Columbia Lake
Foreshore Inventory and Mapping

Prepared for the East Kootenay Integrated Lake Management Partnership

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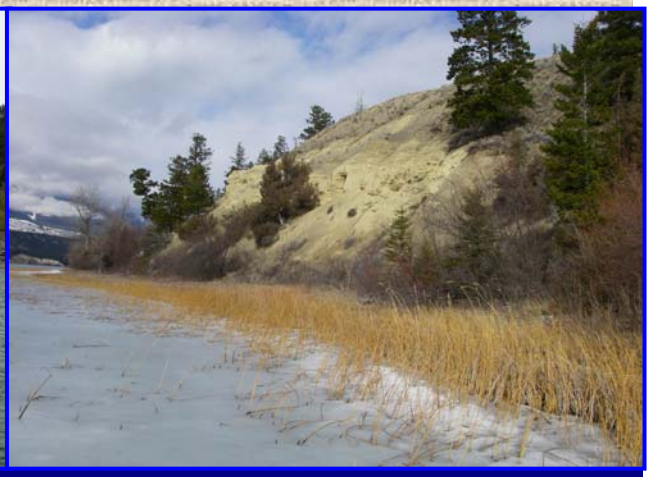

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Cover Photos: Top: Columbia Lake looking south east (Halverson); Bottom Left: western shore (Porto 2007); Bottom Right: eastern shore (McPherson 2009).

Disclaimer

The results contained in this report are primarily based upon data collected during a 1-day field survey completed by parties other than Interior Reforestation Co. Ltd (Interior). This data was augmented using previously documented material and a site inspection during low water level period. Interior and the authors assume that data collected are accurate and reliable. Data in this assessment was not analysed statistically. Use or reliance upon conclusions made in this report is the responsibility of the party using the information. Neither Interior, nor the authors of this report are liable for accidental mistakes, omissions or errors made in its preparation because best attempts were made to verify the accuracy and completeness of data collected and presented.

Executive Summary

Columbia Lake is located in the southern interior of British Columbia (BC), near Canal Flats and Fairmont Hot Springs, BC. The East Kootenay Integrated Lake Management Partnership (EKILMP) commissioned Interior Reforestation Co. Ltd. (Interior) to complete a Foreshore Inventory and Mapping study (FIM) on Columbia Lake. The purpose of the project was to provide baseline information on foreshore condition and environmental values to aid in future decision-making. This was to be achieved through both a literature review of known environmental values and the collection of field data on the foreshore's physical features. Foreshore Inventory Mapping (FIM) methods used for other lakes in British Columbia were followed. Field reviews were completed in September 2007 by EKILMP partners, who collected data on foreshore morphology, land use, riparian condition and anthropogenic alterations for the lake. This information was supplemented by additional field reviews in March 2009, by Interior professionals.

The literature review identified that the foreshore (and adjacent upland areas) of Columbia Lake is biologically diverse and important to numerous plant, fish and wildlife species. Several sensitive species have been reported to inhabit or potentially inhabit the area, including: 4 invertebrates, 2 fish, 1 amphibian, 2 reptiles, 9 birds, and 3 mammal species. As well, there are 3 sensitive plant species potentially in the area. Maintaining a diversity of functioning habitats for these species is important.

The foreshore of Columbia Lake, which was determined to be 42.8 km, was delineated into 8 segments, based on contiguous characteristics. The physical analysis revealed the most prevalent shore type to be gravel beach (43%). Wetland and bluff shore types also extended along substantial lengths (29% and 22%, respectively); while stream mouth and cliff shore types were minimal (4% and 2%, respectively). Emergent aquatic vegetation was common and extended along 75% of the shoreline, covering an overall area of approximately 300 ha. The emergent aquatic vegetation was composed of mainly bulrush species. The study area falls in the Interior Douglas-Fir very dry cool, biogeoclimatic zone (IDFxk) and riparian vegetation along the natural shoreline areas were mainly composed of mature species providing abundant coverage.

Over half (63%) of the lake's foreshore was found to be in a natural condition. A great of extent of this (55%) is protected through a wildlife management area (WMA) and provincial park. The disturbed foreshore sections (37%) were mainly impacted by transportation infrastructure (CPR) (33%) and there was also some private residential and urban parkland influence. Riparian disturbance and upland disconnect was apparent along the segments with CPR influence. The residential and urban areas exhibited loss of riparian and emergent aquatic vegetation as well as some foreshore structures (i.e., retaining walls, boat launches, groynes, docks and a marina). There are some private land areas that have not been developed yet (approx. 3 km). Efforts should be made to minimize further disturbance in these areas and restoration opportunities should be explored for impacted areas.

The information collected will aid government and organizations overseeing foreshore and upland developments. It serves as a benchmark by documenting land use and riparian habitat changes, necessary for the development of regulations, standards, policies and education materials. Several recommended actions are proposed, including: conducting species and habitats inventories, addressing modifications, developing a foreshore protection plan, conducting monitoring and further educating the community.

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1 Introduction

Columbia Lake is situated along Highway 93-95, just north of Canal Flats. Columbia Lake is the largest warm water lake (18 ^{o}C in July) in the East Kootenays and is an important recreation area (BC Parks 2004; 2007a). The lake drains into the Columbia River which enters Windermere Lake approximately 15 km to the north. The Columbia Lake area has been an area of great importance to First Nations for many centuries and it contains important parts of the Ktunaxa creation story such as the Hoodoo formation, the spirit trail along Columbia Lake and the headwaters of the Columbia River (RDEK 2004). Columbia Lake has very important habitat values, for a host of fish, wildlife and plant species. Thus, much of the Crown Land portions of the lake are managed for environmental protection through BC Provincial Parks or Wildlife Management Area (WMA). The lake is also very important to local residents. During the Columbia Lake Management Strategy process the public sent a strong message that 'Columbia Lake must be conserved and not become another Windermere Lake', referring to the perceived overuse of that lake (RDEK 1997).

Overall, as with many lakes across the province, Columbia Lake's growing recreational popularity has resulted in an increase in foreshore disturbance. With escalating property values many of the private properties have experienced development pressure, including: Canal Flats, Lot 48 (potential resort construction), Columere Park, Bella Vista, and Spirits Reach (Leschied pers comm.). Columbia Lake also faces recreation pressures due to its proximity to the resort community of Fairmont, which has a high level of residential and resort development (e.g., golf courses and hotels [BC Parks 2004]). Additional activities such as cattle ranching and the Canadian Pacific Railway (CPR) on the western shore have the potential to impact foreshore environmental conditions and/or water quality. During development, the shoreline is often modified in order to improve recreational access (e.g., docks, vegetation removal, boat launches), and to protect land from erosional forces (e.g., groynes and retaining walls). These alterations and their potential negative impacts on the foreshore environment have become a concern with local citizens and regulatory agencies.

The East Kootenay Integrated Lake Management Partnership (EKILMP) formed in 2006 in response to concerns over the very fast pace of foreshore development in the East Kootenays (EKILMP 2006). The partnership includes:

Core Group

- Regional District of East Kootenay;
- Fisheries and Oceans Canada;
- BC Integrated Land Management Bureau;
- Transport Canada;
- Interior Health Authority;
- Canadian Columbia River Intertribal Fisheries Commission (CCRIFIC);
- BC Ministry of Environment;
- Wildsight
- Wasa Lake Land Improvement District

Columbia Lake Participants

- Village of Canal Flats
- District of Invermere
- Wildsight – Lake Windermere Project

The EKILMP's aim is to protect lakes in the East Kootenays by encouraging integrated and coordinated approaches and providing guidance on best practices and restrictions of use where necessary (EKILMP 2006). This report will be used by EKILMP to help develop science-based coordinated management guidance for land and water uses associated with Columbia Lake, and promote the application of this guidance in decision-making by all levels of government, developers, planners and other interests (EKILMP 2006).

FIM studies have been completed on other lakes in the province as a first step in a three step process aimed at providing foreshore management guidance; with the intermediate step being a Fish and Wildlife Assessment. This information together with the water quality and quantity objectives are the key environmental value components used in developing Comprehensive Lake

Management Plans (Figure 1). This FIM will follow the standards established in other similar studies completed throughout the province including Central Okanagan Lake (Regional District of Central Okanagan (RDCO) 2005), Windermere Lake (McPherson and Michel 2007), and Wasa Lake (McPherson et al. 2009). The main field component for the Columbia Lake FIM was completed in the summer of 2007 by EKILMP partners and/or consultants. Interior prepared this report using this field data, subsequent field findings and available literature relating to the foreshore.

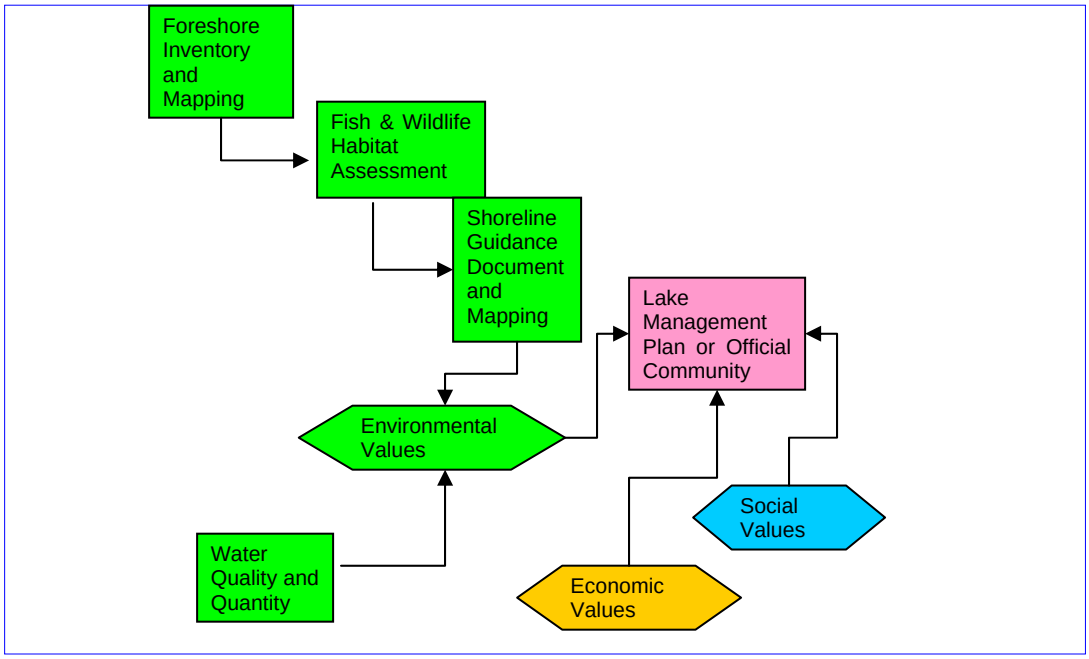

Figure 1. Lakeshore Inventory and Management Planning Process (Source: Holmes, pers. comm.).

1.1 Foreshore Management

In BC, the lake foreshore is defined as the land between the high and low water mark. This area, including the permanently wetted lake area is considered 'Aquatic Crown Land' and falls under the limits of provincial jurisdiction. Land adjacent to foreshore may be privately owned, but in common law the public retains the privilege or "bare licence" to access the foreshore. Individuals cannot build on or develop Aquatic Crown Land, including Crown foreshore, without the province's authorization, even if they own adjacent property or "upland" (BC Ministry of Agriculture and Lands 2009).

Currently, land use activities at Columbia Lake are governed by several bylaws and policies, including the Fairmont Hot Springs Area Official Community Plan (OCP - Bylaw 1734; RDEK 2004), the Village of Canal Flats OCP (Bylaw 50; Village of Canal Flats 2005), the Upper Columbia Valley Zoning (Bylaw 900-Consolidated; RDEK 2009) and the Columbia Lake Management Strategy (RDEK 1997). Details relating to protection of foreshore or other associated environmental features in these documents are as follows:

Fairmont Hot Springs Area OCP (RDEK 2004)

The Fairmont OCP includes the northern portions of the lake, incorporating much of the west and the east side south to and including District Lot 48 (Figure 2). During the public consultation for the OCP, natural and environmental attributes were among the most highly valued characteristics of the area. Broad environmental goals identified in the OCP are to: a) to minimize the impact of human developments on the natural environment by protecting ecologically sensitive natural areas, including floodplains, riparian zones and wildlife corridors; and b) to enhance the wildlife and habitat values by preserving important natural areas and wildlife corridors.

To achieve these goals, several environmental policies are outlined in Section 9 of the OCP, including:

- Support of ecosystem restoration;
- Not supporting perimeter fencing around golf courses, which would hinder animal travel;
- Not to alienate crown lands for private benefit which support important habitat;
- Conduct studies and mitigate impacts of development in wildlife corridor areas; and
- Support of education initiatives.

Further, the OCP (Section 9.6) recognizes Columbia Lake as a special landscape feature with its own specific environmental objectives, which include preserving the character of the lake with careful management of future developments; ensuring that water and sewer systems to not compromise the water quality; providing public access which does not compromise the environment; and adhering to the Columbia Lake Management Plan. The related policies are as follows (RDEK 2004):

a) The few remaining crown land on the west shore should be preserved for environmental function and public use;
b) Support the Lake Management Steering Committee[1];
c) Determine the natural lake water level and configuration of Dutch Creek alluvial fan;
d) Not to support private marina or expansion of on-water overnight boat storage facilities;
e) Support a public day use area and boat launch at the north end of the lake, subject to mitigation of environmental impacts;
f) Not to support foreshore leases in important riparian areas or other environmentally sensitive areas; and
g) Support motorized use of the lake as per Management Plan recommendations.

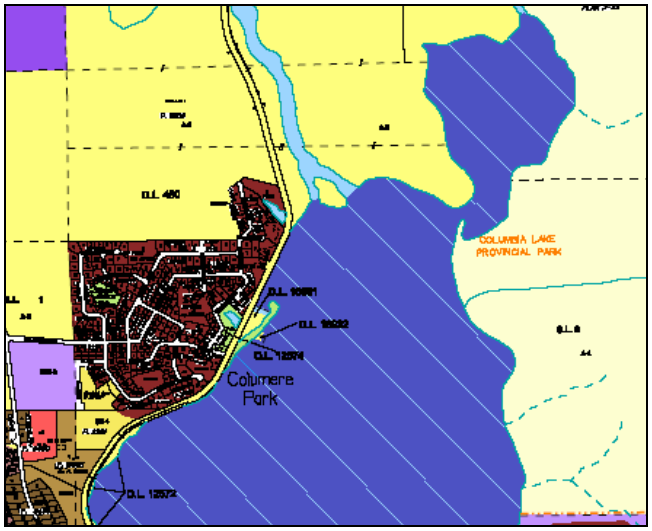

Figure 2. Extent of Columbia Lake within the Fairmont OCP (Source: RDEK 2004).

Village of Canal Flats OCP (2005)

The Canal Flats OCP includes the south end of the lake. The south end wetlands and bighorn sheep (*Ovis canadensis*) habitat which comes down to the lake on the east shore are designated as environmentally sensitive areas in the Canal Flats OCP (Figure 3). Development in these areas is to be limited and the retention of a natural greenbelt along watercourses is encouraged. There are 16 policies related to meeting these objectives with key foreshore related policies including, for example:

[1] The Columbia Lake Steering Committee was formed to develop the water zoning bylaw which is now in place; however, they have not been active for some time.

- Set back development from bodies of water (30 m from high water mark);
- Limit use of sensitive shorelines to education, park or conservation areas and restrict recreational boat use; and
- Limit impacts of storm water and pollution on shoreline.

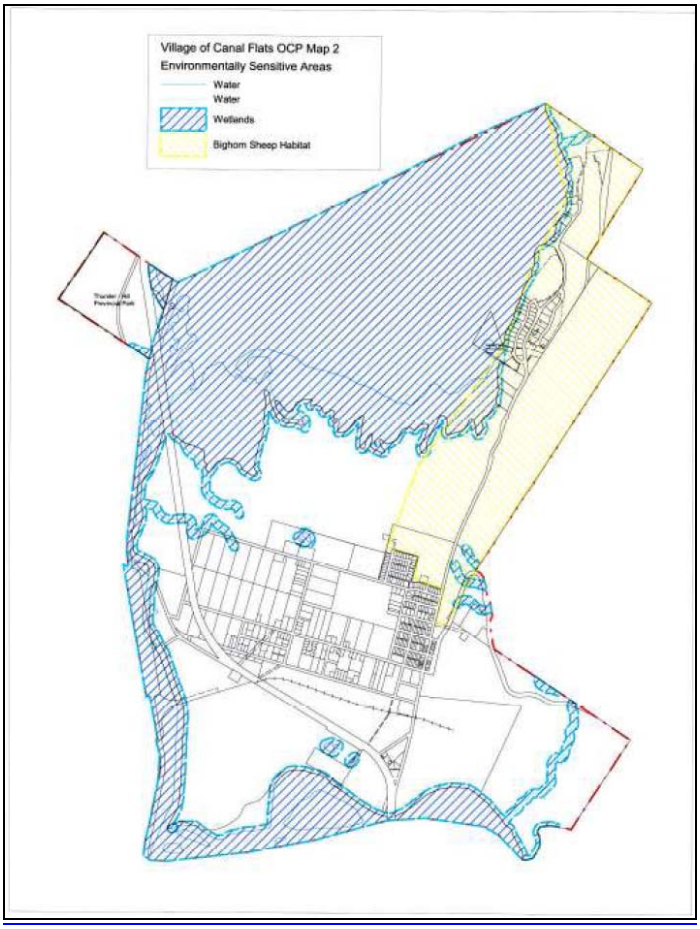

Figure 3. Village of Canal Flats Environmentally Sensitive Areas (wetlands shown as blue hashed area and bighorn sheep habitat shown as yellow area). Source: Village of Canal Flats 2005.

Upper Columbia Valley Zoning (Bylaw 900 Consolidation; RDEK 2009).

The main body of Columbia Lake south of Columere Park, has been designated as a Water Resource Zone (WR-1) by the RDEK and the Village of Canal Flats in 2007 and 2008 respectively (RDEK 2009; Village of Canal Flats 2008). The shoreline adjacent to Columbia Ridge developments (on the west side of the lake), Thunder Hill Provincial Park and Canal Flats Provincial Park has been designated as a Water Resource Community Zones (WR-2) (Figure 4 and Figure 5).

The WR-1 zoning permits only public access, recreational water activities and day use moorage along the shoreline. The WR-2 zoning is similar, but does also permit docks (recreational), launching ramps, and swimming rafts. Specifications are provided for docks, launching ramps and swimming rafts to limit impacts on the shoreline. Examples of specification details are: maximum number of each structure per tenure is one; maximum dock dimensions are 80 m^2 and 3 m wide by 20 m long; and materials are to be untreated and non toxic. With both WR-1 and WR-2 zoning, no overnight moorage is permitted.

