Wasa Lake
Foreshore Inventory and Mapping

Prepared for:
Wasa Lake Land Improvement District

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Interior Reforestation Co. Ltd.

INTERIOR REFORESTATION CO. LTD.

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Disclaimer

The results contained in this report are primarily based upon data collected during a 1-day field survey and by orthophoto delineation completed by parties other than Interior Reforestation Co. Ltd (Interior). This data was also augmented using previously documented material and a site inspection during low flows. 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

Wasa Lake is located in the southern interior of British Columbia, near Cranbrook BC. The Wasa Lake Land Improvement District (WLLID) commissioned Interior Reforestation Co. Ltd. (Interior) to complete a Foreshore Inventory and Mapping study (FIM) on Wasa 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, including those of Okanagan Lake (Regional District of Central Okanagan 2005) and Windermere Lake (McPherson and Michel 2007). Field reviews were completed in June 2008 by BC Ministry of Environment and BC Conservation Corporation staff, 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 December 2008, during low water levels, by Interior professionals.

The literature review identified that the foreshore (and adjacent upland areas) of Wasa 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: seven plant species, two invertebrate species, seven bird species and one mammal. As well, there are potentially three sensitive grassland and open forest ecosystems in the area. Maintaining functioning habitats for these species is considered important.

The foreshore of Wasa Lake, which was determined to be 7.45 km, was delineated into 10 segments, based on contiguous characteristics. The physical analysis revealed the most prevalent shore type to be sand beach (high end of shoreline) /cobble beach (low end of shoreline) (36%). Vegetated and sand beach shore types also covered substantial areas (29% and 25%, respectively); while wetland and stream mouth shore types were minimal (9% and <1%, respectively). Aquatic vegetation was observed along the upper end of approximately 52% of the shoreline. The aquatic vegetation was composed of mainly grasses which were submerged during high water periods and emerged/on dry ground during lower water periods. The vegetation of natural or less disturbed shoreline areas was herbs/grasses, and for many segments, these transitioned to ponderosa pine/grassland ecosystems through the riparian and upland zones.

Over half (60%) of the lake's foreshore area was found to be disturbed through anthropogenic (human induced) modifications. These disturbances were mainly related to residential land use activities (54%), while some were associated with park recreational uses (6%). In the littoral zone (waters edge to where sunlight could penetrate) and the shoreline zone (water's edge), the most prevalent modifications were dock placement and beach grooming (conversion to sand beach through sand placement and/or removal of shoreline vegetation). Beach grooming appeared to have particularly large impacts on the foreshore diversity by reducing vegetation (both terrestrial and aquatic) and cobble substrate features. Higher up the foreshore, disturbances to the riparian and upland vegetation areas included conversion to lawns and other landscaping. Despite the foreshore impacts, a substantial portion of the study area was undisturbed (40%). Twenty eight percent of the undisturbed foreshore was located in the Wasa Lake Provincial Park. Segment 2, located at the south end of the lake was also mostly undeveloped, having 717 m of natural foreshore. 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

Wasa Lake (also known as Hanson Lake) is situated on Highway 93-95, within a half hour drive of Cranbrook and Kimberley. It is a quiet cottage community comprised of summer residences, permanent homes, small businesses, a provincial park and campgrounds. Its sandy beaches, scenic mountain setting, and warm, shallow waters make it an attractive recreation and retirement area. People from nearby communities as well as tourists from the United States and Alberta utilize the lake.

Overall, as with many lakes across the province, Wasa Lake's growing recreational popularity has resulted in an increase in foreshore disturbances. Historically at Wasa Lake, many of the foreshore dwellings were cabins with a relatively small footprint (MacLeod pers. comm.); however, with escalating property values many of these cabins have been sold and the new owners have often converted them into 'dream recreational getaways'. The dwellings that have replaced the cabins tend to cover a larger area of the land, include more or larger shoreline structures (such as docks and groynes) and shoreline alterations (beach grooming, dredging and riparian disturbance). These alterations and their potential negative impacts on the foreshore environment have become a concern with local citizens and regulatory agencies.

