented since the 2009 surveys (e.g., at the southeast corner of the lake in Segment 1) and evaluate if permit conditions were met. Follow-up with property owners if enforcement may be required.

10. **Ensure development near the foreshore is compliant with existing OCPs and Best Management Practices.**

    For example, residential development at the southeast corner of the lake (Segment 1) falls within the Village of Canal Flats OCP's Shoreline DPA which stipulates no development is permissible within 30 m of the natural boundary of Columbia Lake. This is the only area shoreline development had increased between the initial FIM and re-FIM and education and enforcement of existing bylaws is required to protect the undisturbed areas that remain.

11. **Update the Canal Flats OCP.**

    The existing OCP does not currently include Ecological Rankings assigned to shoreline segments during the initial FIMP to guide development recommendations. FHSI Ecological Rankings as presented in the FDG area available for integration into existing OCPs. Sensitive shoreline areas (red and orange shoreline segments) should receive additional conservation protections (e.g., development permit areas) in existing OCPs. ZOS should also be incorporated into the bylaw and receive the same protections as red and orange shoreline segments.

12. **Update the Fairmont Hot Springs & Columbia Lake Area OCP (Bylaw No. 2779, 2017).**

    The existing OCP mentions that the 2009 management guidelines for the shoreline of Columbia Lake (specifically the Ecological Rankings assigned to shoreline segments) should be consulted when considering development along the foreshore. A development permit area for shorelines areas with High and Very High ecological value was not included in the OCP because opportunities for development were limited to the western shoreline where habitat was ranked as Very Low or Low ecological value. Ranks were upgraded for two of the three segments along the west side of the lake (Segments 6 and 7) from Low to Moderate during the re-FIM. The OCP should be updated to reflect the revised ecological value of all shoreline areas as well as to include ZOS.

13. **Update the Columbia Lake Management Strategy.**

    A draft management strategy, updated from the 1997 strategy, was released in 2021 with a public comment period that ended on November 30, 2021. The strategy references the 2010 EKILMP SHIM and includes results and recommendations of the 2009 FIM, AHI and SMG including shoreline colour zones. Sections of the strategy that reference the 2009 FIM should be updated to reflect updates made during the 2021 re-FIM, especially the updated FHSI, FDG and shoreline colour zones.

14. **Support conservation efforts of the Columbia Lake Stewardship Society.**

    Continue to support the water quality and quantity monitoring program, stewardship initiatives and education activities of the Columbia Lake Stewardship Society.

15. **Complete future FIM surveys during peak summer.**

    The 2021 re-FIM survey was conducted in mid-September to be consistent with the timing of the initial FIM survey. However, it was noted that some shoreline modifications such as mooring buoys and docks may have been removed for the season by mid-September. It is recommended that future FIM surveys be conducted during peak summer to ensure all shoreline modifications, including those removed seasonally, are inventoried.

The following are recommendations made by the Shuswap Band:

1. Strengthen the wording within the Canal Flats and Fairmont Hot Springs & Columbia Lake Area OCPs to protect riparian areas. For example, both OCPs could default to the provincial Riparian Areas Protection Regulation (RAPR) Hardship Protocol using Good Guidance (i.e., the 2009 Draft Variance Protocol) instead of putting the onus entirely on the QEP when a property is rendered undevelopable by a riparian setback.
2. Local governments (e.g., Canal Flats and RDEK) should develop environmental protection bylaws that enact a wider variety of options for fines and enforcement, as opposed to just using an OCP which can only be enforced via court injunction.
3. Conduct field-based tributary assessments. This should be done as part of a lake-wide project or by a Qualified Environmental Professional (QEP) on a development-by-development basis.
4. Conduct a cumulative impacts study for Columbia Lake.
5. Seek funding to support increased involvement by First Nations, including complete field mapping and integration of Culturally Valuable Resources (CVRs).

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Appendix A – Foreshore Inventory and Mapping (FIM) Segment Maps

Appendix B – Segment Summaries

Appendix C – Foreshore Habitat Sensitivity Index (FHSI) Segment Maps

Appendix D – Foreshore Habitat Sensitivity Index (FHSI) Calculations

Appendix E – 2009 Aquatic Habitat Index (AHI) Calculation using 2021 Data

Appendix F – Foreshore Development Guidelines