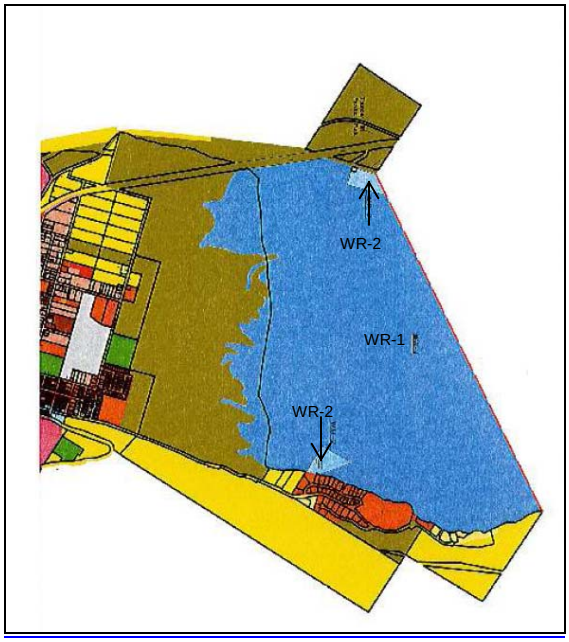

Figure 4. Water Resource Zones (WR-1 and WR-2) at south end of Columbia Lake (Source: Village of Canal Flats 2008).

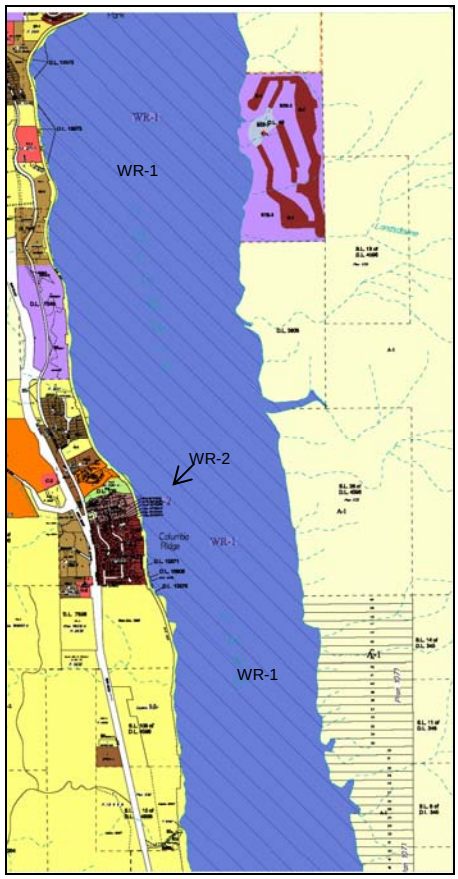

Figure 5. Water Resource Zones in Central Columbia Lake (Source: RDEK 2009).

Columbia Lake Management Strategy (RDEK 1997).

The Columbia Lake Management Strategy encompasses all of the lake. The strategy provides the results of a study reviewing a number of issues as expressed by the public, including: water quality,

lake levels, Dutch Creek channel movements and alluvial fan, weed growth, boating activities, conservation of fish and waterfowl habitats, protection of aesthetic values, regulation of private marina development, public access points and CPR's activities and side casting practice. Details on these findings are summarized throughout this report, including in particular, the Recommendations Section.

Protected Areas Management

In addition to these policies, substantial stretches along the lake fall into the WMA and the Columbia Lake Provincial Parks; these areas are managed for conservation of fish and wildlife values and are discussed in greater detail in the Results Section (3.1.5 Protected Areas).

Boating Restrictions

To protect environmental values, Transport Canada (2001) regulations identify that no person shall operate a power-driven vessel or a vessel driven by electrical propulsion in excess of the 10 km/h maximum speed in the part of the channel connecting Columbia Lake to Mud Lake and within 100 m from the shore on the east side of Columbia Lake. These restrictions should be indicated with buoys and/or signs).

These land use bylaws provide general direction for lake management. Site specific ranking of segments based on their fish and wildlife value and associated shoreline designation would be beneficial to direct future development. Management agencies in the Kootenay Region have been striving to better deal with the increased number of development proposals by improving coordination of efforts and communications and providing consistent policy information and direction. Windermere Lake was a pilot for this type of planning, with recent completion of Shoreline Management Guidelines (EKILMP 2009). The advantages of using this approach are currently being realized.

1.2 Foreshore Definition

Columbia Lake's foreshore is the primary focus of this report. The foreshore is an important link between the aquatic and terrestrial environments, is known to have important biological, ecological and social significance and to be extremely sensitive to disturbance (RDCO 2005). This natural foreshore has four components, beginning underwater and extending upland. These four components are: the *littoral zone*, the *shoreline,* the *riparian area and the upland zone*. A summary of each is as follows (Fisheries and Oceans 2008):

Littoral Zone

From the water's edge to where sunlight no longer penetrates the lake bottom.

Up to 90% of the species in the lake either pass through or live in this zone. This area is important for primary production (production of plants). Stones, twigs and plants are important components, serving as substrates for food production and providing a variety of habitats for animals. This is a typical area for ducks to forage on plants and invertebrates; as well as for fish to spawn, and then to forage and seek cover as juveniles. Plants in this area are important in converting sunlight into food and releasing oxygen.

Shoreline

Where the land and the water meet.

This is an important barricade against erosion. Naturally, it is a profusion of stones, plants, shrubs, fallen limbs and tree trunks. It is also a busy intersection for animals, insects and birds travelling back and forth between the lake and the upland areas. Overhanging vegetation here shades and cools the water and provides important food sources for fish.

Riparian and Upland Zones

The riparian area is the land closest to the foreshore and the upland is the higher, drier ground.

Vegetation in the riparian and upland zones provides a barrier for contaminants entering the lake as runoff (including septic seepage, fertilizers and pesticides). Deep roots of trees stabilize the slopes and the forest canopy cools the area. This is an important refuge for wildlife, for example, tall grasses are used by water birds for nesting, and in the winter it provides shelter to many animal species.

1.3 Purpose

The purpose of this foreshore inventory and mapping project is to provide baseline information on the ecological condition of the foreshore to aid future decision-making. This will be achieved through completion of the following:

- provide an overview of foreshore habitat condition on the lake;
- inventory foreshore morphology, land use, riparian condition and anthropogenic alterations;
- develop an easily accessible GIS database on the ecological integrity of the lake's foreshore;
- collect information that will aid in prioritizing critical areas for conservation/protection, restoration or enhancement; and
- provide a baseline and planning tool for review agencies.

2 Methods

A summary of Columbia Lake's foreshore values was prepared using field assessments of the physical features collected in early fall (September 27, 2007) and in late winter (March 4, 2008). This was supplemented with available 'environmental values' information attained through a literature review. Field inventory and mapping of the Columbia Lake foreshore was conducted according to Sensitive Habitat Inventory Mapping (SHIM) procedures (Mason and Knight 2001), which have been adapted to the lake foreshore environment from riverine system classification. Foreshore Inventory and Mapping Standards have recently been drafted (Schleppe and Mason 2009) and have been used as additional guide during report development.

With funding from Fisheries and Oceans and Ministry of Environment, Terrasaurus Ltd. flew Columbia Lake in July 2008 and created orthophotos. These orthophotos were also used to supplement findings for this study.

2.1 Field Assessment

The primary assessment of the physical foreshore features was conducted on September 27, 2007 from a boat, by EKILMP partners and/or consultants Brad Mason (Fisheries and Oceans), Heather Leschied (Wildsight) and Louise Porto (Fisheries and Oceans). A GPS unit was used to delineate foreshore segments, which are contiguous sections of foreshore that are determined by similar foreshore characteristics. These characteristics include Shore Type, Land Use Designation adjacent to the foreshore, Foreshore Condition and Modification and Disturbance. Tables 2-5 and Figures 1 and 2 provide detailed descriptions of these parameters. This data as well as other information on the physical foreshore features was input into a database via field cards and a GPS unit. A key to the field headings for all the features assessed and presented in the database is provided in Appendix A.

Table 1. Shore Types (adapted from RDCO 2005).

Shore Type	Description
Cliff	Adjacent to steeper slopes, usually indicating a steep-sided lake basin or sudden drop-off. Hard rock or bedrock
Bluff	High bank or bold headland of glacial till or outwash, which due its erodible nature, often has a beach at their base.
Gravel Beach	Often associated with low gradient foreshore, coves with pockets of riparian vegetation among steeper hillsides or alluvial fans.
Low Rocky Shore	Cobble, boulder or bedrock substrate often prevalent along the base of steeper foreshores.
Sand Beach	Often associated with alluvial fans or other foreshore deposition areas.
Stream Mouth	Stream inlet to the lake or outlet from the lake.
Wetland	Characteristic of wide littoral zones with fine substrates promoting abundant emergent vegetation such as sedges, reeds and cattails.

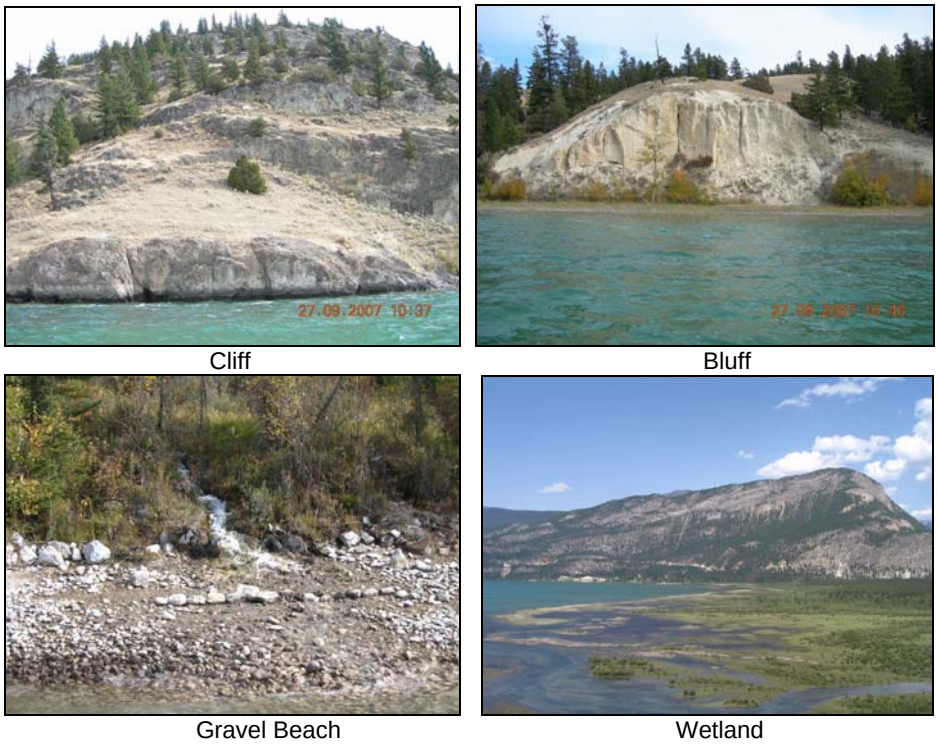

Figure 6. Examples of Shore Types observed at Columbia Lake.

Table 2. Land uses adjacent to the foreshore.

Land Use Designation	Purpose
Private / Residential	To accommodate varied density residential use (mainly single family), with some associated uses.
Commercial	To accommodate a mix of commercial, retail, recreation and service uses primarily intended for Town Centre areas.
Agricultural	To accommodate agricultural operations and related activities on parcels usually located on the Agricultural Land Reserve.
Park	To accommodate provincial, federal or local government parks that are natural, relatively undisturbed.
Conservation	To accommodate crown land managed for conservation of critical or important habitats – example Wildlife Management Areas
Urban Parklands	To accommodate urban park areas (e.g., public beaches, picnic areas) that have few natural features intact.
Crown	To accommodate crown land not otherwise accounted for by parks or conservation areas (e.g.,TFL)
Railway	To accommodate railway (CPR) right of way.

Table 3. Foreshore conditions.

Condition	Description
Natural	Foreshore is unmodified.
Disturbed	Foreshore has been modified through human alteration.

Table 4. Foreshore modifications.

Modifications	Description
Docks	Long, narrow structures stretching into a body of water.
Retaining Walls	Structural walls with the primary function of supporting soil from behind or any caused by wave action.
Groynes	Protective structures of stone or concrete that extend from shore into the water to prevent a beach from washing away.
Boat Launches	Sections of foreshore dedicated to launching boats and removing boats with vehicles.
Marine Railways	Railway tracks used to lift boats in and out of the water or to adjacent boat houses.
Marinas	Harbours specially designed to moor a collection of boats.

Figure 7. Examples of foreshore modifications including boathouse, dock, retaining wall (left); and marina, dock and retaining wall (right). Source: Windermere Lake photos - provided by Wildsight.

Field personnel used visual observations, not direct measurements, to estimate percentages of shore features. For example, a value of 80% disturbed was an estimate rather than a physical measurement of the length of disturbed foreshore within the segment. As a method of qualifying the overall health of the foreshore, each segment was assigned a value describing Level of Impact (LoI) by field personnel. The LoI was a qualitative measurement of the overall health of the foreshore, categorized as Low, Medium, or High (Table 5 and Figure 4). The LoI was based on visual observations during the assessment, including attributes from the database such as percent disturbed and presence of man-made structures (e.g. retaining walls, docks, groynes and marinas).

Table 5. Level of Impact (LoI)

Level of Impact	Description
Low	Segments that show little or limited signs of foreshore disturbance and impacts (<10% disturbed). These segments exhibit healthy, functioning riparian vegetation. They have substrates that are largely undisturbed, limited beach grooming activities and no to few modifications.
Medium	Segments that show moderate signs of foreshore disturbance and impacts (10-40% disturbed). These segments exhibit isolated, intact, functioning riparian areas (often between residences). Substrates (where disturbed) exhibit signs of isolated beach grooming activities. Retaining walls (where present) are generally discontinuous. General modifications are well spaced and do not impact the majority of the foreshore segment.
High	Segments that show extensive signs of disturbance and impacts (>40% disturbed). These segments exhibit heavily disturbed riparian vegetation, often completely removed or replaced with non-native species. Modifications to the foreshore are extensive and likely continuous or include a large number of docks. Generally, residential development is high intensity. Modifications often impact a majority of the foreshore.

Figure 8. Examples of low, medium and high levels of impact along foreshore of lakes.

Interior was responsible for providing the written report and map products using the field data and established standards. In order to do so, Interior was provided with all data collected during the field review, including the GPS data of segment breaks; database of physical characteristics and photo documentation from the field assessment. Upon review of the field data, Interior identified that supplemental information was required and that an additional field visit would be necessary. The foreshore was revisited by way of ATV, over the frozen lake, on March 4 2009 by Interior staff (Darcy Hlushak and Sherri McPherson). This supplemental assessment was conducted in order to:

1) Map emergent vegetation areas using GPS; and,
2) Re-assess shore types in order to have the total percentage add up to 100% for each segment, which involved;
    a. Removing vegetation shore type;
    b. Demarcating cliff from bluff shore type;
    c. Demarcating wetland shore type from emergent vegetation; and
    d. Demarcating stream mouth shore type.

2.2 Report Preparation

Report development involved 1) summarizing available information on environmental values; and, 2) preparing detailed descriptions for each segment, analyzing and summarizing physical conditions for the lake using the FIM database. A GIS map of Columbia Lake was also constructed depicting segment break locations, emergent vegetation polygons, and a summary of pertinent segment data.

In order to report on the physical condition of the foreshore, Interior first reviewed the September field database and addressed any inconsistencies or omissions. Several updates were made to the foreshore database following Interior's (March 4, 2009) field review and an office analysis of the orthophotos.

2.2.1 Wetland Shore Types and Emergent Vegetation

The Foreshore Inventory and Mapping Standards (Schleppe and Mason, 2009), identify that the wetland shore type is based on extent of 'shore marsh wetland' as defined in the Wetlands of British Columbia (MacKenzie and Moran 2004). Schleppe and Mason describe the shore marsh as having seasonally or permanently flooded, non tidal, mineral wetland that is dominated by emergent grass like vegetation. From a review of the Wetlands of BC Guide, this definition appears to include both Marsh Wetlands Class and Shallow-Water Wetlands. For this study, following literature research and the advice of our ecologist/riparian specialist, we found it necessary to distinguish between the Marsh Wetland Class and Shallow-Water Wetlands. Soils and hydrology were the key differences between these two wetland types. In this study, the seasonally flooded wetlands which had soil development (Marsh Wetland Class) were classified as the Wetland Shore Type, while the permanently flooded wetlands with little in the way of soil development (Shallow-Water Wetlands) were typed as Emergent Vegetation.

If the Marsh Wetlands Class and Shallow-Water Wetlands were included together to classify the Shore Type, most of the Columbia Lake would be described as a Wetland Shore Type; precluding the opportunity to describe the other physical features (cliffs, bluffs, gravel beaches etc.) and their influences/habitat benefits. Identifying the influence of these physical features is important to the potential completion of a fish and wildlife habitat index analysis, particularly if the analysis methods used on Windermere Lake (McPherson and Hlushak 2008) are to be followed, which account for the fish and wildlife value of the emergent vegetation as well as the respective shore types.

Wetland Shore Type (Marsh Wetland Class)
In this study, Wetland Shore Types included those wetlands that were categorized under the Marsh Wetland Class, which contain the following characteristics according to the Wetlands of BC Guide:

> 'A marsh is a permanently to seasonally flooded mineral wetland dominated by emergent grass-like vegetation. A fluctuating water table is typical, with an early season high

> dropping though the growing season. Exposure of the substrate in late season or during dry years is common. The substrate is usually mineral, but may have a well-decomposed organic veneer derived primarily from marsh emergents. Nutrient availability is high due to circum-neutral pH, abundant waterflow, and periodic exposure and aeration of the substrate. Marshes have simple plant communities with low species diversity and strong dominance by one or two species. The high nutrient availability in marshes favours "aggressive" species that spread vegetatively. Marshes have >10% cover of emergent grasses, rushes, sedges, or (occasionally) forbs or horsetails. The tree, shrub, and bryophyte layers in marshes are usually absent or very sparse (< 10%). Aquatic plants are common, especially in marshes that retain standing water for most or all of the year.'

The areas delineated as marsh wetlands at Columbia Lake had a variety of plants but most were dominated by bulrush. Most also had sedges but they were not identified to species and thus all marshes were categorized together whether they were sedge or bulrush dominated. Many also had common pondweed, cattails, reedgrass, pond lily, horsetail, etc in varying percentages (RDEK 1997). According to the Wetlands of BC Guide, the marsh wetlands would be classified as Wm06 in complex with Wm05 while others would be a complex of Wm06, Wm05, and Wm-sedges in general. These marsh wetlands were differentiated from the shallow-water wetlands (emergent vegetation) (Figure 9). Using this definition, extent of the wetland shore types was recalculated for each segment.