The Wasa Lake Land Improvement District (WLLID) provides representation for Wasa Lake citizens. The WLLID works in close association with regulatory agencies, including the British Columbia Ministry of Environment (MoE), the Regional District of East Kootenays (RDEK) and Fisheries and Oceans Canada (Fisheries and Oceans). The WLLID's objective is to identify management issues, provide development direction and education, and initiate necessary planning activities required for the improvement of the Wasa Lake area. In order help provide foreshore management direction and educate the public, the WLLID commissioned the completion of this foreshore inventory and mapping report (FIM) to Interior Reforestation Co. Ltd. (Interior). The report is intended to identify foreshore values and outline the types and extent of anthropogenic (or human-caused) impacts.

A future goal of the WLLID is to develop a Lake Management Plan (LMP) for Wasa Lake (Ashmore pers. comm.). This FIM project is one important component that would feed into the development of the LMP (Figure 1). 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 the completion of a Fish and Wildlife Assessment. The foreshore management guidance information, as well as water quality and quantity objectives are the key environmental values components typically used in the development of the LMP.

Examples where FIM studies have been previously completed include Windermere Lake (McPherson and Michel 2007) and Central Okanagan Lake (Regional District of Central Okanagan (RDCO) 2005). This Wasa Lake FIM will follow the standards established in these studies. The main field component for the Wasa Lake study was completed in the summer of 2008 by MoE and BC Conservation Corporation (BC CC) staff, experienced with FIM methods. Interior prepared this report using this field data, subsequent field findings and available literature relating to the foreshore. The FIM is a community driven initiative under the stewardship and funding from the WLLID, with in-kind help and funding from MoE, Fisheries and Oceans and the Columbia Basin Trust (CBT). The WLLID has worked very hard to secure funds and lobby government for this study and to achieve overall improved foreshore protection and management. This document is considered to be a "living document" and it is inherent that the WLLID and Wasa Lake community will be actively involved in the protection and advocacy for their lake (Ashmore pers. comm.).

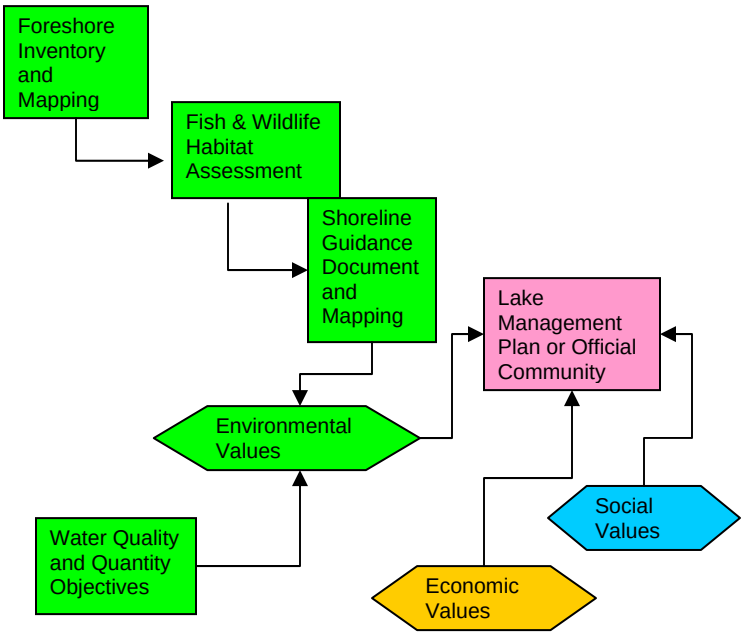


Figure 1. Lakeshore Inventory and Management Planning Process (Holmes, pers. comm. – 2008 North American Lake Management Presentation).

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 Wasa Lake adhere to the Wasa - Ta Ta Creek – Skookumchuck - Sheep Creek Land Use Bylaw (RDEK 2007), administered through the RDEK. The Environmental Policies (Section 3.07) in the bylaw are generally aimed at higher level planning. Policies that appear most relevant to foreshore protection are as follows:

- Item 10 - new development near watercourses and water bodies will only be approved in accordance with floodplain management provisions provided by MoE;
- Item 20 - The feasibility of establishing boating restriction on Wasa Lake will be investigated;
- Item 21 - Further alienation of the foreshore for private use will not be supported;
- Item 22 - All alterations to the foreshore, including adding or removing fill require a permit from the Water Management Branch of MoE;
- Item 23 - Excavation below 766.72 m GSC is not supported;
- Item 24 - An application will not be supported for private commercial marina on Wasa Lake. The concept of owners presently having docks, wishing to consolidate them into one facility will be supported, for improving safety and public access;

- Item 25 - Removal of all unlicensed water intakes on the lake is supported. Further licenses for private irrigation are not supported;
- Item 27 - Habitat and riparian improvement initiatives on private lands will be supported, subject to regulatory approvals; and
- Item 29 - In order to protect water quality, further subdivision around Wasa Lake will be restricted through minimal parcel size, floodplain management considerations and sewage disposal regulations.