Figure 9. Wetland shore type or marsh wetland class (left) versus emergent vegetation area or shallow-water wetlands (right).

Emergent Vegetation (Shallow-Water Wetlands)

For this study, Emergent Vegetation fell under the definition of 'Shallow-Water Wetlands'. The Wetlands of BC Guide, describes Shallow-Water Wetlands as being:

> 'Permanently flooded by still or slow-moving water and dominated by rooted submerged and floating leaved aquatic plants. Like marshes, the shallow water wetlands are often simple communities dominated by one to several species and they have less than 10% emergent cover. The most common shallow-water habitats occur in littoral zones of lakes, particularly in protected waters where fine sediments collect and in potholes.'

The areas we considered to be shallow-water wetlands at Columbia Lake had standing emergent vegetation (bulrush), but not the usual submerged or floating aquatic plants dominating. However, the Canadian Wetland Classification System (Wetlands Research Centre 1997) substantiated our classification by providing that these 'Shallow Water Class Wetlands have free surface water up to 2 m deep, present for all or most of the year, with less than 25% of the surface water area occluded by standing emergent or woody plants. Submerged or floating aquatic plants usually dominate the vegetation.' The Canadian Wetland Classification System further classifies these areas as 'Lacustrine Water – Lacustrine Shore Water wetlands, which occur in the zone of wave action in beach or strand areas (including the high shore, and low shore and littoral zones)'.

Another important differentiation between the shallow water wetlands and the marsh wetland class is that the shallow water wetlands do not have as diverse of a soil profile. As stated in the Wetlands of BC Guidebook, 'aquatic substrates are generally classified as non-soil because they are permanently flooded at depths greater than 60 cm and do not undergo profile development'. Substrates can be sands, silts, clays, muck (a mix of silt, clay, and organic matter), degraded peat sediments, marl, or limnic sediments'. Although sampling was not conducted through the ice, the aquatic substrates in the emergent vegetation area at Columbia Lake likely fall into the 'non-soil' category. Observations along the north end of Columbia Lake found that most of the shallow-water wetlands were a mix of silt, clay, and a small amount of organic matter. Some areas had no visible organic matter with more cobble covered with silt and clay.

Interior used GPS to map the presence of emergent vegetation along the foreshore of Columbia Lake during their March field review using this definition. Remnant emergent vegetation from the 2008 growing season, which was dominated by bulrush, extended above the ice and was clearly visible (Figure 9). The orthophotos (July, 2008) were also used as a tool for mapping extent of emergent vegetation, since the orthophotos provided evidence of the outer extent of vegetative growth during ice-free, summer conditions. The extent (metres) of emergent vegetation was determined from the GIS application for each segment.

2.2.2 Removing Vegetation Shore Type

Extent of Vegetated Shore Type was estimated during the September field visit. All shore type values had to be re-visited by Interior since the database indicated total shore type for segments exceeding 100%. Differentiating between Gravel Beach and Vegetated Shore Type was difficult, since in many areas visited in March, under low water levels, vegetated areas were closely associated with a narrow gravel beach. Because of situations like this, the newly developed Foreshore Inventory and Mapping Standards (Schleppe and Mason 2009) had removed the Vegetated Shore Type from the database options. We were advised to do so as well for this project (Holmes pers. comm.). The orthophotos and field notes/still photos were used to confirm what the shore type should be. In many cases, the Gravel Beach Shore Type values increased, while in some areas Wetland or Stream Mouth Shore Types were appropriately assigned.

2.2.3 Demarcating Cliff from Bluff Shore Type

The FIM standards (Schleppe and Mason 2009) and studies completed by Interior on Windermere Lake have cliff and bluff shores identified as one combined shore type (Cliff/Bluff). However, in this study Cliff and Bluff Shore Types have been identified separately because the influences and values of these features are recognized as being quite different (Figure 6 above). Cliffs are typically very steep, comprised of hard bedrock material, which tend to have deep drop-offs into the lake. These deep water areas often provide valuable cool water refuge for fish. Bluffs, although also steep, consist of mostly erodible silts and clays, often lending to a beach area along the shore that may be vegetated. Bluffs provide unique wildlife habitat (e.g., support grasses for foraging and provide homes for nesting birds) and would be expected to provide different fisheries values than cliffs (e.g., more likely to have a beach supporting spawning or rearing).

2.2.4 Demarcating Stream Mouth Shore Type

The database was also updated to include the Stream Mouth Shore Type. The Stream Mouth Shore Type was recognized as an important fisheries and biodiversity feature in similar studies completed by Interior (e.g., Windermere Lake and Wasa Lake) and has now been included in the FIM standards (Schleppe and Mason 2009). The stream mouth was measured using the orthophotos and by measuring the shoreline distance of the stream's zone of influence on the lake (as evident from sediment deposition).

2.2.5 Addressing Other Data Gaps

1. Where information was absent, Interior updated the database, using available tools (orthophotos, still photos, and other sources). For instance, riparian stage and shore cover for

Segments 5 and 8 were estimated by Interior using the 2008 orthophotos. Riparian bandwidth was updated to provide data for Segments 3, 4 and 7 and riparian bankslope estimates were included for Segments 3 and 6. Land use percentages were also updated using legal maps obtained through the RDEK.

2. Submergent vegetation extent was not collected for all segments during the fall sampling and could not be obtained by Interior due to the ice coverage. The submergent vegetation data that was provided should be double checked, since it was substantially less than the measured extent of emergent aquatic vegetation and would be expected to be fairly close in value. Also, RL&L (1993) found submergent macrophytes in approximately 80% of the main body of the lake.
3. The percent substrates were not collected for all segments during the fall sampling and could not be obtained by Interior due to the ice coverage. The typical substrate composition for segments will have to obtained prior to the initiation of a Fish and Wildlife Analysis.
4. Numbers of riparian veterans and snags should likely be more intensively reviewed. This is suggested for Segments 1 and 2 in particular, which are reported to have mixed mature forest, yet zero veterans or snags were documented.

2.3 GIS Products

The shoreline of Columbia Lake was defined using TRIM base mapping. Segment breaks were interpolated by overlying GPS locations onto existing the 1:20,000 TRIM base map. The legal boundaries of properties (parcel fabric) around the lake were provided by the RDEK. The RDEK parcel fabric metadata states horizontal accuracy of approximately +/- 10 m. The RDEK makes no warranties or representations concerning the validity or accuracy of the data.

The Sensitive Habitat Inventory and Mapping Methods (Mason and Knight 2001) and the Foreshore Inventory and Mapping Standards (Schleppe and Mason 2009) provide additional technical procedures including GPS, data management, database development and quality control.

2.4 Integration of the FIM into the Community Mapping Network's Digital Atlas

The Community Mapping Network (CMN) provides online natural resource information and maps and makes it accessible to the public through a user friendly mapping system. The database and mapped results from this study will be provided to the CMN database manager so that it may be incorporated into the digital atlas, located at www.cmnbc.ca.

2.5 Presentation of Results

This FIM results are presented in two parts. Part I contains a summary of Environmental Values for the study area using available literature and local knowledge. Part II contains an overall summary of the Physical Nature of the foreshore from 2007 and 2009 field inspections.

Appendices contain the following information:

Appendix A. Key to the Field Headings in the Columbia Lake ArcMap Foreshore Database (adapted from Mason and Knight 2001)

Appendix B. Foreshore Summary Maps

Appendix C. Bathymetric Map of Columbia Lake

Appendix D. FIM Database

Appendix E. Segment Descriptions

Appendix F. Digital Copy of the Columbia Lake FIM Report

3 Results

3.1 Known Environmental Values

The following sections provide an overview of the environmental conditions for the Columbia Lake foreshore, which was compiled using available literature and professional input. The overview discusses physical features, water quality, fish and sensitive plant and wildlife species.

3.1.1 Physical

The Columbia Lake Management Strategy (RDEK 1997) provides a detailed description of the physical setting of Columbia Lake. This study will highlight the general physical nature of the lake, summarizing information provided in the Lake Management Strategy. For more detail, please refer to the original document.

> *Columbia Lake is located in the southern interior of British Columbia in the Rocky Mountain Trench Ecosection. The lake is bound by the Kootenay Ranges of the Rocky Mountains to the east, the Purcell Range of the Columbia-Omineca Mountains to the west, the glacial terrace of the Kootenay River at Canal Flats to the south, and Dutch Creek's alluvial fan to the north. Columbia Lake it is situated in the headwaters of the Columbia River. The lake's location, configuration and morphometry, combined with the frequent wind action in the Rocky Mountain Trench, produces well-mixed water throughout the lake during the ice free period.*
>
> *Historic data indicates that Kootenay River flowed north during the last glacial period not south, as it presently does, and that Columbia Lake currently occupies a glacial channel of the Kootenay River.*

This study reviews the foreshore perimeter of Columbia Lake, which using the TRIM lake boundary, was calculated to be 42.9 km and is depicted on the Foreshore Summary Maps (Appendix B). Table 6 provides a summary of Columbia Lake's physical parameters and a bathymetric map showing the depth profile for the lake is provided in Appendix C.

Table 6. Columbia Lake Physical Characteristics

Parameter[1]	Amount
Elevation[1]	809 m
Surface Area[1]	25.74 km^2
Length[1]	13.6 km
Maximum Depth[1]	5.2 m
Mean Depth[1]	2.9 m
Watershed Area[1,2]	881 and 185 km^2
Foreshore Perimeter	42.9 km

[1] Columbia Lake Management Strategy (RDEK 1997)

[2] Area including and excluding the Dutch Creek basin (RDEK 1997)

Columbia Lake has several small creeks draining into it along its periphery and it feeds into the Columbia River at its north end. It has extensive wetlands situated at the south and north (outlet) ends which were mapped based on the provincial wetlands maps (GeoBC 2009a).

3.1.2 Water Quality

The large surface area of Columbia Lake relative to shallow depth suggests that it warms quickly during the summer and does not stratify (Westslope 2002). Groundwater contributions, however, may add some diversity to temperature conditions (Westslope 2002).The water quality of Columbia Lake has been reported to be oligotrophic and clear by BC Ministry of Environment (1985) and RDEK (1997) except during freshet when turbidity levels frequently exceeded the water quality standards (5 NTU) for drinking water. However, other accounts indicated it was eutrophic (RL&L 1993; Prince 2007). The trophic stage generally reflects the productivity or nutrient levels of a lake, and the differences between these authors may reflect seasonal changes (Figure 10).

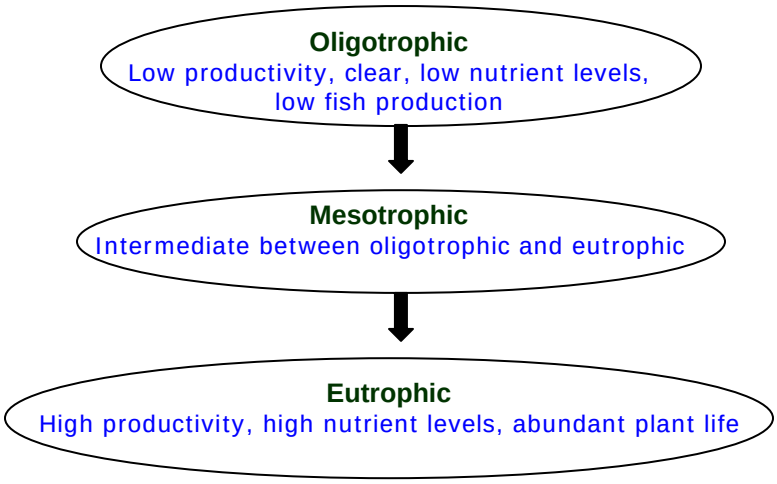

Figure 10. Lake Productivity Chart

Columbia Lake was also identified as having a moderate water quality sensitivity, which relates to its ability to assimilate phosphorus without a detrimental affect on water quality and its sensitivity to additional sources of phosphorus (RDEK 1997). This moderate rating means that the control of additional phosphorus loads is important, such as that from domestic effluent and agricultural (cattle) runoff (RDEK 1997).

The water of Columbia Lake is replaced by inflow once a year (BC Ministry of Environment 1985, RDEK 1997). This 'flushing rate' is considered to be quite fast and helps keeps nutrients from building up in the lake (RDEK 1997). Dutch Creek's water contribution was not considered in the flushing rate determination, since it is located at the lake outlet (BC Ministry of Environment 1985).

3.1.3 Water Availability and Uses

As a result of the lake's drainage basin being fairly steep, small and restricted, only small creeks flow into the basin (RDEK 1997). During a September survey, RL&L (1993) found 14 out of 15 streams entering the lake to be dry. These creeks thus only contribute to the lake's water quantity in minor way. Principal east side tributaries are Warspite, and Landsdown Creeks. West side tributaries are Dutch, Hardie, Marion and Sun Creeks. The contribution of Dutch Creek entering the lake at the northern end is unknown, since it has been reported that some of its flow is lost through the alluvial fan and channeled as groundwater into the Columbia River (RDEK 1997). At the south end, a considerable amount of water from the Kootenay River enters the lake as ground water (estimate is 100 million m^3/yr) (RDEK 1997). This groundwater inflow prevents the lake from freezing. This was the one flowing inlet during the RL&L sampling in September 1992, and the south end was clear of ice during our early March (2009) inspection, while most of the lake had ice at a depth of greater than 1.5 feet.

The Lake Management Strategy considered whether or not the water level of Columbia Lake was changing with time (RDEK 1997). Using data dating back to 1967, the Strategy found that that the

lake levels were mainly influenced by precipitation, the levels had not fluctuated extremely from the average and that from 1990-1995 lake levels closely approximated long term averages. Dutch Creek's channel movement (at its alluvial fan) toward the Columbia River was not considered to be a significant concern for lake water levels (Figure 11; RDEK 1997).

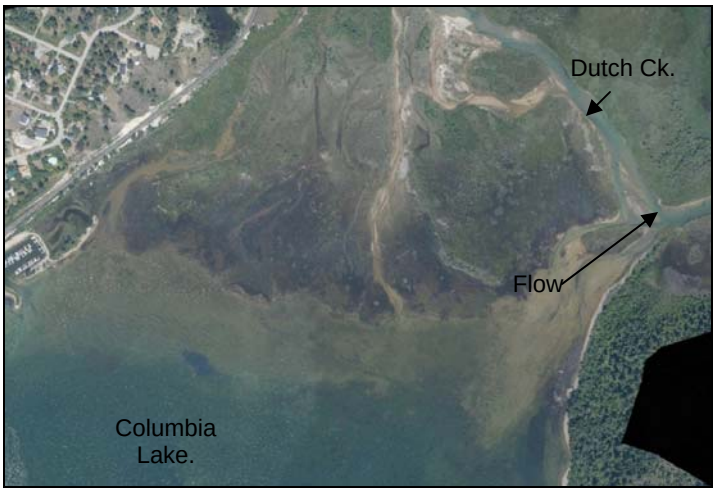

Figure 11. Dutch Creek alluvial fan at the north end of Columbia Lake. Orthophoto – July 2008.

The water in Columbia Lake is licensed for several uses including: domestic use (2 licenses, totaling 1000 gallons/day), irrigation (2 licensees, totaling 25 acre feet/annum) and waterworks (6 licenses, totaling 71 million gallons/year) (GeoBC 2009b). Together this totals 300,983 m^3/year. The Lake Management Strategy identified that the lake and tributaries were licensed to their maximum and withdrawals had insignificant effects on lake levels (RDEK 1997).

3.1.4 Habitat

Columbia Lake is situated in the Interior Douglas-Fir, very dry cool, biogeoclimatic zone variant (IDFxk) (BC Ministry of Forests and Range 2008). The BC Ministry of Forests and Range (2006) description of this zone has been the basis for information provided here. This zone has been recently defined (most of this area was previously IDFun and IDFdm2) and occupies the valley bottom of the Rocky Mountain trench from Canal Flats north to Edgewater. It follows the Columbia River and is approximately 6-8 km wide and 100 km long. It is characterised by warm, dry climatic regime and soil moisture deficits, particularly on the south aspects. Winters are generally mild, with snowfalls being intermittent and rarely exceeding 25 cm. As a consequence, the IDFxk provides important winter habitat for ungulates including elk (*Cervus elaphus*), bighorn sheep (*Ovis canadensis*) and mule deer (*Odocoileus hemionus*).

Most of the landscape is dominated by multi-story, uneven-aged Douglas-fir stands. Douglas-fir (*Pseudotsuga menzesii* var. *glauca*) is the dominant seral tree species and the dominant climax tree species. Ponderosa pine (*Pinus ponderosa*) occurs on dry south aspects; while, hybrid spruce (*Picea engelmannii* x *glauca*), trembling aspen (*Populus tremuloides*) and black cottonwood (*Populus balsamifera trichocarpa*) commonly occur on wet seepage sites, riparian areas and floodplains. Because of disturbance (fire, grazing, etc), climax plant communities are rare. The shrub layer tends to be poorly developed and dominated by Rocky Mountain Juniper (*Juniperus scopulorum*) and a low cover of Saskatoon (*Amelanchier alnifolia*), snowberry (*Symhoricarpos albus*) and rose. The herb layer contains a diverse mixture of species and is dominated by bluebunch wheatgrass (*Pseudoroegneria spicata*), rough fescue (*Festuca altaica*), northern goldenrod (*Solidago spathulata*), kinnikinnick (*Arctostaphylos uva-ursi*) and cut-leaved fleabane (*Erigeron compositus* var. *glabratus*). The bluebunch wheatgrass and rough fescue have been significantly reduced by domestic and wild ungulate grazing.

3.1.5 Protected Areas

Columbia Lake Provincial Park

Columbia Lake Provincial Park is located at the northeast corner of Columbia Lake (Figure 12). It is an undeveloped park that provides front country, non-consumptive recreational opportunities (such as wildlife viewing, paddling, nature appreciation, hiking and mountain biking; BC Parks 2004). The park encompasses 257 hectares of land, which includes 3 km of undeveloped beach area (BC Parks 2004). The park was designated primarily to protect a grassland ecosystem and essential wetland habitat. (BC Parks 2004). A secondary purpose is to provide recreational opportunities on Columbia Lake without development or services. The park is largely nested within the adjacent East Side Columbia Lake WMA, further protecting essential habitat for ungulates and waterfowl (BC Parks 2004). Known species at risk in the park are Rocky Mountain bighorn sheep (park provides overwintering habitat), badger, the great blue heron, and the two plant species Gastony's cliff-brake and Hooker's townsendia. The Park also hosts an "abundance of known [Ktunaxa] archaeological and traditional use sites" (BC Parks 2004).

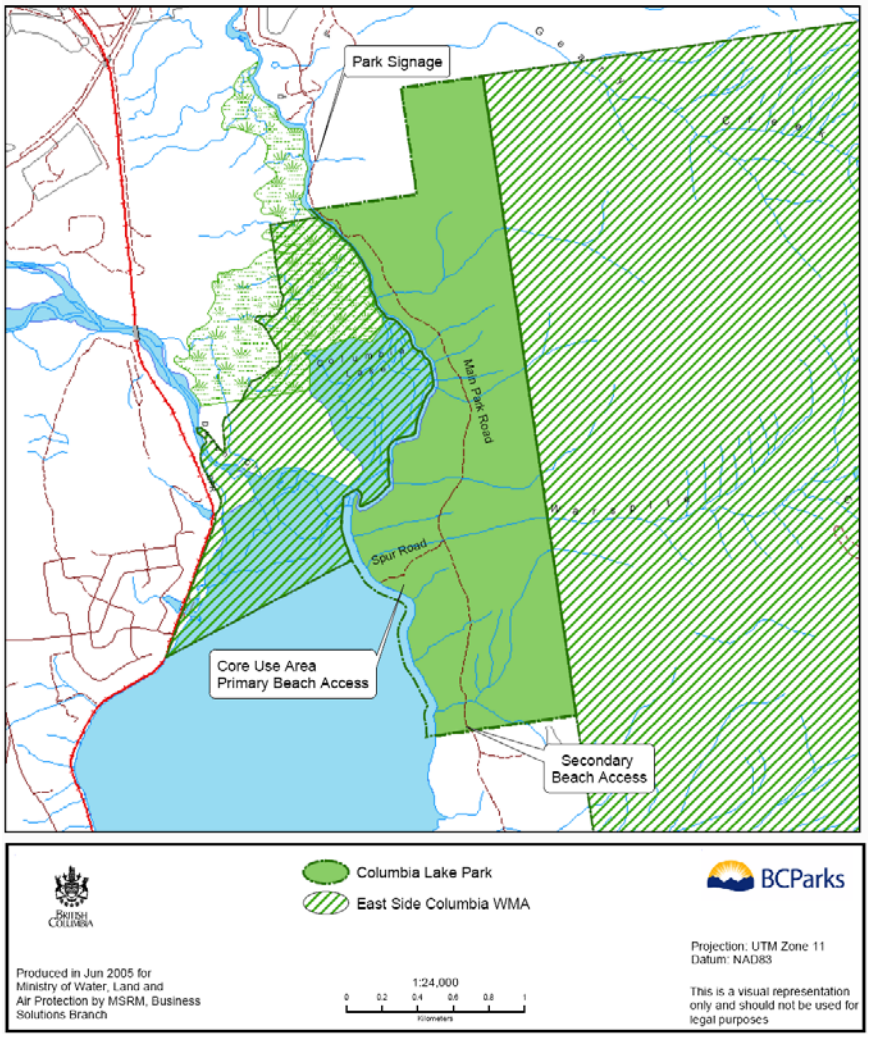

Figure 12: Columbia Lake Provincial Park in relation to Columbia Lake. Source: BC Parks 2004.

Thunder Hill Provincial Park

Thunder Hill Provincial Park is located at the southwest corner of Columbia Lake. It is approximately 44 ha and primarily protects "remnant open forest and grassland ecosystems" (BC Parks 2003a). The park is mostly upland forest at elevations well above the lake and west of

Highway 93/95. However, it does reach to Columbia Lake and borders a short length of shoreline in the small pond cut-off from the main lake by the CPR railway berm (Figure 13). This pond supports a variety of breeding and staging waterfowl as well as painted turtles and beavers (I. Adams pers. obs.). Thunder Hill Park had all recreational developments removed in the early 1990s and there are no signs on the highway indicating its presence. Virtually all of the park (43 ha, 98%) is zoned "Natural Environment". The remaining hectare is a "Special Feature" protecting significant archaeological values (BC Parks 2003a).

Figure 13: Location of Thunder Hill Provincial Park in relation to Columbia Lake.

Canal Flats Provincial Park

Canal Flats Provincial Park occupies 125 m of foreshore (much of which is heavily altered) at the southwest corner of Columbia Lake, closely situated to the Village of Canal Flats. The primary purpose of the park is to provide recreational opportunities. The entire 6 ha of the park is zoned for "intensive recreation" (BC Parks 2003b). The park is expected to be withdrawn entirely from the provincial park system in the near future and turned over to the Village of Canal Flats and managed as by the Village (Volp pers. comm.).

Figure 14: Location of Canal Flats Provincial Park in relation to Columbia Lake.

East Side Columbia Lake Wildlife Management Area

Wildlife Management Areas (WMA) are established under the BC *Wildlife Act* and are not considered legal "protected areas". Within their boundaries, wildlife habitat is the primary management concern, however other activities are permitted. The East Side Columbia Lake WMA was first designated as a game reserve in 1957, and was formally adopted as a WMA in the late 1990s.

The Canada Land Inventory depicts the entire east side of Columbia lake as representing the largest contiguous Class 1[2] ungulate winter range in the upper Columbia sub-region, and one of the least impacted of the low elevation Class 1 Rocky Mountain bighorn sheep winter ranges in BC (BC Parks 2004).

The East Side Columbia Lake WMA was designated in September 1997 and is 6,886 hectares in size (BC Parks 2007). The WMA provides extremely important winter range for ungulates such as bighorn sheep, elk, mule and white-tailed deer, and creates a connectivity and migratory corridor between important habitat south and north of the lake (Columbia Wetlands WMA) (BC Parks 2007). The area is also important for Grizzly Bear, Black Bear, Cougar, Coyote, American Badger, rare Flammulated Owls, Bald Eagle, Golden Eagle, Osprey and Red-tailed Hawk (BC Parks 2007). Species dependent upon grassland or open forest habitat types at low elevations also frequent the WMA, such as Prairie Falcon, Townsend's Big-eared Bat, Tailed Frog, and Rubber Boa (BC Parks 2007). The WMA includes lake and lakeshore areas, wetlands, dry open grasslands and open Douglas fir stands at low elevations, while Lodgepole Pine, Englemann Spruce and subalpine fir forests rise sequentially from low elevations to the highest ridges (BC Parks 2007).

In addition to the known values of the south and north end wetland areas and the east side upland area, Armstrong Bay is also known to be a special place in this WMA. It offers shelter from lake winds to many wildlife species and may have riparian and littoral plant associations which are unique on the lake (I. Adams pers. obs.).

This area is internationally significant in its biological diversity as it is home to many rare and endangered species (CORE 1994 *In* RDEK 1997). The management activities in the WMA will be designed, where possible, according to the 'leave alone' approach where natural processes will continue without interruption (Phelps 1996 *In* RDEK 1997). Habitat enhancement was also envisioned where feasible and desirable to maintain and increase the carrying capacity of the forage base (Phelps 1996 *In* RDEK 1997). The entire WMA has an approved restoration plan, and to date 310 ha of habitat restoration has been completed (Holmes, pers comm.).

3.1.6 Sensitive Plant Species

The BC Conservation Data Centre (2009) sensitive species listing (Table 7) for the IDFxk zone indicates that there are three vascular plant species potentially occurring in the Columbia Lake area that are considered sensitive. All of these species are provincially blue-listed meaning that they are sensitive to disturbance. These species are also provincially designated as imperiled (S2) or vulnerable (S3) (BC Conservation Data Centre 2009).

3.1.7 Fish

Fishing is popular on Columbia Lake year round, with mountain whitefish, burbot, kokanee, rainbow trout, bull trout and cutthroat trout being favoured sport fish (BC Parks 2007).The ecosystem in and around Columbia Lake is known to provide good to excellent habitat for a variety of fish species (RDEK 1997). The Fish Inventory Summary System (FISS; BC Ministry of Environment 2008) identifies that a diversity of fish species have been known to utlilize Columbia Lake. The lake is

[2] Class 1 defined as winter range in which animals from surrounding areas depend on for survival. Classified by the Canada Land Inventory (2002).

utilized by several species of fish including those that are native (12 species), non native (1 species) and hatchery produced (2 species), which are listed as follows:

Native Species

- burbot *(Lota lota);*
- bull trout (*Salvelinus confluentus*);
- longnose dace *(Rhinichthys cataractae);*
- largescale sucker *(Catastomus macrocheilus);*
- longnose sucker *(C. catastomus);*
- mountain whitefish *(Prosopium williamsoni);*
- northern pike minnow *(Ptychocheilus oregonensis);*
- peamouth chub *(Mylocheilus caurinus);*
- prickly sculpin *(Cottus asper);*
- torrent sculpin *(C. rhotheus);*
- redside shiner *(Richardsoniums balteatus);*
- westslope cutthroat trout *(O. clarkii lewisi);*

Hatchery Production

- kokanee *(Oncorhynchus nerka);*
- rainbow trout *(O. mykiss);*

Non-Native Species

pumpkinseed (*Lepomis gibbosus*)

The lake provides habitat for many lifestages, which depending on the species, include spawning, rearing, feeding, migration and overwintering lifestages. The Lake Management Strategy (in Table 6 and Map 6; RDEK 1997) identifies known areas of utilization, quality of habitat, and life history function provided for many species using the lake (including the inlet and outlet streams). These figures should be referenced when planning for further field investigations. The lake outlet, gravel shoals along the shoreline, and in particular, the shallow south end provide suitable spawning habitat for many species (Entech 1978) as does Dutch Creek and the alluvial fan (Westover pers. comm.). Since the majority of streams on the east and west side only run intermittently, they are not known to provide good spawning habitat (Westover pers comm.).

3.1.8 Sensitive Wildlife Species

We searched BC's Conservation Data Centre's online Species and Ecosystem Explorer (BC Conservation Data Centre 2009) for terrestrial species at-risk associated with lacustrine (lake) and palustrine (wetland) habitat (Table 8). This list was further delimited by expert knowledge of what species are known to occur in the area and removing species known not to be in the area. In total there were 21 sensitive species potentially inhabiting the area including, insects (2 species), gastropods (2), fish (2), amphibians (1), reptiles (2), birds (9) and mammals (3).

Table 7 Vascular plant species at risk that occur in the Columbia Lake area (Interior Douglas Fir –very dry cool Biogeoclimatic Zone (IDFxk) (Source: BC Conservation Data Centre 2009).

Scientific name	Common name	Habitat Type	Global Rank[1]	Prov Rank[1]	BC CDC[2]	Conservation Goals[3]			IWMS	COSEWIC
						Goal 1	Goal 2	Goal 3		
Calamagrostis montanensis	plains reedgrass	Terrestrial	G5	S3	Blue	6	4	4		
Carex lenticularis var. *dolia*	Enander's sedge	Lacustrine Palustrine Riverine Terrestrial	G5	S2S3	Blue	3	6	3		
Pellaea gastonyi	Gastony's cliff-brake	terrestrial	G2G3	S2S3	Blue	2	6	3		

Column acronyms: BC CDC: British Columbia Conservation Data Centre (provincial); IWMS: Identified Wildlife Management Strategy (under BC *Forests and Range Practices Act*); COSEWIC: Committee on the Status of Endangered Wildlife in Canada (federal); SARA: Species at Risk Act (federal).

[1] Rank codes: **G = Global** rank; **S = Sub-national** (provincial/state) rank; 1= **Critically Imperiled**—At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors. **2 = Imperiled**—At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors; **3 = Vulnerable**—At moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors; **4 = Apparently Secure**—Uncommon but not rare; some cause for long-term concern due to declines or other factors.; **5 = Secure**—Common; widespread and abundant; **H = extirpated**—considered no longer in British Columbia. **NR = not ranked.** A **numeric range rank** (e.g., S3S4) is used to indicate the range of uncertainty in the status of a species; **Q = questionable taxonomy**—taxonomic existence is uncertain. Source: NatureServe (2008).

[2] **Red-listed** species and ecological communities are considered to be extirpated, endangered or threatened (at risk of becoming endangered) in British Columbia. **Blue-listed** species and ecological communities are considered "particularly sensitive to human activities or natural events". Neither listing provides any legal protection to the animals or their habitat.

[3] Conservation Framework Goals (available: http://www.env.gov.bc.ca/conservationframework/index.html):
Goal 1 Contribute to global efforts for species and ecosystem conservation
Goal 2 Prevent species and ecosystems from becoming at risk
Goal 3 Maintain the diversity of native species and ecosystems

Table 8. Lacustrine and palustrine associated animal species at risk that known to, or may occur in the Columbia Lake area (Source: BC Conservation Data Centre 2009).

Common name	Global Rank[1]	Prov Rank[1]	BC CDC[1]	Conservation Goals[1]			IWMS	COSEWIC	SARA Schedule
				Goal 1	Goal 2	Goal 3			
Odonates (dragonflies and damselflies)									
Pronghorn Clubtail	G5	S2S3	Blue	6	6	2		not assessed	na
Vivid Dancer	G5	S2	Red	6	6	2		not assessed	na
Gastropods (slugs, snails)									
Pale Jumping-slug	G3G4	S3	Blue	4	4	4		not assessed	na
Glossy Valvata	G5Q	SH	Red	6	6	1		not assessed	na
Fish									
Westslope Cutthroat Trout	G5	S2S3	Blue	2	2	3	✓	Special Concern	1
Bull Trout	G5	S2	Blue	2	2	3	✓	not assessed	na
Amphibians									
Western Toad	G4	S4	Yellow	3	2	4		Special Concern	Schedule 1[4]
Reptiles									
Painted Turtle	G5	S2S3	Blue	6	2	3		Special Concern	Shedule 1
Rubber Boa	G5	S4	Yellow	5	3	4		Special Concern	Schedule 1[4]
Birds									
Western Grebe	G5	S1S2	Red	6	6	1		not assessed[2]	na
Great Blue Heron	G5	S3S4	Blue	6	2	3		not assessed	na
American Bittern	G4	S3	Blue	5	2	3		not assessed	na
American White Pelican	G3	S1	Red	4	6	1	✓	Not at risk	na
American Avocet	G5	S2	Red	4	6	2		not assessed	na
Common Nighthawk	G5	S4	Yellow	6	2	4		Threatened	not listed[3]
Lewis' Woodpecker	G4	S2	Red	3	6	2	✓	Special Concern	Schedule 1[4]
Barn Swallow	G5	S3S4	Blue	6	2	3		not assessed[5]	na
Bobolink	G5	S3B	Blue	6	2	3			
Mammals									
Townsend's Big-eared Bat	G4	S3	Blue	5	2	3		not assessed	na
Badger	G5	S1	Red	6	6	1	✓	Endangered	Schedule 1[4]
Bighorn Sheep	G4	S2S3	Blue	4	6	3	✓	Not assessed	na

[1] For codes and column acronyms, see Table 7
[2] Western Grebe is on COSEWIC's priority 1 list for status assessment (no timeline for when it will be assessed).
[3] Nighthawks are undergoing extended consultation prior to potential listing on SARA Schedule 1.
[4] Schedule 1 is the "official" species at risk list approved by federal cabinet under the SARA. Note that SARA prohibitions do not apply to species ranked as Special Concern.
[5] COSEWIC initiated a status report for Barn Swallow in autumn, 2008.Assessment expected in 2010.

3.2 Physical Data Summary from 2007 and 2009 Field Reviews

In total, 42,857 m of foreshore were surveyed and divided into 8 contiguous segments. The segments ranged in length from 657 m to 12881 m. GIS maps showing segment locations and key segment information are provided in Appendix B; while the database of all physical findings is provided in Appendix D and detailed descriptions of each segments are located in Appendix E. Natural vs. disturbed areas, land use, foreshore type, modifications along the foreshore and level of impact have been reviewed in detail in order to provide an inventory of the foreshore condition.

Land Use and Natural vs. Disturbed Extent

Overall, results indicate that more than half (63% or 27,017 m) of the foreshore is in a natural condition and that 37% (15,840 m) has been disturbed (Table 9). The natural areas include lands located within the following areas:

- Columbia Lake Provincial Park (3,495 m in Segments 3,4);
- Wildlife Management Area (WMA = 20,048 m; Segments 2, 3, 4 and 8);
- Small Crown Land parcels between the lake and the railway on the west side of the lake (350 m, Segment 6); and,
- Substantial portions of the private/residential land located along the east side of the lake (approx. 3,125 m, Segments 1, 2 and 3).

The disturbed areas along the foreshore include those areas with the following land uses:

- Urban Parkland areas (786 m), including Canal Flats Provincial Park (Segment 1) and Columere Park (Segment 5);
- Some of the private residential areas including areas in the Canal Flats municipality (east side of lake) (611 m, Segment 1) and small pockets along the west side of the lake between the lake and the railway (350 m, Segment 6);
- Small portion of WMA (in Columere Park area – 46 m, Segment 5); and
- The railway (transportation) running the length of the west side of the lake (14,047 m, Segments 6, 7 and 8).

The land use types and extent for each segment are depicted in Figure 15 and the extent of disturbed and natural foreshore areas for each segment are provided in Figure 16.

Table 9. Columbia Lake shoreline condition (natural vs. disturbed) and land use summary.

Foreshore		Length (m)	% of total
Total Shoreline	Natural	27,017	63%
	Disturbed	15,840	37%
Land Use Summary	Private/Residential	4,086	10%
	Park (provincial)	3,495	8%
	Crown (non WMA)	350	1%
	Conservation (WMA)	20,094	47%
	Urban Parkland	786	2%
	Transportation	14,047	33%
Total Foreshore		42,857	100%

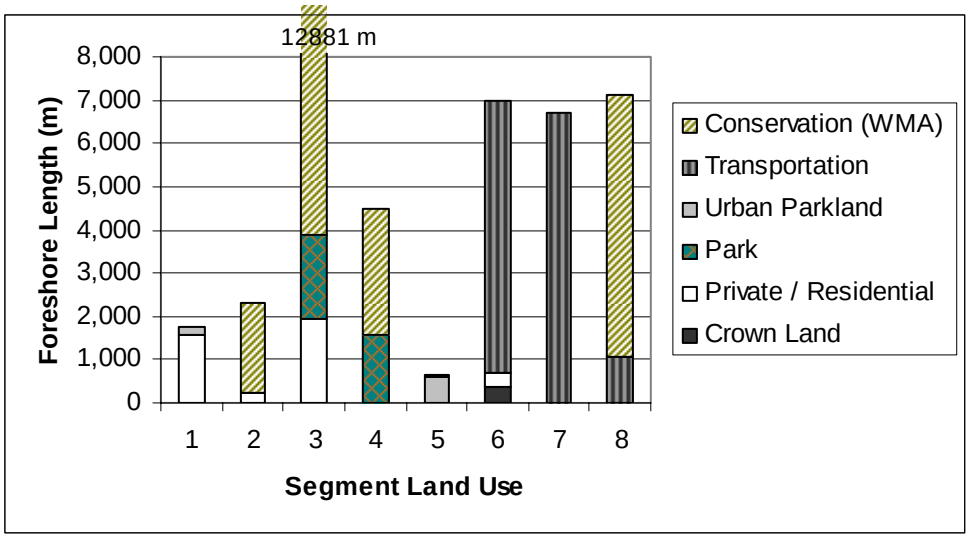

Figure 15. Land use type and extent for each segment

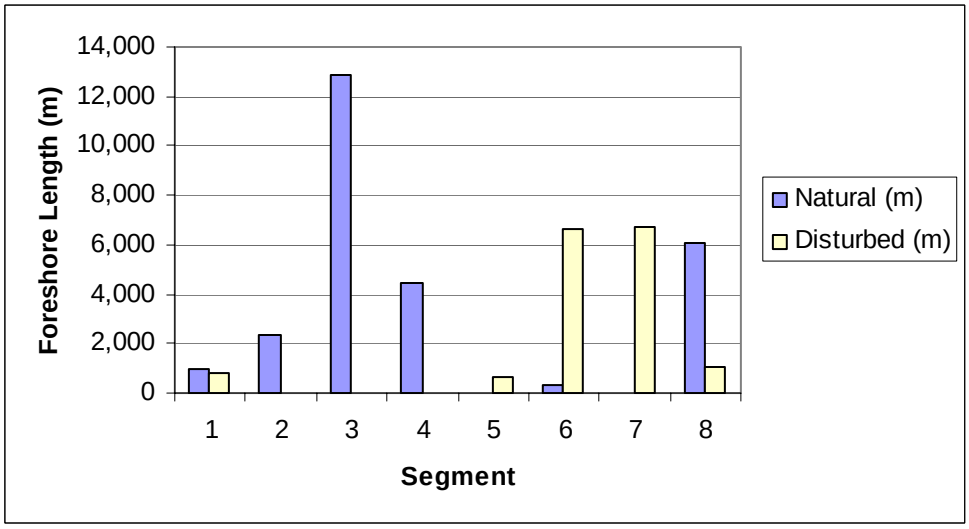

Figure 16. Extent (m) of natural and disturbed shoreline for each segment.