Although this land use bylaw determines what can occur on an individual parcel of land and references some federal and provincial regulatory requirements, it is limited in providing specifics relating to environmental protection or implementing a community vision; this increased level of detail would typically be found in an Official Community Plan or a Lake Management Plan.

Discussions with RDEK Planning Department (Macleod pers. comm.) identified that for Wasa Lake, the RDEK has typically only received referrals for projects requiring a License of Occupation under the Land Act (such as docks or sale/other alienation of Crown Land), and that not very many referrals have come forth. A contributing factor to this is that there is generally no land available for new foreshore developments; as it has been either developed or is undevelopable. Examples of other possible uses that would require an application to the Crown are (from EKILMP 2008):

- Groin,
- Marina,
- Breakwater,
- Boat launch (new & upgrade),
- Waterline (drilled, trenched etc),
- Geothermal loop,
- Infill,
- Overwater piling,
- Erosion protection (incl. soft bioengineered, hard-joint planted or vertical wall),
- Rail launch system,
- Beach creation above high water mark (HWM),
- Invasive weed removal,
- Aquatic plant removal,
- Upland vegetation removal,
- Elevated boardwalk below HWM,
- Mooring buoy
- Boat house, (above or below HWM),
- Groynes,
- Dredging (new or maintenance), and
- Fuel facility.

Management issues at Wasa Lake are that some land owners ignore or 'creatively interpret' statutory requirements relating to the protection of habitat and there has been a lack of related enforcement by governing bodies (Ashmore pers. comm.). West Coast Environmental Law (2007) provided examples of violations of the province's *Water Act* at Wasa Lake, particularly in respect to the practice of spreading sand on the beach and damaging the foreshore. In one case, the property owners completed beach grooming and then after the fact were requested by government to make an application for the works and do remediation; however, the remediation was not completed. In a second example, approval for similar works was granted, with strict conditions imposed. The conditions were breached and a letter from government ensued identifying that the charges would be recommended if the problem occurred again. In both cases, the *Water Act* was violated and no charges were issued. A lawyer has been retained by the WLLID to help deal with future non-compliance issues, which are considered to have both environmental and economic impacts (West Coast Environmental Law 2007).

In the Kootenay Region, management agencies 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. The WLLID is a partner in the East Kootenay Integrated Lake Management Partnership (EKILMP), which is a partnership made up of stakeholders with common concerns and joint responsibilities, who have combined resources to address issues of concern in an integrated way (EKILMP 2006). The EKILMP is completing foreshore studies and management guidelines for several lakes, in order to help provide timely and cost effective reviews of proposals, to determine cumulative impacts and sustain water quality (for aquatic life, recreation and drinking water). Windermere Lake was a pilot for this type of planning, with completion of a FIM (McPherson and Michel 2007), Fish and Wildlife Habitat Assessment

(McPherson and Hlushak 2008) and Shoreline Management Guidelines (EKILMP 2009). The advantages of using an integrated and collaborative approach to lake management are currently being realized.

1.2 Foreshore Definition, Significance and Sensitivity

Wasa 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 (from 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 in this area serving as substrates for food production and providing a variety of habitats for animals. For example: 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 source 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, water birds nest in tall grasses, and in the winter, it provides shelter to many animal species.

Holmes (pers. comm.) complimented these definitions by providing additional description on their importance as wildlife habitat and potential impacts.