Shore Type

The foreshore of Columbia Lake is diverse consisting of gravel beach, wetland, cliff, bluff and stream mouth shore types. A breakdown of the length and overall percentage of each of these foreshore types along the perimeter of the lake is provided in Figure 17. The foreshore is mainly Gravel Beach Shore Type (18,612 m or 43% of shoreline), which on the east side of the lake is typically backed by a well vegetated area, and on the west side of the lake is situated next to a railway with a bluff upland (Figure 18). Wetland and Bluff Shore Types also make up substantial lengths of the shore (12,258 and 9,452 m respectively), while Stream Mouth and Cliff Shore Types make up the smallest lengths of foreshore (1,724 m and 811 m respectively).

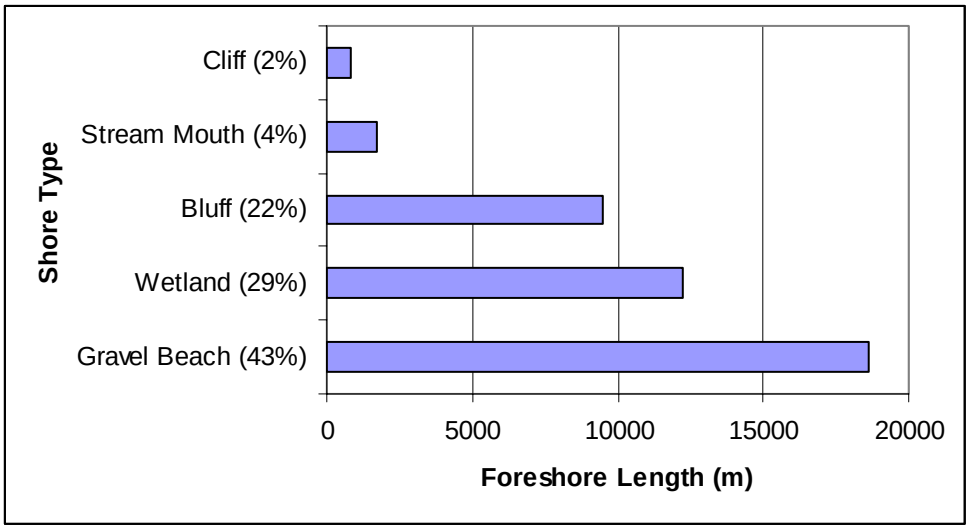

Figure 17. Total length (m) and percentage (%) of each Shore Type.

Figure 18. Gravel beach shore types - left photo shows beach backed by vegetated area along the eastern shore (Leschied Sept 2007) and the right shows railway and bluff features beyond (McPherson Mar 2009).

Figure 19 provides detail on the extent of each of these shore types within each segment. This figure indicates that there are some streams along the foreshore. Other than the Columbia River outlet in Segment 4, the shore sections which have been typed as Stream Mouth are small creeks. Based on their outlet fan width, these creeks have been calculated to have an influence of approximately 75 m each respectively. The streams along the west side of the lake all flow under the railway through culverts (Segments 6 and 7, Figure 20). There are likely additional ephemeral streams not considered in this analysis. The streams considered here include (*See* Appendix B - GIS maps for locations):

- Segment 3 – Landsdown and Warspite Creeks;
- Segment 4 – Columbia River (lake outlet);
- Segment 6 – Hardie and Major Creeks;
- Segment 7 - Marion Creek; and
- Segment 8 – Unnamed Creek

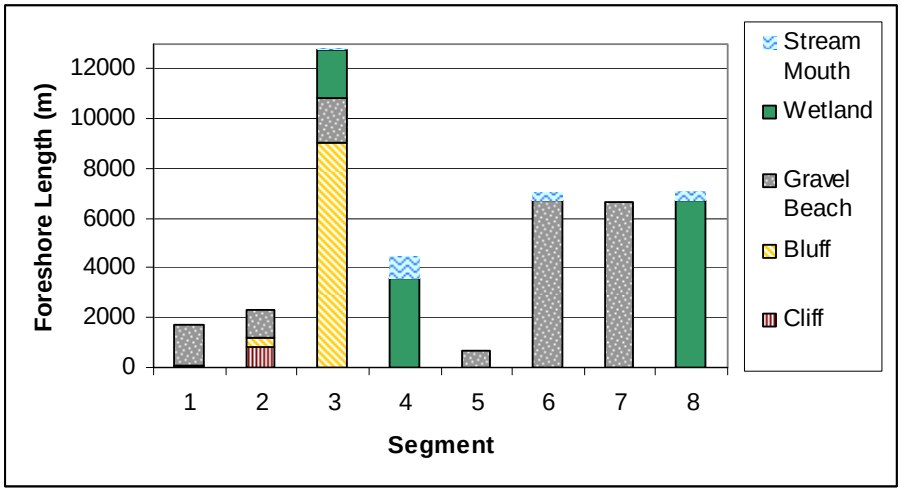

Figure 19. Shore Type extent (m) for each segment.

Figure 20. Marion Creek in Segment 7 entering lake through culvert under the railway. Photo: Porto Sept 2007.

Wetlands are an important Shore Type along Columbia Lake. There are extensive wetlands at the north and south ends of the lake (Segments 4 and 8 respectively) and some along the east shore in the low lying areas between the bluffs (Segment 3) (Figure 21). All of these wetlands are incorporated in the WMA. In Segment 3, wetlands were found along approximately 15% (or 1,932 m) of the shore. Wetlands comprised 80% (or 3,571 m) of Segment 4 and 95% (or 6,755 m) of Segment 8.

Figure 21. View of south end wetland and unnamed creek (left photo: Leschied June 2007), and wetland along eastern shore in Segment 3 (right photo: McPherson 2009).

The cliffs and bluffs were distinguished from one another in this investigation since they provide different habitats and influences along the shoreline (*See* Methods). There was only a small extent of Cliff Shore Type, which was identified in Segment 2 (Figure 22). Conversely, Bluff Shore Type extended along substantial lengths of Segment 3, as well as Segments 6 and 7 (in the upland area beyond the railway).

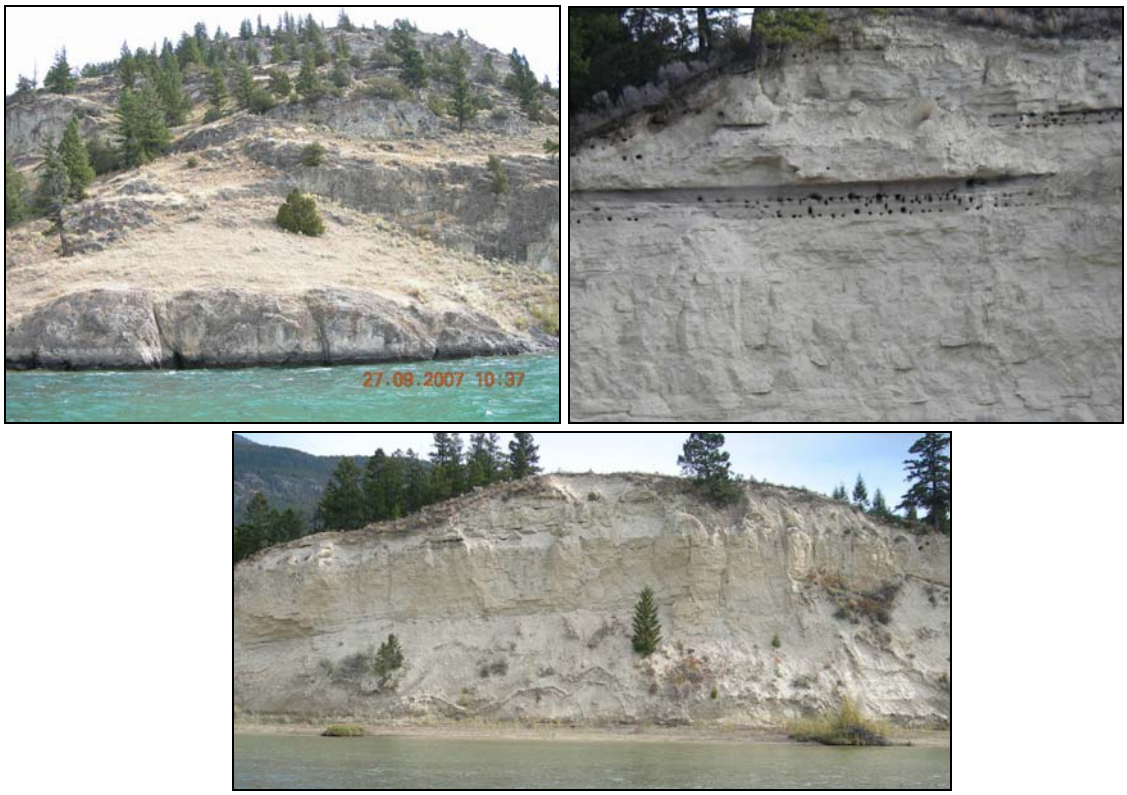

Figure 22. Cliff Shore Type with steep shoreline in Segment 2 (top left, photo: Porto Sept 2007); Bluff Shore Type with swallow nest sites in Segment 3 (top right, photo: McPherson Mar 2009); and Bluff Shore Type with beach in Segment 3 (bottom photo: Porto Sept 2007).

Emergent Aquatic Vegetation

In Columbia Lake, emergent aquatic vegetation (shallow-water wetlands) was common along the shallow-water habitats of the littoral zone (Figure 23). The dominant emergent species was great bulrush (soft stem) and as provided by RDEK (2007), common pondweed also is expected to occur in some places. The emergent aquatic vegetation was mapped on the Foreshore Summary Maps (Appendix B).

Figure 23. Bulrush above the ice along the shoreline of Segment 3. Photo: McPherson, Mar 2009.

Extent of shoreline with emergent aquatic vegetation is provided in Figure 24. The total lake foreshore with emergent aquatic vegetation was estimated to be 32,176 m (or 75% of the shoreline length). This represents a total area of approximately 300 ha. Segments 3, 4, and 6 and 8 had particularly high coverage (>80%).

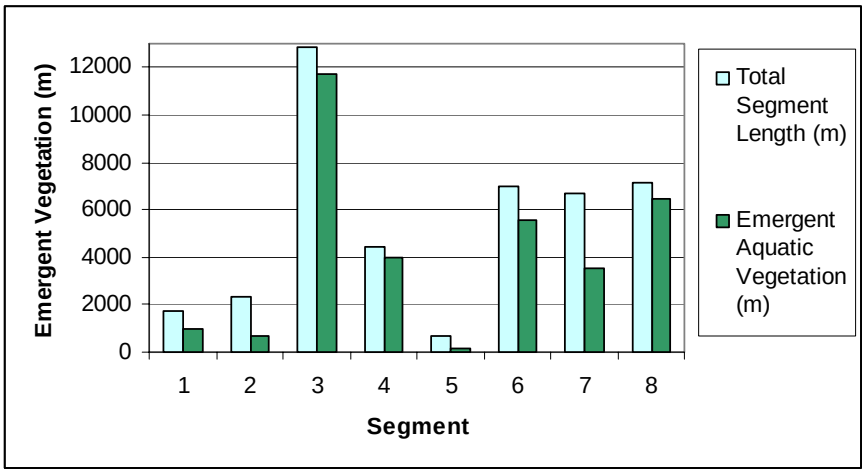

Figure 24. Segment length (m) with emergent aquatic vegetation.

Modifications to the foreshore (such as placement of docks, retaining walls or other structures) could have an impact on natural shoreline vegetation. In order to review potential impacts on the aquatic vegetation from these disturbances a comparison between percent foreshore with emergent vegetation and percent disturbed foreshore for each segment was conducted (Figure 25). From this data and field review observations, it appears that urban park and residential developments such as that found in Segment 1 (Canal Flats) and in Segment 5 (Columere) have resulted in a reduction of emergent aquatic vegetation, mostly likely through clearing for lake access. Most of the natural areas did have a high aquatic vegetation component (Segments 3, 4 and 8); however, some natural areas, such as Segment 2, did not have a high percentage of aquatic vegetation. Physical conditions, such as the deeper shoreline along the cliff area may be a factor behind the lower percentage here. As well, there was variability along the western shoreline segments which were disturbed by the railway, with Segment 6 having a high level of aquatic vegetation (80%) and Segment 7 having less (55%).

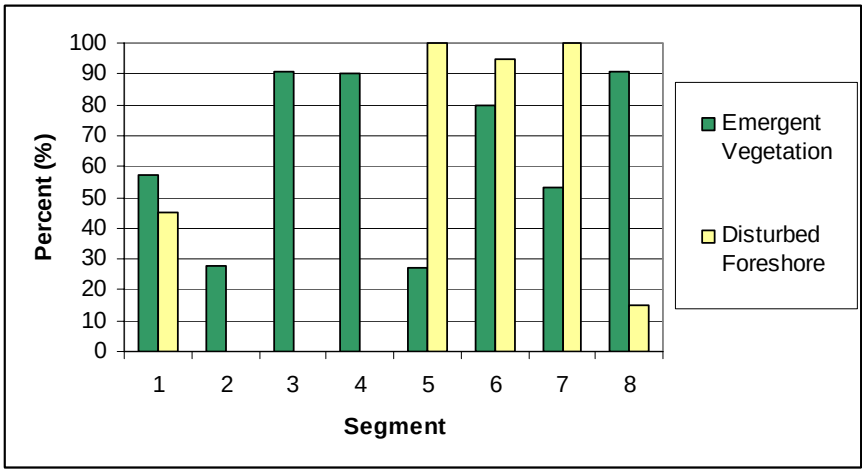

Figure 25. Comparison between percentage of foreshore with emergent aquatic vegetation and percentage of undisturbed land.

Riparian Vegetation

The FIM database provides information on the riparian condition and from this it is apparent that generally anthropogenic developments and infrastructure have resulted in the disturbance of riparian vegetation. For instance, Segments 5 (Columere), and Segments 6 and 7 (railway) all had sparse (<5%) or no riparian coverage and had been disturbed (Figure 26). Meanwhile, Segments 3, 4 and 8 which were undisturbed and covered by the WMA or Columbia Lake Provincial Park, had abundant coverage (>20%) with mature species. Segment 1 in Canal Flats, also had abundant coverage with a mature forest; which was positive to see, given that it had experienced some private residential and urban park development resulting in riparian disturbance (Figure 27). Since, further development is likely in this segment, efforts should be taken to minimize or reverse riparian impacts.

Segment 2 was reported to have moderate coverage (5-20%) with mature forest even though it had not been developed. This is likely a factor of the cliff (rock topography) section. However, abundantly vegetated riparian sections did exist in Segment 2 (Figure 27).

There were few riparian veteran trees or snags reported during the Sept. 2007 field review; a more detailed assessment may be required. It is worthy to note that the riparian data was collected during 2007 using standards of the time and that the current 2009 FIM standards have become more rigourous and detailed (Schleppe and Mason 2009). For instance, under the current (2009) standards, percent cover would be classified as: ‘Abundant’ if >50%, ‘Moderate’ between 10 and 50% and ‘Sparse’ if less than 10%.

Figure 26. Sparse or no riparian vegetation was evident along the railway, as evidenced by this photo of Segment 6. Photo: Leschied Sept 2007.

Figure 27: Development has impacted some of the riparian area along Segment 1, although it is rated as having a high shore cover (>20%) (Left); while, Segment 2 was reported to be moderately vegetated, although there were areas with dense mature riparian habitat (Right). Photos: McPherson, Mar 20 2009.

Foreshore Modifications

Shoreline modifications along Columbia Lake included: retaining walls, docks, groynes, boat launches and transportation infrastructure (i.e., railway and highway) (Figure 28). Riparian vegetation removal was another anthropogenic modification, which was discussed above. No shoreline modifications were observed in Segments 2, 3 and 4 (along the east end). Modifications along the east side of the lake are concentrated in Segment 1 (Canal Flats) which had the highest number of docks (nine wooden docks) and groynes (two) around the lake. Potential habitat concerns would be the two retaining walls situated below the high water mark and the one constructed of pressure treated wood.

Along the west end of the lake, Segment 5 (Columere) had the greatest number of modifications, which included: a retaining wall (below high water mark), railway extending along 100% of shore, a dock and a groyne (Figure 30). Segment 5 also has a 70 slip marina. This marina is situated near the outlet of Dutch Creek and the WMA and within the vicinity of the withdrawal point for Columere's drinking water supply (RDEK 1997).The railway is the major modification along the remainder of the west side of the lake.

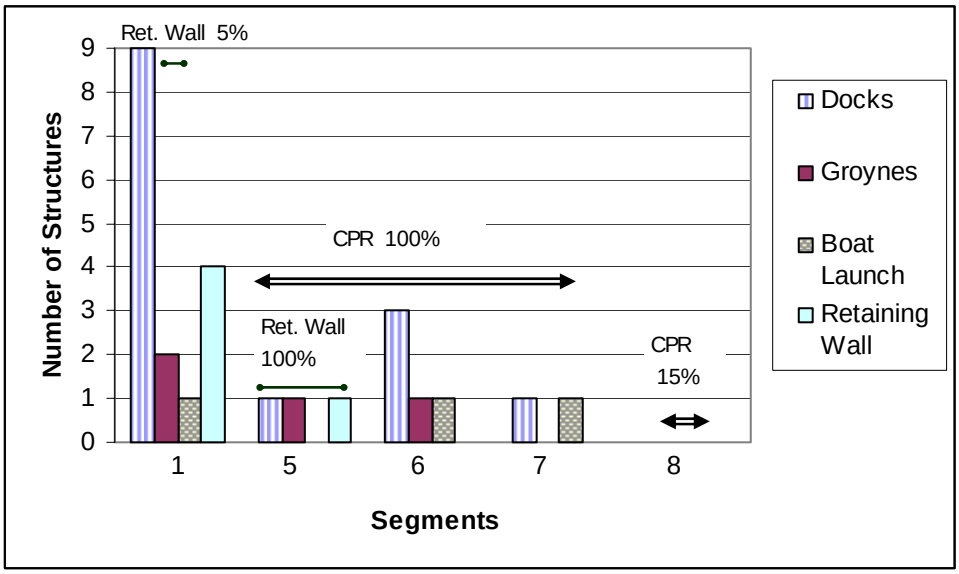

Figure 28. Segment modifications, depicted as numbers of structures, and percent of segment length (for CP Rail & retaining walls).

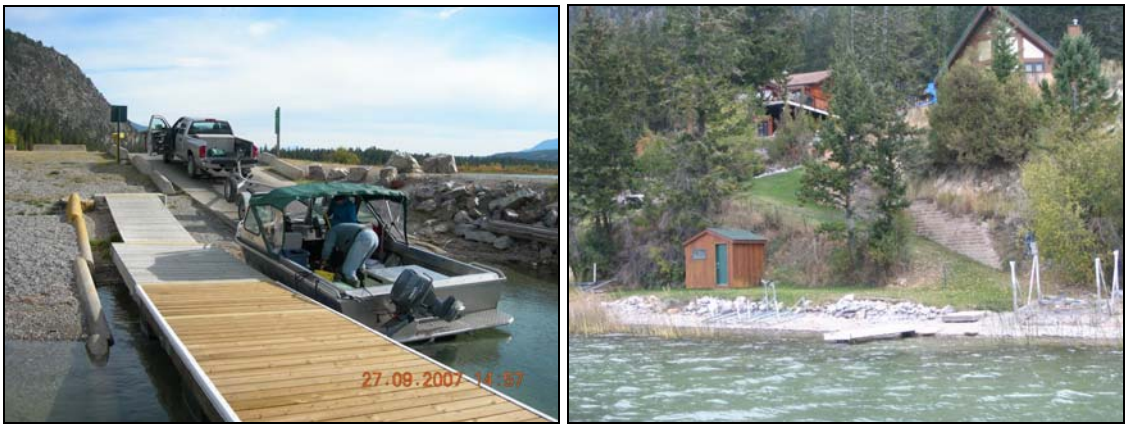

Figure 29. Segment 1 examples of modifications: left photo - boat launch with associated dock and groyne at Canal Flats Park (Porto Sept 2007), right photo: retaining wall, dock and vegetation removal (Leschied Sept 2007).

Figure 30. Shoreline modifications along Segment 5 (Columere) include retaining wall, riparian and aquatic vegetation removal and railway. Photo: Leschied Sept 2007.

Since docks were a prevalent modification, the number of docks per kilometer of shoreline was also determined. Results are as follows:

Segment 1 = 5.3 docks/km;
Segment 5 = 1.5 docks/km;
Segment 6 = 0.4 docks/km; and
Segment 7 = 0.1 docks/km.

Additional foreshore modifications are anticipated in the future. At the north end of Segment 6 for example, the construction of a CPR berm is currently being planned. The slumping bluff is threatening the tracks and the plans are to build a balast berm out into the lake to help support it.

3.3 Level of Impact (LoI)

LoI provides a qualitative indication of the overall health of the foreshore and considers the land use, level of disturbance, and modification information presented above. Generally a High LoI refers to a segment with >40% alteration along its shoreline, a Moderate LoI is between 10 and 40% alteration, and a Low LoI segment is mainly natural with <10% alteration. However, modification density and type, extent of grooming of aquatic vegetation and riparian impacts also play a role in determining LoI. Figure 31 provides a summary of the LoI ratings for Columbia Lake, and reveals that 33% (14,337 m) of the foreshore was determined to have a High LoI, 4% (1,766 m) had a moderate LoI, and 62% (26,774 m) had a low LoI.

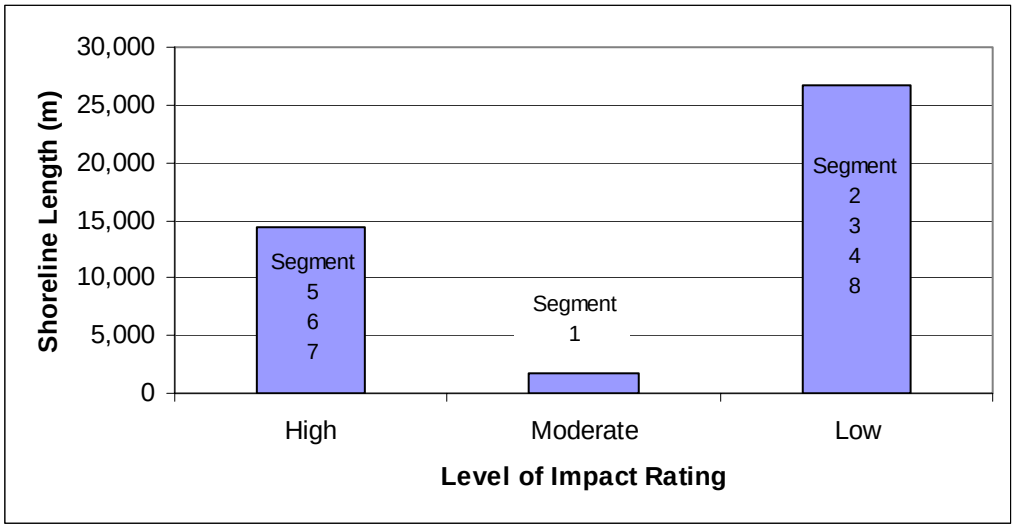

Figure 31. Segment level of impact (LoI) rating (High = >40%, Moderate = 10-40% and Low = <10%) and total shoreline length (m) attributed to each of the LoI ratings.

The Segments 5, 6, and 7 were rated as High LoI since they had been impacted along their full length. In the case of Segment 5, the urban park, riparian and aquatic vegetation removal and the

retaining wall all had greatly modified the shoreline characteristics. The fact that the substrates remained as natural gravels was considered beneficial. The railway running the extent of Segments 6 and 7 also had a high level of impact, particularly related to loss of riparian habitat and connectivity with the terrestrial bluffs.

Segment 1 was determined to have a Moderate LoI. This is because approximately half of the segment has been affected by urban park and residential development. The remaining intact areas could be under development pressure in the future and opportunities to minimize foreshore impacts should be considered.

The great extent of Low LoI shoreline (Segments 2, 3, 4 and 8), was largely attributed to the Crown Land which has seen little in the way of development as a result of the established WMA and protected area.

4 Discussion

The foreshore includes the littoral zone, shoreline, riparian and upland zones. These areas are important to humans and provide valuable habitat to many plant and animal species. Often, foreshore development results in alterations of important features or habitats. When the natural foreshore is altered, the intricate balance between the flora, fauna and ecological processes can easily be altered (Fisheries and Oceans 2008). Protecting the foreshore environment, however, can be a difficult task for managers. The Regional District of Central Okanagan, provided the following synopsis of difficulties faced with providing protection to the foreshore (RDCO 2005):

> *Historically, the long-term effects of foreshore disturbance were not well understood, resulting in inadequate protection, a cumulative loss of foreshore habitats, and ultimately, public and agency frustration over management. There are numerous reasons for such frustration: the difficult task of coordinating a large-scale effort in managing resources over multiple jurisdictions and agencies; lack of inter-agency cooperation and program integration; limited funding resources; and limited consequences for foreshore degradation. Further, the lack of comprehensive information on foreshore ecosystem relationships makes foreshore management difficult.*

The environmental foreshore values of Columbia Lake have been in the forefront of planning for some time. Efforts to protect valuable foreshore habitats is evidenced through the protection of significant extents of Crown Land through a WMA and protected areas, public involved processes such as development of the Lake Management Strategy, and development restrictions through policies such as Water Resource Zoning (RDEK 2009). Columbia Lake, however, has historically experienced foreshore development pressures and this pressure continues, particularly on the private land areas. This FIM study is intended to help direct future management objectives by providing an inventory of known environmental values and physical conditions of the foreshore. This study found a myriad of species dependant on the foreshore of Columbia Lake and examples of human-induced alterations to the foreshore.

4.1 State of Columbia Lake's Foreshore

Foreshore ecosystems function upon intricate relationships, provide living space for permanent and transitory species, and support primary production and food webs
(Batelle et al. 2001, *In* RDCO 2005).

The literature review of environmental values identified that the foreshore (and adjacent upland areas) of Columbia Lake is biologically diverse and important to numerous plant, fish and wildlife species. Several sensitive species have been reported to inhabit or potentially inhabit the area, including (at a minimum): 3 plant species, 4 invertebrates, 2 fish, 1 amphibian, 2 reptiles, 9 birds, and 3 mammals.

The physical analysis of Columbia Lake's foreshore revealed Gravel Beach (43%) to be the most prevalent shore type. Wetland and Bluff shore types also covered substantial areas (29% and 22%, respectively); while Stream Mouth and Cliff shore types were minimal (4% and 3%, respectively). These shore type provide unique and valuable habitats for plants and animals and are important to the ecological function of the lake environment; particularly where disturbance is low. For example, gravel beach areas and stream mouths are important habitat for fish spawning, wetlands are important for numerous species including waterfowl, bluffs provide nesting sites for swallows and cliffs typically have deeper refuge waters for fish at their base. The presence of emergent aquatic vegetation along extensive stretches of the shoreline (75% of length and total area equaling approx. 300 ha) and natural mature riparian forest (along the east side) also contributes to good ecosystem function. This vegetation is anticipated to be beneficial in many ways such as providing bank stability, a filtering agent nutrients and potential toxins, habitat for fish and/or wildlife and foraging opportunities (either directly or through related invertebrate production).

Over half (63% or 27 km) of the lake's foreshore area was found to be in a natural condition. This extent of natural area is very positive and significant for Southern Interior lakes, especially given that disturbances are mainly attributed to the railway at Columbia Lake (Holmes, pers com.). With good management strategies in the WMA and the provincial parks (approx. 24 km) most of the natural area should remain intact into the future. However, there still are private lands along the eastern shore (approx. 3 km) which should be carefully planned in a way to minimize foreshore impacts. As well, care needs to be taken with existing developed areas (approx. 16 km) to minimize further disturbance. Some of the residential lots in the Canal Flats area (Segment 1) appear to have been developed in a way that minimized foreshore disturbance (e.g., riparian areas intact and minimal shoreline structures; Figure 32, which can be contrasted to Figure 27a). Good development examples should be sought and used as templates for future planning. Further, at Okanagan Lake (RDCO 2005), Windermere Lake (McPherson and Michel 2007), and Wasa Lake (McPherson et al. 2009), foreshore modifications tended to be similar for adjacent properties. With the likelihood of further residential development (i.e. in Segment 2 of Canal Flats), care should be taken to limit shoreline impacts and protect existing conditions.

Figure 32. Residence set back on the bluff with minimal foreshore disturbance evident. Photo: Leschied Sept. 2007.

Approximately 37% (or 16 km) of the foreshore was assessed to be disturbed. The disturbances were mainly transportation infrastructure (33%), which was mostly attributed to the CPR along the west side of the lake. Losses of riparian vegetation and connection between the shoreline and the upland (e.g. culverted streams) were the obvious implications of this disturbance. Much of the residential areas along Columbia Lake are situated on the bluffs of the western shore and do not directly impact the foreshore environment. The private/residential areas along low elevation areas next to the shoreline and urban parks such as Columere and Eagle Nest Estates (Canal Flats

area), contributed equally to the remaining disturbed length (4% combined). If comparisons to adjacent undeveloped segments are made, disturbances in these areas appear to have resulted in reduction of emergent vegetation and riparian vegetation. This was particularly apparent in Columere Park, which had 27% emergent vegetation and only sparse riparian vegetation

Shoreline structures including docks, groynes, retaining walls, boat launches and a marina were also situated in developed areas along the lake. Dock densities were relatively low when compared to other lakes. For instance, Columbia Lake's Segment 1 had the highest density: 5.3 docks/km. In comparison, Wasa Lake had dock densities in developed areas ranging from 16 to 28 docks per km (McPherson et al 2009) and Windermere Lake ranged from 7 to 12 docks/km (McPherson and Michel 2007). Retaining walls were identified in Segment 1 (n=4) and Segment 5 (n=1) along Columbia Lake. There is concern with the walls being constructed since Segment 5's extended along 100% of the segment and was below the high water mark. Two retaining walls in Segment 1 were also situated below the high water mark and one was constructed of pressure treated wood, which contains toxic substances. The shoreline modifications have the potential to degrade sensitive freshwater habitats in many ways including changing the lakebed and water column, shading vegetation, introducing pollutants from motors, causing damage from boat propellers, and altering fish dynamics (e.g., disrupt shoreline migration and modifying predator prey relationships) (BC Ministry of Environment 2006). Construction of these structures may also cause sediment and contaminants to enter the water column where they may interfere with rearing fish and insects, plants and algae. Best management practices and local policies Water Resource Zoning (RDEK 1992 and Village of Canal Flats 2008) need to be followed to ensure proposed structures protect water quality and aquatic shoreline habitat. Restoration could improve the disturbed foreshore areas, such as removing foreshore modifications (e.g., docks and retaining walls) and vegetating riparian areas with native species.

The CPR tracks seem to have a significant impact on the western shore. In many respects this is a negative impact ecologically (alteration of riparian habitat, etc). In other ways it's positive as the tracks limit development on the immediate shoreline. CPR should be an important partner in Columbia Lake management direction because of their presence.

The practice of importing sands to create artificial beaches was not common around the lake. This form of beach grooming is known to impact the shoreline diversity through a reduction of riparian, shoreline and aquatic vegetation and cobble substrates in the littoral zone (McPherson et al 2009). Studies on Kootenay Lake have shown that beach grooming also affects fisheries abundance, diversity and utilization (MacDonald pers. comm.).

4.2 Foreshore Protection Policies

Federal and provincial legislation protect shoreline habitats such as the *Fisheries Act* (federal) and *Land Act* and *Water Act* (both provincial). Several regional and municipal foreshore protection policies are also in place at Columbia Lake (*See* Section 1.1 Foreshore Management). The EKILMP has recognized that accurately mapping and classifying fish and wildlife areas along the foreshore is integral to coordinating proposal review efforts and decision making. The EKILMP has thus been working to develop Shoreline Management Guidelines for Fish and Wildlife Habitats for high priority lakes in the East Kootenays. Windermere Lake was the first lake that had these Guidelines completed (EKILMP 2009) and the intent is to have them completed for Columbia Lake in the near future (Leschied pers. comm.).

The 'Shore Primer' produced by Fisheries and Oceans (2008), is another information booklet, which provides general guidelines for shoreline habitat protection. Suggestions for landowners provided in this guide that relate to modifications observed at Columbia Lake are as follows:

- Use docks as a bridge over the weedier shallows and moor a raft in deeper water, rather than removing habitat (for fish, amphibians and birds) by ripping out aquatic plants to a make a swimming area right at the edge of the shore.
- Leave trees where they fall (when safe to do so).

- Do not cover the area with sand - eroding sand smothers spawning areas, buries invertebrates (e.g., mayflies, clubtail dragonflies) and covers vegetation important to species such as frogs and birds. The impact will ripple through the food chain.
- Keep the foreshore intact – do not remove vegetation, roots hold the foreshore together. If the vegetation is damaged, the resulting erosion causes sediment to enter the water. This could damage spawning areas by suffocating eggs if they are in the vegetation or gravels/cobbles.
- Avoid hardened surfaces like retaining walls since they limit the ability of plants to grow, having a ripple effect on animals.
- Keep the riparian and upland zones intact - in a natural system, these zones form an effective buffer where most (90%) of the runoff does not make it to the lake and much of the sediments and pollutants are filtered. With plants in the littoral area, much of what does make it to the water is assimilated.
- On the upland - eliminate potential contaminants, maintain properly functioning septic systems, use permeable surfaces (gravel or wood chips) rather than concrete or asphalt and replant disturbed areas with native vegetation.

4.3 Cumulative Impacts

Individual lot-by-lot impacts, that may seem insignificant on their own, can collectively interact in complex ways to alter fish and wildlife growth and production rates. Jennings et al. (2003) found that cumulative changes to watersheds and riparian zones were associated with measurable differences in littoral habitats that may not be detectable at smaller scales. Radomski and Goeman (2001) described that foreshore management, which is often conducted through regulations and permits, fails to address the cumulative effects on aquatic habitats. They state that natural resource management agencies should do more to discourage actions that cause small losses or alterations to aquatic habitat. Thus, cumulative impacts need to also be considered when studying and managing foreshore environments.

5 Conclusions

Conservation of the intact ecosystems along Columbia Lake is an important goal of public and agencies. Intact ecosystems have biological, social, and economic value and the cost of protecting these areas may be low compared to the cost of restoration (Battelle et al. 2001 *In* RDCO 2005). Additionally, the effectiveness of restoration is often unclear (RDCO 2005). At Okanagan Lake, for example, most foreshore restoration efforts are recent and have not been monitored for long-term effectiveness (RDCO 2005). The simplest way to keep the foreshore environment functioning is to leave it as natural as possible. Good examples may initiate a trend of leaving the foreshore more natural, and of designing modifications in a more environmentally sensitive manner. The values of living on a lake depend on maintenance of foreshore habitat including: fishing, bird watching, wildlife viewing and good quality water for recreation and drinking.

Clearly defined principles and associated policies and strategies will help guide future decisions and promote a coordinated approach to foreshore management among regulatory agencies. The science-based methods employed at Windermere Lake, which included the development of Shoreline Management Guidelines for Fish and Wildlife and a Lake Management Plan provide an excellent template for developing or fine-tuning management strategies for other lakes such as Columbia Lake. These steps will help ensure that the EKILMP's objectives of achieving quality developments that preserve the integrity of upland areas and maintain environmental attributes of the foreshore while facilitating human requirements are met. Local public involvement from the outset is very important to the success of developing guidelines and strategies.

Conservation of these ecosystems is critical in maintaining the environmental, social, and economic values that have drawn people to the East Kootenay Region. Other potential tools include public

education, which can be used to curtail the loss of critical habitat on private property, and expanding partnerships, which can increase local government's ability to adapt to increasing development pressure.