> *Lakeshores form a transitional ecological community between aquatic and terrestrial habitats, referred to as an ecotone. Ecotones are important for wildlife since they provide the benefits of differing habitats in close proximity to each other. Lakeshore habitats are important for a variety of invertebrates and vertebrates for nesting, feeding, resting and protection from the elements and predators. Vegetated shorelines help to reduce erosion through both soil stabilization and through a reduction in the erosional energy of rainfall and wave action. Leaf litter and fallen branches/trees provide food and/or habitat for aquatic organisms including fish breeding and feeding sites. The vegetation is distinct from upland habitats due to the presence of water and in ecological terms is considered more productive than drier or wetter habitats.*
>
> *The lakeshore riparian habitat is typically a narrow ecosystem that varies in size depending on the influence of water. Even though this is a very important ecosystem, adjacent habitats also provide attributes required by many species dependent on lakes. Clay banks, wildlife trees, coarse woody debris, adjacent wetlands, tributaries, grassland, forested habitats and shrub cover provide important components of life cycle*

requirements. For instance, six species of ducks in British Columbia are secondary cavity nesters and require wildlife trees (dead or decaying standing trees) to nest in. They select cavities excavated by primary cavity nesters such as pileated woodpeckers or northern flickers in either deciduous or coniferous trees that are usually greater than 50 cm diameter breast height (dbh). They prefer trees near the lake or pond but in cases such as the wood duck, will select wildlife trees up to 500 meters from the lake. Therefore, management of development pressures around lakes must take into account these other habitat attributes. Several species are also known to depend on the lakes for foraging while nesting habitats may be several kilometers away, such as the Common Loon.

Very few studies have been undertaken to assess the impacts on wildlife resulting from increased development around lakes. One in-depth study showed increased lakeshore development does have a significant influence on the presence of some breeding bird species (Lindsay et al. 2002). This study reviewed the effect of lakeshore development on various species of birds focusing on the differences in species diversity and ecological guild (species with common habitat requirements or behavior) composition. The study showed that the most dramatic effects from development on lakeshores were changes in nesting guilds. Developed lakes had more seed-eaters and fewer species dependent on insects and shrub nesting birds. It is inferred that supplemental feeding by bird feeders and increased occurrence of non-native ornamental vegetation increases the abundance of the seed-eaters guild. They did not show any significance that these species were an out competing presence but did find increased abundance of detrimental species such as cowbirds that are brood parasites. The reduction in shrub nesters was explained by the removal of shrubs in yards and by increased success of predators such as raccoons (Pocyon lotor) and domestic cats.

Lakeshore vegetation, habitat structure and species use is commonly altered by anthropogenic disturbances. Types of disturbance include direct habitat loss, loss of native plant communities, avoidance, alteration of predator prey relationships and direct mortality. For instance, road and house construction result in direct habitat loss and alterations of natural drainage patterns. Conversion of natural vegetation to ornamentals results in removal of native nesting and foraging habitats. Human presence reduces species use of desired attributes through avoidance and through alteration of structure such as kids playing in a sand or clay bank and destroying nesting sites of bank swallows. Most predator species tend to avoid areas with high human densities which results in prey species congregating in other areas and abnormal population levels. Furthermore, many species considered a nuisance, such as bats, are killed by property owners, and as mentioned earlier, domestic animals prey on birds and other small vertebrates.

Habitat complexity in the littoral zone is also known to be particularly important to fish productivity. Coarse woody debris (CWD), aquatic macrophytes and substrate compositions are examples of habitats important to fish that often become compromised as a result of residential development. These habitats provide many functions including predation refugia, foraging substrates, spawning or nesting habitat, cover from the sun and nutrient cycling (Schindler et al. 2000 and Engel 1990). The littoral zone is also particularly important for early life-history stages of fish (Radomski and Goeman 2001). Residential developments can impact these habitats through direct removal of vegetation, construction of structures (such as piers, docks and marinas), and alteration of the shoreline with riprap or concrete (e.g., retaining walls and groynes). There have been some studies, particularly from the Eastern United States examining the potential effects that lakeshore residential development may have on these habitats and fish. For example, Schindler et al. (2000) found that extensive residential development significantly reduced the growth rate and productivity for bluegill sunfish (*Lepomis macrochirus*) in eastern temperate lakes. They speculated that the growth rate decreases were associated with significant losses of CWD and riparian tree density reported by Christensen et al. (1996) for the same lakes. Radomski and Goeman (2001) found that developed shorelines had substantially less emergent and floating leaf vegetation than undeveloped

shorelines; and that the abundance of three fish species in Minnesota Lakes was positively correlated with emergent and floating plants. At lakes with greater development density, Jennings et al. (2003) also found that the quantity of woody debris, emergent vegetation and floating vegetation decreased and that littoral sediment contained more fine particles increasing substrate embededdness. Embededdness occurs when finer materials (silts/sands) fill in the interstitial spaces between courser substrates and bind them together (Bisset pers. comm.). This is a concern because it reduces flow/permeability, surface area for phytoplankton and invertebrates and can smother eggs (Bisset pers. comm.). Woodford and Meyer (2002) found that human caused riparian and littoral zone alterations also impact amphibians. Their study revealed that green frog densities were reduced where CWD and wetland plants were removed.

Holmes (pers comm.) summarized these findings by stating that:

> *Overall, there are several habitat attributes associated with lake ecosystems that play an important role in the life cycle of fish and wildlife species. These include: open water, littoral, shoreline and riparian/upland areas. The shallow open water areas provide easy access to deeper/benthic habitats for species such as diving ducks and river otters. The littoral and shoreline zone contains specialized habitat for many invertebrates that are important food sources for vertebrates. Emergent and submergent vegetation in these wetted areas provide nesting and foraging areas for many species. The riparian/upland zone contains the most diverse number of attributes, including: wildlife trees, coarse woody/large organic debris, overhanging vegetation, adjacent wetlands, grasslands, forests and clay banks.* Table 1 provides examples of organisms which are know to utilize these habitats.

Table 1. Known foreshore habitats for fish and wildlife (Holmes pers. comm.)

Habitat Type	Species	Utilization
Forest Canopy Cover	• Ungulates • Small mammals	• Cover • Feeding
Wildlife Trees	• Birds (e.g., Great blue heron, Woodpeckers, Nuthatches, chickadees, Owls) • Small mammals including bats • Salamanders	• Nesting • Feeding • Roosting • Perching
Coarse Woody Debris	• Amphibians • Reptiles • Small mammals • Woodpeckers • Bears	• Cover • Dens/nesting • Food storage • Food source (invertebrates)
Shrub Cover	• Amphibians (e.g., western toad)	• Cover
Grasslands	• Long-billed curlew • Ungulates	• Feeding • Overwintering
Clay Banks	• Bank swallow	• Nesting
Adjacent Wetlands	• Reptiles and amphibians (e.g., rubber boa, western toad) • Ducks	• Rearing
Littoral Zone	• Shore birds • Fish • Invertebrates	• Feeding • Spawning • Rearing
Shallow Lake Edges	• Amphibians (e.g., long-toed salamander, western toad) • Fish	• Egg laying • Rearing
Emergent / Sub-emergent Vegetation	• Amphibians (e.g., long-toed salamander, northern leopard frog) • Ducks/geese • Fish	• Egg laying • Nesting • Feeding • Rearing • Migration path

Individual lot-by-lot impacts, that may seem insignificant on their own, can overtime, collectively interact in complex ways to also 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 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.

1.3 Purpose and Objectives

The **purpose** of this foreshore inventory and mapping project is to provide baseline information to aid future decision-making. The project will provide an easily accessible inventory of physical attributes of the foreshore (including land use, shore type, riparian condition and anthropogenic alterations). Supplemented by available literature, this information will be used to identify the ecological condition of the foreshore, evaluate resource values and explore conservation and restoration opportunities.

The information will be useful for local, regional, provincial, and federal organizations when addressing development issues related to foreshore sensitivity. Specifically, it will aid in developing land use policies, regulations and standards aimed at increasing the long-term environmental capabilities for the protection of aquatic and riparian habitat. The information can also be integrated with upland development planning, to ensure protection of sensitive foreshore areas; so that lake management planning is watershed based. The project may also provide evidence for regulatory investigations.

The Objectives of this project are to:

- provide an overview of foreshore habitat condition on the lake;
- inventory foreshore morphology, land use, riparian condition and anthropogenic alterations;
- obtain spatially accurate digital video of the foreshore of the lake, made available through Geographic Information Systems (GIS);
- 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 enhancment; and
- provide a baseline and planning tool for review agencies.

2 Methods

A summary of Wasa Lake's foreshore values was prepared using field assessments of the physical features collected during both water high water conditions (June 5, 2008) and low water levels (December 7th and 10th, 2008). This was supplemented with available 'environmental values' information attained through a literature review. Field inventory and mapping of the Wasa Lake foreshore was conducted according to standard Sensitive Habitat Inventory Mapping (SHIM) procedures (Mason and Knight 2001), which have been adapted to the lake foreshore environment from riverine system classification.