6 Recommended Actions

The Central Okanagan Lake FIM (RDCO 2005) and Windermere Lake FIM (McPherson and Michel 2007) were used as templates in completing this foreshore inventory. Due to their relevance, the following recommendations are based largely on these reports. Relevant recommendations from the Columbia Lake Management Strategy (RDEK 1997), were also reiterated in this report.

Decisions regarding the management of the Columbia Lake foreshore should be based on the best available science and should reflect policies set out in regional strategies and guidelines as well as those of senior levels of government. Measures should be taken to conserve and restore sensitive foreshore ecosystems and to preserve the ecological integrity of Columbia Lake. Regional and local governments possess a variety of means to ensure development is sensitive to environmental values, including Official Community Plans, Lake Management Plans, zoning, and bylaws. These are useful in many situations, provided the baseline information on which decisions are made is both current and accurate. Action items recommended to help further understand and protect the natural integrity of Columbia Lake are as follows:

Action #1. Conduct inventories to determine <u>current</u> status of sensitive species and habitats associated with the foreshore.

- Complete fish inventories and determine fisheries sensitive zones, including identification of spawning, migration and rearing areas for fish.
- Conduct inventories of reptile, amphibians, birds and mammals.
- Conduct plant inventories in undisturbed foreshore areas, to identify whether listed "at risk" or "sensitive" species or ecosystems are present.
- Complete a Wildlife Tree Assessment for the foreshore and protect wildlife trees during development, where safely possible.
- Use the quantitative and qualitative fish and wildlife information to complete a Fish and Wildlife Habitat Assessment and to develop associated Shoreline Management Guidelines, similar to that recently completed at Windermere Lake by McPherson and Hlushak (2008).
- Rate habitat conditions that would allow for re-introduction of any extirpated species.
- The percent substrate data for each segment should be collected to allow for analysis during any subsequent Fish and Wildlife Habitat Foreshore Assessment.

Action #2. Identify and protect critical and natural areas

- Protect undeveloped areas adjacent to the foreshore.
- Protect substrates from alteration. Beach grooming, lake infilling, importation of sand, armouring and dredging all have the potential to negatively impact substrate materials.
- Where the habitat is sensitive only during critical periods (e.g., during bird breeding/nesting and rearing/fledgling periods), boat launches should remain closed. Motorized and non-motorized recreation should also be restricted in sensitive and significant habitat areas, particularly during critical periods.
- Ensure that buffer leave strips are required on all new developments.
- Restrict marinas, boat launches and foreshore modifications in sensitive and significant habitat areas.
- Restrict high horsepower boats/jet skis in sensitive areas (e.g., wetlands). Consider requesting 'a year-prohibition on the operation of power-driven vessels in the wetlands of the Columbia Lake' to Transport Canada, similarly to the amendment currently under review for the Columbia Wetlands Wildlife Management Area.

Action #3. Address modification impacts

- Identify areas where restoration or enhancement would likely benefit habitat quality. Restore or enhance foreshore areas affected by past modifications.
- Prevent or mitigate further modifications to foreshore areas where they are likely to reduce habitat quality.
- Make technical guidance available to agencies and the public regarding alternatives to traditional foreshore modifications.

Action #4. Develop a Foreshore Protection Plan (or Lake Management Plan)

- Set objectives which consider shore type and disturbance level for lake management.
- Include regulations and guidelines (e.g., riparian area regulations) for new development, re-development and management of existing developments.
- Designate protection of critical areas in policies.
- Develop jointly with all partnering agencies and explore a memorandum of understanding with all levels of government regarding foreshore management roles and responsibilities.
- Link foreshore activities to upland portions of the watershed.
- Determine if there would be a benefit in calculating the carrying capacity[3] of foreshore modifications and activities on shore zone ecosystems. If so, obtain necessary foreshore data to determine carrying capacity. Although not easily measured, carrying capacity may be useful in assessing cumulative loss of foreshore habitats resulting from human disturbance (RDCO 2005).

Action #5. Monitor habitat losses and gains to measure success

- Create a new database of all properties around the lake and rank the development activities on a house by house basis. This should include riparian area, substrates, boat launches etc.
- Develop and produce indicators, actions and timelines.
- Initiate a detailed habitat monitoring program.
- Develop coordinated enforcement protocol with all levels of government to respond to foreshore habitat impacts.
- Compare results from a monitoring program to the original inventory data to determine compliance with best management practices and effectiveness of protection activities.

Action #6. Continue to make inventory data and habitat information available

- Provide federal, provincial, and local jurisdictions with inventory data.
- Make the inventory data available to the public via the Internet through continued partnership with the Community Mapping Network.

Action #7. Educate developers and property owners on the foreshore values

- Prepare an educational program for developers and existing lakeshore owners and users. This will assist stakeholders to: 1) understand the value of retaining natural foreshore features; 2) ensure existing sewage systems are properly operated and maintained; 3) develop lots in a way that minimizes impact on the environment and; 4) understand the economic value inherent in protecting the ecological integrity of the lake.

[3] The carrying capacity of a lake with respect to development is defined as *a 'lake's ability to accommodate recreational use (e.g. boating, skiing, bathing) and residential occupation of the foreshore and adjacent upland areas without excessive overcrowding, pollution and consequent danger to human health and safety'* (RDCO 2005).

Action #8. Continue monitoring water quality

- Implement a water quality monitoring program with the cooperation of area citizens.

Action #9. Review and act on relevant recommendations outlined in the Columbia Lake Management Strategy (RDEK 1997)

- Establish a community based steering committee with representatives from developments and Canal Flats.
- Prepare a Watershed Management Strategy for Columbia Lake
- Update the Lake Management Plan (i.e. address criteria included at Windermere Lake).
- Address issues of potential hazardous spills and occurrence of side casting with CPR.
- Establish a water level monitoring program.
- Complete Management Objectives for the East Side Columbia Lake WMA and manage water and lands within the boundary accordingly.
- Direct boating away from the WMA and other sensitive habitat. Restrict boats from entering or exiting Columbia Lake from the Columbia River.
- Conduct a comprehensive study of Dutch Creek and the surrounding area.
- Check the elevation of and the blockage from the culvert in the southwest corner of the lake.
- Do not develop a new private marina.
- Establish a subdivision policy (Transportation of Highways in consultation with the steering committee).
- Close the boat launch at the south west end of the lake.
- Allow foreshore tenure for dock facilities for subdivisions.
- Do not allow foreshore leases in WMA or other areas of excellent fish or waterfowl habitat.
- Review terms and conditions of the Columere Park Marina.
- Establish education panels at all boat launches.
- Marina to establish a code of practice to reduce potential for pollutant and invasive plant introduction (especially aquatic plants such as Eurasian milefoil, lustrife, etc).

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Appendix A. Key to the Field Headings in the Columbia Lake ArcMap Foreshore Database (adapted from Mason and Knight 2001)

Column Heading	Heading Description / Defining Parameters
Segment Number	Unique identifier
Segment Length	Total length (in metres) of the segment along the foreshore
Photo Number	Lists all photos taken in segment.
Lot #	Legal lot numbers according to cadastral (RDEK) maps
Dominant Shore Type	Dominant shore type for the segment based on shore type percentages.
Dominant Land Use	Dominant land use for the segment based on local land use or zoning maps.
% Natural	Approximate percentage of segment which remains natural.
% Disturbed	Approximate percentage of segment which has been disturbed.
Level of Impact	Overall extent of disturbance (Low (L), moderate (M), high (H)) that has occurred throughout the segment. Level of impact is based on attributes such as % disturbed and modifications.
Cliff Shore Type	Approximate percentage of segment which is occupied by Cliff shore type (CL).
Bluff Shore Type	Approximate percentage of segment which is occupied by Bluff shore type (BL).
Gravel Beach Shore Type	Approximate percentage of segment which is occupied by Gravel Beach shore type (GB).
Sand Beach Shore Type	Approximate percentage of segment which is occupied by Sand Beach shore type (SB).
Low Rocky Shore Type	Approximate percentage of segment which is occupied by Low Rocky shore type (LRS).
Wetland Shore Type	Approximate percentage of segment which is occupied by Wetland shore type (W).
Stream Mouth Shore Type	Approximate percentage of segment which is occupied by Stream Mouth shore type (SM).
Private / Residential	Percentage of segment occupied by private / residential land use (Res)
Commercial	Percentage of segment occupied by commercial land use (Com)
Conservation (WMA)	Percentage of segment occupied by conservation area such as Wildlife Management Area (Con)
Agricultural	Percentage of segment occupied by agricultural land use (Ag)
Urban Park	Percentage of segment occupied by urban park, designated primarily for recreational use, and typically has associated infrastructure.
Park	Percentage of segment occupied by park land use (i.e., federal or provincial protected area aimed at conserving the natural elements (P)
Crown	Percentage of segment occupied as Crown land which has not been designated specifically for conservation purposes.
Industrial	Percentage of segment occupied by industrial land use (Ind)
Transportation	Percentage of segment occupied by the transportation infrastructure such as railway or road
Livestock Access	Evidence of livestock utilization along the foreshore.
Substrate Fines	Approximate substrate percentage that is composed of fine material. Identified separately for areas above and below high water mark.
Substrate Gravel	Approximate substrate percentage that is composed of gravel material. Identified separately for areas above and below high water mark.
Substrate Cobble	Approximate substrate percentage that is composed of cobble material. Identified separately for areas above and below high water mark.
Substrate Boulder	Approximate substrate percentage that is composed of boulder material. Identified separately for areas above and below high water mark.
Substrate Bedrock	Approximate substrate percentage that is composed of bedrock material. Identified separately for areas above and below high water mark.
Submergent Veg (%)	Percentages shoreline length with submerged vegetation.
Emergent Veg (%)	Percentages shoreline length with emergent vegetation
Littoral Zone Width	General width of the littoral zone. Low is 0-10 m, Moderate is 10-50 m and Wide is >50 m)

Spawning Habitat	Presence/absence of fish spawning habitat.
LWD	Presence/absence of large woody debris in the water.
Riparian Class	Land cover classes (i.e. based on % crown cover and dominant vegetation). Field key includes: coniferous, shrubs, landscaped, disturbed wetland, broadleaf, herbs/grasses, lawn, row crops, mixed, exposed soil, natural wetland and rock
Riparian Stage	Structural Stage (meters) of the dominant vegetation. Field key includes: sparse, tall shrubs (2-10m), mature forest, grass/herbs, sapling (>10 m), old forest, low shrubs (<2 m) and young forest.
Riparian Shore Cover	Percentage of the shore that is occupied by riparian vegetation. Field key includes: none, sparse (<10%), moderate (10-50%) and abundant (>50%).
Riparian Band Width	Number of metres of riparian area reviewed (up from the water line).
Riparian Overhang	Distance (m) that riparian vegetation overhangs within 1 m of the channel.
Riparian snags	Number of snags- dead standing trees
Riparian Veteran	Number of veteran trees - mature trees that are significantly older than the dominant forest cover.
Retaining Wall	Number of retaining walls per segment.
Retaining Wall Percent	Percent of shoreline length covered with retaining walls.
Retaining Wall Material	Primary material that the retaining wall(s) are constructed from.
Retaining Wall Type	Type of retaining wall coverage (i.e. discontinuous or continuous).
Docks	Number of docks along the shore per segment.
Docks/km	Number of docks per km of segment shoreline.
Groynes	Number of groynes per segment.
Boat Launch	Number of boat launches per segment.
Railway	Presence or absence of a railway along the foreshore of the segment.
Roads	Presence or absence of a road along the foreshore
Marine Railway	Number of marine railways /trams per segment.
Marinas	Number of marinas per segment.
Modification Comment	Comments regarding modifications.
General Comments	Additional comments regarding observations in the segment

Appendix B. Foreshore Summary Maps

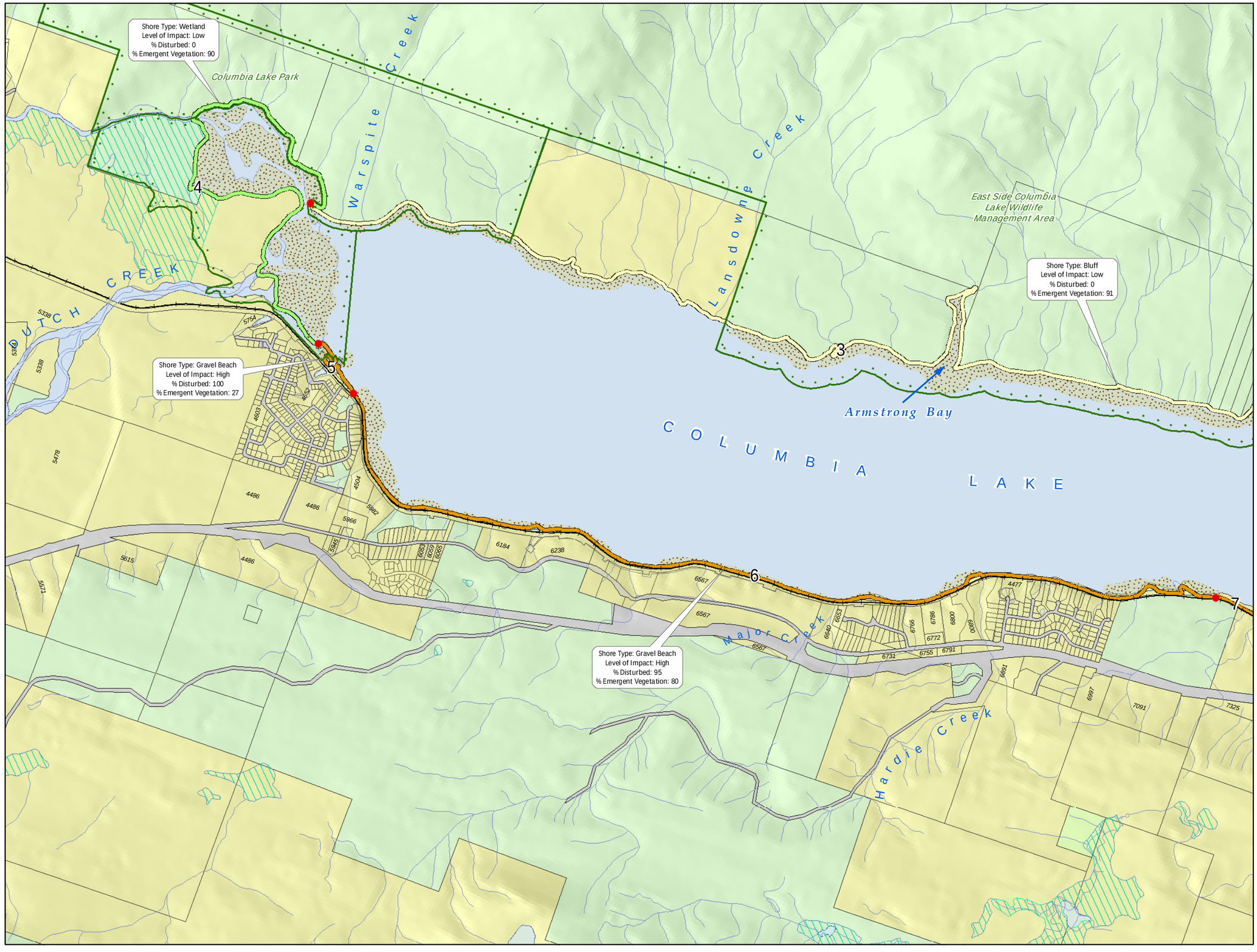
COLUMBIA LAKE FORESHORE INVENTORY AND MAPPING

Columbia Lake North FIM Map

Map 1 of 2
Date: June 01, 2009
Scale: 1:25,000

0 250 500 750 1,000 Meters

Fisheries and Oceans Canada
- Pacific Region



Legend

Dominant Shore Type
- Bluff
- Gravel Beach
- Wetland

Features
- Segment Break
- Wetlands
- Emergent Vegetation
- Park/Protected Area
- Railway
- River/Stream

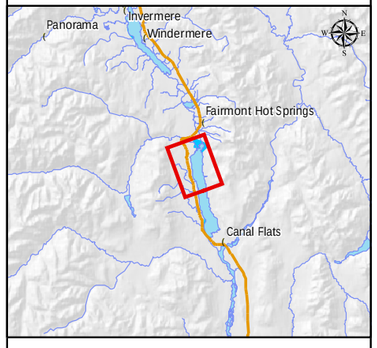
RDEK Parcel Fabric
- Legal Boundaries
- Villiage of Canal Flats
- Crown Land (Default)
- Private Lands
- Roads/Access
- Waterbody

Data Sources
- Regional District Base Map and Legal Plans: Regional District of East Kootenay (Accuracy +/- 10 meters)
- Transportation, Stream, Lake: TRIM (1:20,000)
- Parks/Protected Areas: GeoBC, Province of BC
- Shoreline Segments: Digitized from TRIM Lake data (1:20,000)
- CWB Wetlands: GeoBC, Province of BC
- Emergent Vegetation: Digitized from 2008 Orthophoto (20 cm res.) in conjunction with Field verification/GPS mapping - March 2009

Map Information
Map Projection: UTM 11
Map Datum: NAD 1983
Issue Date: 2009.06.01

Cartographic Information
Created By: D.Hlushak
Reviewed By: S.McPherson
08WILD6A\ColumbiaLake_FIM

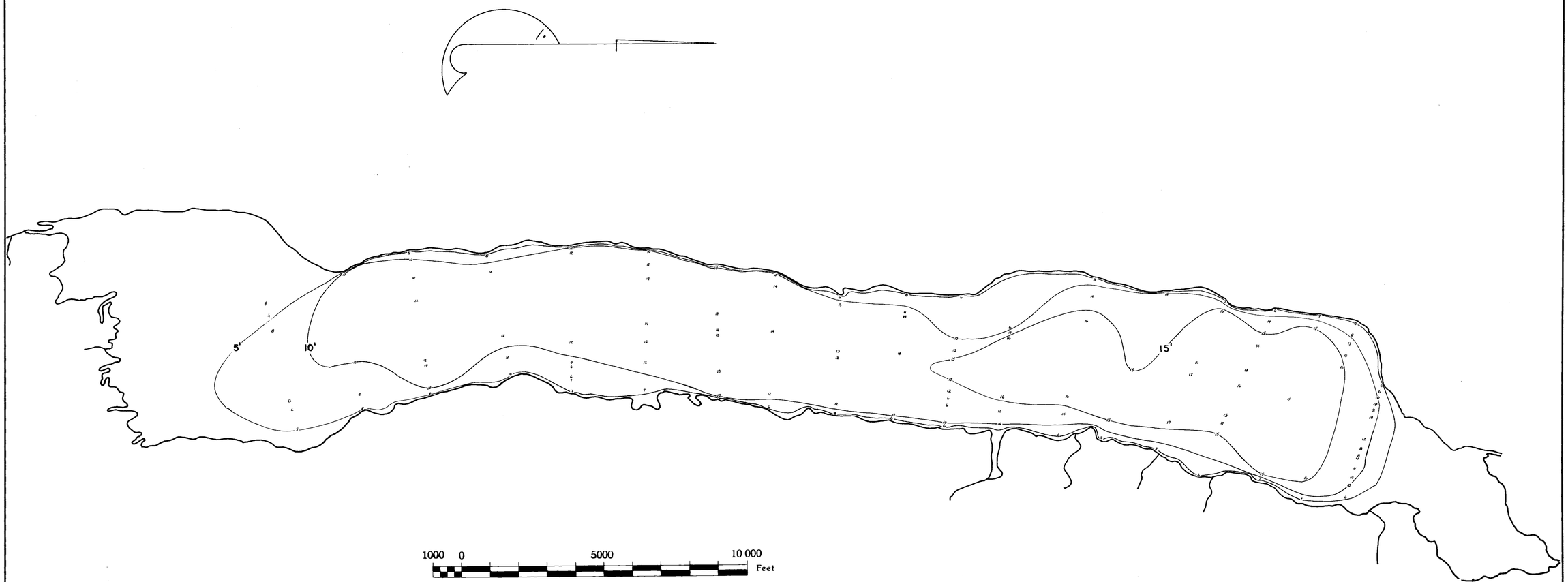
Note:
This map is used for illustrative purposes only and should be used in conjunction with the Columbia Lake Foreshore Inventory and Mapping Database



Digital Mapping By:

INTERIOR REFORESTATION CO. LTD.
Leadership In Natural Resource Management

Appendix C. Bathymetric Map of Columbia Lake



1000 0 5000 10 000
Feet

CAUTION: DO NOT USE THIS MAP FOR NAVIGATIONAL PURPOSES
This map may not reflect current conditions. Uncharted hazards may exist.