With funding and technical direction from Fisheries and Oceans (Brad Mason), Terrasaurus Ltd. (Terrasaurus) flew Wasa Lake in July 2008, created orthophotos and delineated foreshore features. These orthophotos and the subsequent delineation results were also used to supplement findings for this study.

2.1 Field Assessment

The primary assessment of the physical foreshore features was conducted on June 5, 2008 from a boat, by MoE staff (Peter Holmes) and BC CC staff (Erica Heel, Brendan Guy and Erica Jenkins). The entire foreshore was recorded using digital video and still photos. 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 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 2. Shore Types (adapted from RDCO 2005).

Shore Type	Description
Cliff/Bluff	Adjacent to steeper slopes, usually indicating a steep-sided lake basin or sudden drop-off
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 (high) / Cobble Beach (low)	Sand beach is prevalent above the median and high water mark (often human induced), with cobble beach in the lower sections of the foreshore and littoral zone.
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.
Vegetated Foreshore	Characters of undisturbed foreshore with narrow littoral width. Vegetation is commonly shrubs, small trees, or grasses. Overhanging vegetation occurs to the mean water level.


Cliff/bluff


Sand Beach


Vegetated Shore


Wetland


Sand Beach High / Cobble Low

Figure 2. Examples of Shore Types (photos of Wasa and Windermere Lake).

Table 3. Land uses adjacent to the foreshore (adapted from RDCO 2005).

Land Use Designation	Purpose
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.
Rural	To accommodate agricultural and rural uses on parcels that are 0.5 ha or greater and located outside the Agricultural Land Reserve.
Agricultural	To accommodate agricultural operations and related activities on parcels usually located on the Agricultural Land Reserve.
Park	To accommodate active conservation and/or recreation uses.
Industrial	To accommodate industrial activities.

Table 4. Foreshore conditions (RDCO 2005).

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

Table 5. Foreshore modifications (RDCO 2005).

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 3. Examples of foreshore modifications including boathouse, dock, retaining wall (left); and marina, dock and retaining wall (right, [photo of Windermere Lake 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 6 and Figure 3). 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 6. Level of Impact (RDCO 2005)

Level of Impact	Description
Low	Segments that show little or limited signs of foreshore disturbance and impacts. 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. 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. 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.

Low Level of Impact | Medium Level of Impact | High Level of Impact

Figure 4. Examples of low, medium and high levels of impact along foreshores.

Interior was responsible for providing the written report and map products from the field data following standards established in FIM studies completed on Windermere Lake (McPherson and Michel 2007) and Central Okanagan Lake (RDCO 2005). In order to do so, MoE provided Interior 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. Through a separate contract with Fisheries and Oceans, Jamie Heath of Terrasaurus delineated the physical features of the shoreline using the 2008 orthophotos. This GIS product was also provided to Interior for review and inclusion into this FIM report. 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 on foot, on December 7th and 10th 2008 by Interior staff (Darcy Hlushak and Sherri McPherson). This assessment was conducted in order to:

1) Obtain additional information relating to the bay in Segment 2, which was not demarcated during the June 2008 field review;
2) Obtain additional information relating to Segment 6, which was not initially demarcated during the June 2008 field review;
3) Gather information on littoral substrates and extent of emergent vegetation at the low water levels for all segments;
4) Demarcate two additional Shore Types which were considered important to understanding natural conditions and physical features for the lake. The shore types added were, 'cobble

(low water level)/sand (high water level) shoreline' and 'stream mouth'. The cobble shoreline in particular, would not have been evident during the higher lake levels of the summer, but was quite apparent, throughout much of the shoreline in the winter low conditions; and,

5) Confirm some of the orthophoto shoreline delineation results completed by Terrasaurus.

2.2 Report Preparation

Report development involved summarizing available information on environmental values to the area, preparing detailed descriptions for each segment, analyzing and summarizing physical conditions for the lake. Interior's GIS department constructed a map of Wasa Lake depicting segment break locations, emergent vegetation polygons, littoral zone areas containing cobble, and a summary of pertinent segment data. GIS analysis of the orthophoto delineation of shoreline features was also completed and summarized.