SURVEYED BY: J.A.B. & D.B. DATE: Aug 28, 1958
SHORE OUTLINE FROM: Air Interim

STATISTICS AT TIME OF SURVEY

1.	ELEVATION	=2652
2.	SURFACE AREA	=6360 Acres
3.	VOLUME	=60,700 Acre ft.
4.	EST. ANNUAL FLUCTUATION	
5.	MEAN DEPTH	=9.5'
6.	MAX. DEPTH	=17'
7.	PERIMETER	=138,400'

DATE	No.	REVISION	BY

FISH AND GAME BRANCH
DEPARTMENT OF RECREATION AND CONSERVATION

COLUMBIA LAKE

DATE: | DRAWN: J. Chadsey | SCALE: 1" = 1600'
DESIGN: | CHECK: C.K.H. & J.A.B.
APPROVED: Chas. S. Hanna, DIVISION ENGINEER. — J. A. Motz for, CHIEF BIOLOGIST.
DWG. No. 82-J-4-W½

Appendix D. FIM Database

	General						Land Use (%)									
Segment Number	**Segment Length (m)**	**Lot #**	**Photo Number (LP and HL's cameras)**	**Predominant Shore Type**	**Predominant Land Use**	**Level of Impact**	**Natural**	**Disturbed**	**Crown Land**	**Private / Residential**	**Agricult-ural**	**Park**	**Urban Parkland**	**Transportation**	**Conservation (WMA)**	**Livestock Access**
1	1746.3	Lots 8533-8211	LP: 0917 d/s start, 0918 East. HL: 1 to 10	Gravel Beach	Private / Residential	Moderate	55	45	0	90	0	0	10	0		No
2	2317.9	DL 4596	LP: 01919 d/s start, 0920 waterfall (pt 2), 0921 cliff/bluff (pt 3), 0922 eroding bank (pt 4), 0923 u/s end. HL: 11 waterfall, 12 cliff/bluff	Gravel Beach	Conservation	Low	100	0	0	10	0	0	0	0	90	No
3	12881.1	DL 4596, SL 9 (Columbia Lake Provincial Park), DL 48	LP: 0924 (pt 5), 0925 u/s end. HL: 13 campsite, 14 cliff/bluff, 15 bald eagle	Bluff	Conservation	Low	100	0	0	15	0	15	0	0	70	No
4	4464.3		LP: 0926. HL: 16	Wetland	Conservation	Low	100	0	0	0	0	35	0	0	65	No
5	657.2	DL 16931, DL 16932, DL 12574	HL: 17	Gravel Beach	Urban Parkland	Mod	0	100	0	0	0	0	93	0	7	No
6	6997.1	DL12572 to end of DL 7558	LP:0927 boat launch (pt 6), 0928 dock/marina (pt 7); HL: 18 & 19	Gravel Beach	Transportation	High	5	95	5	5	0	0	0	90	0	No
7	6682.9	DL 4596 to DL 12564	LP: 0929 inflow @ Hwy 93/95	Gravel Beach	Transportation	High	0	100	0	0	0	0	0	100	0	No
8	7110.4	DL 12564, 16433	LP: 0930	Wetland	Conservation	Low	85	15	0	0	0	0	0	15	85	No
	42857.2															
		September 27, 2007: Crew - Brad Mason, Heather Leschied, Louise Porto; weather-overcast, air and water temp 7°C														
		March 4, 2009 Crew: Darcy Hlushak and Sherri McPherson; ice on the lake														

		Shore Type (%)								Substrates (%)						
Segment Number	**Land Use Comments**	**Cliff**	**Bluff**	**Gravel Beach**	**Sand Beach**	**Low Rocky Shore**	**Wetland**	**Stream Mouth**	**Shore Type Comments**	**Fines**	**Gravel**	**Cobble**	**Boulder**	**Bedrock**	**Substrate Compaction**	**Substrate Comments**
1	Canal Flats Provincial Park	0	5	95	0	0	0	0		50	50	0	0	0	Unknown	some artificial substrates
2	Columbia Lake Wildlife Management Area (WMA)/ Columbia Lk. Ecol Res.(upland); section within Canal Flats District	35	15	50	0	0	0	0	All gravel beach sections are backed by vegetated areas.	0	10	60	20	10	Low	
3	Private area is zoned for resort; Crown is WMA; and Park is Columbia Lk. Prov. Park. WMA is situated on land that is zoned A-1 (rural resource) .	0	70	14	0	0	15	1	Wetland areas are found in lowlying areas (valleys) between the bluffs. Landsdown and Warspite Creeks	0	5	0	0	0	Unknown	
4	WMA; Park is Col. Lk. Prov. Park.	0	0	0	0	0	80	20		0	0	0	0	0	Unknown	
5	WMA and Columere. WMA section has had riparian vegetation removal	0	0	100	0	0	0	0		0	50	0	0	0	Unknown	
6	Railway transport. Small crown/private pockets btwn lake and railway (beaches used by public-docks, canoes etc)	0	0	96	0	0	0	4	Railway and then bluffs are situated upslope from the gravel beaches. Hardie and Major Creeks.	0	100	0	0	0	Unknown	
7	Railway transportation.	0	0	99	0	0	0	1	Marion Creek.	0	0	0	0	0	Unknown	
8	WMA; ThunderHill Provincial Park in SW corner beyond railway. Highway runs along portion of	0	0	0	0	0	95	5	Wetland on inland side of road; unnamed creek in SW corner.	0	0	0	0	0	Unknown	

	Riparian											Littoral Zone			
Segment Number	**Riparian Class**	**Riparian Qualifier**	**Riparian Stage**	**Shore Cover**	**Riparian Veteran**	**Riparian Snag**	**Riparian Bandwidth**	**Riparian Bankslope**	**Riparian Overhang**	**Riparian Comment**	**Emergent Vegetation (%)**	**Submergent Vegetation (%)**	**Littoral Zone**	**Spawning Habitat**	**Retaining Wall**	**Retaining Wall Material**
1	Mixed forest	Natural	mature forest	Abundant (>20%)	No	No	50	30	0		57%	1	Shallow	Unknown	4	3-rock, 1 pressure treated wood
2	Mixed forest	Natural	mature forest	Moderate (5-20%)	No	No	50	40	1		28%	0	Shallow	Unknown	0	
3	Mixed forest	Natural	mature forest	Abundant (>20%)	>=5	>=5	50	45	0	mature cotton wood patch	91%	40	Shallow	Unknown	0	
4	Natural wetland	Natural	mature forest	Abundant (>20%)	No	No	50	0	0	lake outlet	90%	60	Shallow	Unknown	0	
5	Herbs/grasses	Urban Residential	Herbs/grasses	Sparse (<5%)	No	No	0	0	0		27%	>5	Shallow	Unknown	1	rock
6	Shrubs	Disturbed	low shrubs <2m	None	No	No	2	45	0		80%	0	Shallow	Unknown	0	
7	Shrubs	Disturbed	low shrubs <2m	Sparse (<5%)	>=5	>=5	2	45	0	railway on edge of lake , cotton wood areas behind have riparian veg	53%	0	Shallow	Unknown	0	
8	Natural wetland	Natural	low shrubs <2m	Abundant (>20%)	No	No	50	0	0		91%	0	Shallow	Unknown	0	

	Shoreline Modifications												
Segment Number	**# Ret. Wall Below High Water Mark**	**% of shoreline with Ret. Wall**	**Docks**	**Dock Material**	**Groynes**	**Groyne Material**	**Railway**	**Marine Railway**	**Marinas**	**Boat Launch**	**Other / Comments**	**Fauna Observed and General Comment**	**GIS_ID FID**
1	2	5	9	Wood	2	Stone (pt 9), Mixed (pt 1)	No	0	0	1		mergansers	1
2			0		0		No	0	0	0		Sept: king fisher, gulls, crow.	3
3			0		0		No	0	0	0		Sept: bald eagle, mergansers, geese, coots, king fisher. March: mass of eagles in middle of lake around deer carcass; beaver house in wetland; cliff swallow nests in bluffs, muskrat homes on ice all around lake (every 100 m or so), mussel shells evident in muskrat diggings. Includes Armstrong Bay, a significant bay within the WMA with potentially unique ecological features.	4
4			0		0		No	0	0	0			5
5	1	100	1	Wood	1		Yes	0	1	0	Marina has 70 slips. Includes a canoe storage facility		6
6			3	Wood	1	Other	Yes	0	0	1	Railway on edge of lake,	Sept: merganser.	9
7			1	Wood	0		Yes	0	0	1			10
8			0		0		Yes	0	0	0		Sept: geese+gulls. The isolated pond west of the railway is an important area for waterfowl, painted turtles, beaver and other wildlife.	0

Appendix E. Segment Descriptions

Segment Descriptions

Segment delineation proceeded counter clockwise around the lake, beginning with Segment 1 at Canal Flats Provincial Park in the south east end of the lake and ending at the south end wetland at Segment 8. Segment locations are mapped in Appendix B. Summary descriptions and Level of Impact (LoI) of each Segment are provided below.

Segment 1 (1746.3 m) – LoI Moderate

Segment 1 starts at the Canal Flats Provincial Park. This park comprises approximately 10% of the shoreline and was classified as 'Urban Parkland' due to the fact that it is has been modified for recreation purposes (parking lot, boat launch and grassy area). The remainder of the segment is private land. In terms of shore types this segment is predominantly Gravel Beach (95%), with some Bluff Shore Type (5%). The substrates were estimated to be an equal proportion of fines and gravels, with some artificial substrates placement (beach grooming) evident. The riparian area was identified as a mixed mature forest (containing both coniferous and broadleaf trees) with abundant (>20%) shore cover. Emergent vegetation was found along 57% of this segment. Approximately 45% of this segment was identified as being disturbed. Four retaining walls were observed, extending along approximately 5% of the shoreline. Three of the retaining walls were constructed of rock and one of pressure treated wood; two were located below the high water mark. There were also nine wooden docks and two groynes (one each of stone mixed material) identified. Mergansers were observed during the September field review.

Segment 1. View to the south from the north end of Canal Flats Provincial (left), area under development) (right). Photos: McPherson, Mar 2009.

Segment 1. Emergent vegetation along bluff area (left photo: Porto Sept 2009), and developed foreshore property (right photo: Leschied, Sept 2009).

Segment 2 (2317.9 m) – LoI Low

Segment 2 was undisturbed, with no modifications evident. 90% of the shoreline falls into the East Side Columbia Lake Wildlife Management Area (zoned Rural Resource (A-1) by the RDEK). A small section (approximately 10%), located at the southern end of the segment is undeveloped private land. Half of this segment (50%) was Gravel Beach Shore Type, characterized by a narrow beach backed by a well-vegetated area. The remainder of the shore was typed as Cliff (35%), the only cliff along the lake's foreshore and Bluff (15%) shore types. Substrates observed were mainly cobbles (60%) with the remainder being a mix of boulder, bedrock and gravel components. The riparian area was mainly a mixed mature forest with moderate cover (5-20%). Emergent vegetation was measured to extend along 28% of the segment.

Segment 2: Cliff Shore Type alongside Gravel Beach in Segment 2. Photo: McPherson, Mar 2009.

Segment 3 (12881.1 m) – LoI Low

Segment 3 is situated along the remainder of the eastern shore and is the longest segment on the lake. The foreshore along this segment has generally not been developed and remains in a natural condition. Seventy percent of the land falls in the East Side Columbia Lake Wildlife Management Area (zoned Rural Resource), 15% is a private/residential area (DL 48 includes resort lodge and resort recreation and single family), and 15% is in the Columbia Lake Provincial Park (north end of segment). Most of this segment is Bluff Shore Type (70%). Wetland Shore Type (15%) areas are typically found in the low lying depressions between the bluff sections. Other shore types include: Gravel Beaches (14%) and Stream Mouth (1% - Landsdown and Warspite Creeks). The riparian area was contiguous with that of the previous segments, and was comprised of mixed mature forest with abundant shore cover. Numerous (≥5) riparian veteran and snag trees were noted as well as a mature cottonwood patch. Most of the foreshore length (91%) was lined with emergent vegetation. There were several wildlife observations: bald eagle, mergansers, geese, coots and a kingfisher in September; and: bald eagles, beaverlodge, swallow burrows, muskrat dens on ice (actually observed all around the lake), and mussel shells in the muskrat diggings in March. Segment 3 includes Armstrong Bay, a significant bay within the East Side Columbia Lake Wildlife Management Area with potentially unique ecological features.

Segment 3. Bluff (left: Leschied, Sept 2007) and wetland Shore Types (right: McPherson, Mar 2009).

Segment 4 (4464.3 m) – LoI Low

This segment includes the Columbia Lake outlet, located at the lake's north end. The foreshore here is in a natural condition; and is situated within the Columbia Lake Provincial Park (35% of segment) and East Side Columbia Lake Wildlife Management Area (65%). The shore type is comprised of 80% Wetland[1] and 20% Stream Mouth Shore Types. The riparian vegetation is classified as natural wetland, which is mature and provides abundant coverage. Emergent vegetation was mapped along 90% of this segment.

Segment 4. Overhead photo of wetland at north end of Columbia Lake. Photo: July 2008.

Segment 5 (657.2 m) – LoI High

Segment 5 is situated along the low-lying section of the Columere Park Development on the north-west shore of Columbia Lake. The northern extent of this segment lies within the Wildlife Management Area (7%) and the remainder is on urban parkland, which is an open recreational beach access area for the community. This Segment has been 100% disturbed by means of a rock retaining wall which extends along the total extent of shoreline, riparian vegetation removal, dock (1), groyne and presence of a railway. Gravel Beach Shore Type extends along the length of this segment. The riparian area is comprised of manicured herb/grasses. Emergent aquatic vegetation was found along 27% of the shoreline.

Segment 5. Columere shoreline, which has been largely altered from its natural condition (Photo: Leschied Sept 2007)

[1] Geo BC. BC's geographic gateway. Accessed 2009 http://www.geobc.gov.bc.ca/

Segment 6 (6997.1 m) – LoI High

Segment 6 is located to the south of Segment 5, starting at the point where the bluff topography initiates along the west side of the lake. The shore type is mostly gravel beach (96%), with the high bluffs lying just beyond the narrow bench upon which the railway has been constructed. The Stream Mouth Shore Type makes up a small proportion (4%) of shore as well, as demarcated by the outlets of Hardie and Major Creeks. These creeks enter the lake via culverts under the railway. Most (95%) of the area has been disturbed by the presence of the railway. A few narrow crown and private land pockets buffer the shoreline from the railway. These pockets were utilized by the public (e.g. presence of 3 wood docks, 1 groyne and canoes on shore). The riparian area was disturbed and was comprised of low shrubs (<2 m), providing no cover. Emergent aquatic vegetation was found along a great extent of the shoreline (80%). Three wooden docks, one groyne and a boat launch were additional modifications observed along the shoreline. The bluff at the northern end of Segment 6 (below Columere) is slumping and threatening the CPR railway. The CPR is seeking approval to counter the slumping bluff with a large deposit of coarse material on the foreshore (including in the lake).

Segment 6. The cross section of the shoreline up from the lake in this segment is gravel beach, railway and then bluffs. Photos: left - Leschied Sept 2007, right - McPherson, Mar 2008.

Segment 7 (6682.9 m) – LoI High

Segment 7, extends along the southern half of the west side of the lake. Similar to Segment 6, the railway runs along the gravel shoreline and bluffs form the terrestrial backdrop. The segment has been 100% disturbed as a result of the railway. The shore type is predominantly Gravel Beach (99%), with 1% being Stream Mouth (Marion Creek – culvert opening to lake). The riparian area along this segment was disturbed and limited to low shrubs providing sparse coverage. Some riparian veteran trees and snags (equal or greater to 5 for both) were noted in the cottonwood stands behind the railway. Emergent aquatic vegetation was determined to extend along 53% of this segment. Additional modifications noted were a wooden dock, a groyne and a boat launch.

Segment 7. Marion Creek flow entering into the lake through a culvert under the railway. Photo: Porto Sept 2007.

Segment 8 (7110.4 m) – LoI Low

This segment incorporates the south end of the lake, which is primarily situated in the East Side Columbia Lake Wildlife Management Area. The railway and highway runs along the western edge of this segment, owing to 15% of shoreline disturbance. The shore type here is mostly Wetland (95%; as provided by GeoBC), with some Stream Mouth influence (5%) on from the unnamed spring fed creek in the south western corner. Emergent aquatic vegetation is prevalent throughout, extending along approximately 91% of the shoreline and infilling much of the southern area. The riparian area is classified as natural wetland and is abundantly covered with low shrubs. Wetland shore type is also found on the upland side of the highway. Geese and gulls were observed utilizing this segment during the September, 2007, survey. The isolated pond west of the railway is an important area for waterfowl, painted turtles, beaver and other wildlife and is partially bordered by Thunder Hill Provincial Park.

Segment 8. Looking east across highway towards the southern wetlands. Photo: Leschied, June 2007.

Appendix F. Digital Copy of the Columbia Lake FIM Report