2.2.1 Updating the Foreshore Database

In order to prepare this report, Interior first reviewed the foreshore database containing field data collected by MoE and BC CC and addressed any inconsistencies or omissions. The following updates were made to the foreshore database following an office exercise using orthophotos and field review findings:

1. Segment 2 data was updated using a winter field assessment and orthophoto delineation results to include the bay at the southern tip of the lake. The bay itself may not have been initially included since it was likely too shallow to access by boat.
2. Segment 5 initially extended along the western from the midway point to the northern tip. This area was mainly represented by private dwellings; although, near the mid point, a substantially sized, natural, vegetated park area existed. Interior decided to identify this park area as its own segment and to appropriately update the database, which involved: describing the physical parameters for the now smaller Segment 5, adding in the park section as Segment 6, and updating the database for a new Segment 7, which was originally at the north end of Segment 5.
3. The substrates were classified to all be 'fines' during the June field assessment (high water levels). Upon field inspection under lower water conditions, it was apparent that the substrates at the mid-low water levels were more diverse than originally observed and included cobble substrates along much of the shoreline perimeter. This finding was important to document since it appeared to represent natural conditions, where sand placement (beach grooming) had not been completed and altering shoreline conditions. A new Shore Type was thus incorporated that described segments having Sand Beach at the high water mark and Cobble Beach at the low water mark. As well, the composition of the substrates (%) under low water conditions was included in the database.
4. The database was also updated to include the 'Stream Mouth' Shore Type. Although this did not include a significant area of the Wasa foreshore, it is important to fisheries values and overall biodiversity.
5. Aquatic vegetation including emergent and submergent vegetation is an important component of the shoreline since it provides valuable fish and wildlife habitat and foraging areas, helps stabilize the shoreline and acts as water purifier/filter. Aquatic vegetation was not evident during the June field review as a result of high water levels and perhaps the difficulty for boat access through the shallow littoral zone. Emergent vegetation was also not included in the orthophoto delineation completed by Terrasaurus. During the December field review (low water levels) aquatic vegetation was evident below the high water mark. This aquatic vegetation was mainly composed of grasses and/or sedges, which depending on the water levels, would be emergent for part of the year and likely submergent during other times. Areas with aquatic vegetation were delineated using field inspection results and the 2008 orthophotos. The

mapped results were used to identify the percentage of shoreline length with aquatic vegetation.

6. The riparian and upland vegetation estimates of class, stage, cover were checked and updated using the Terrasaurus orthophoto delineation results.
7. The 2008 orthophotos were used to confirm and, as necessary, to update the number of docks present in each segment. The number of docks attached to the shoreline were discerned separately from those floating further off from the shore. This is because the attached docks tend to have a larger footprint and potentially disturb the shoreline to a greater extent (i.e. vegetation).

2.3 GIS Products

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. Any errors evident in the parcel data (legal lines) may either stem from the RDEK base data or the orthophoto rectification completed by Terrasaurus.

The Sensitive Habitat Inventory and Mapping Methods (Mason and Knight 2001) and the Central Okanagan Lake Foreshore Inventory and Mapping Report (RDCO 2005) provide additional technical procedures including GPS and video data collection, data management, database development and quality control.

2.4 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 2008 field inspections.

Appendices contain the following information:

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

Appendix B. Foreshore Summary Map

Appendix C. Orthophoto Delineation Map

Appendix D. Bathymetric Map of Wasa Lake

Appendix E. List of Waterfowl and Shorebirds Observed at or Near Wasa Lake.

Appendix F. Wasa Lake Foreshore Inventory and Mapping Database

Appendix G. Segment Descriptions

Appendix H. Orthophoto Delineation Statistics

Appendix I. Digital Copy of the Wasa Lake FIM Report and Video Documentation

2.5 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, mapped results and video footage 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.

3 Results

3.1 Known Environmental Values

Wasa Lake is located in the southern interior of British Columbia in the East Kootenay Trench Ecosection (Figure 5). The Wasa Lake watershed is comprised of mainly forested (52%), private (20%) and open range or agricultural cleared lands (17%) (BC Lake Stewardship Society (BCLSS) and MoE 2008). This study reviews the foreshore perimeter of Wasa Lake, which has been calculated to be 7.4 km and is depicted in Appendix B and C.

Table 7 provides a summary of Wasa Lake's physical parameters and a bathymetric map for the lake is provided in Appendix D.

Table 7. Wasa Lake physical characteristics

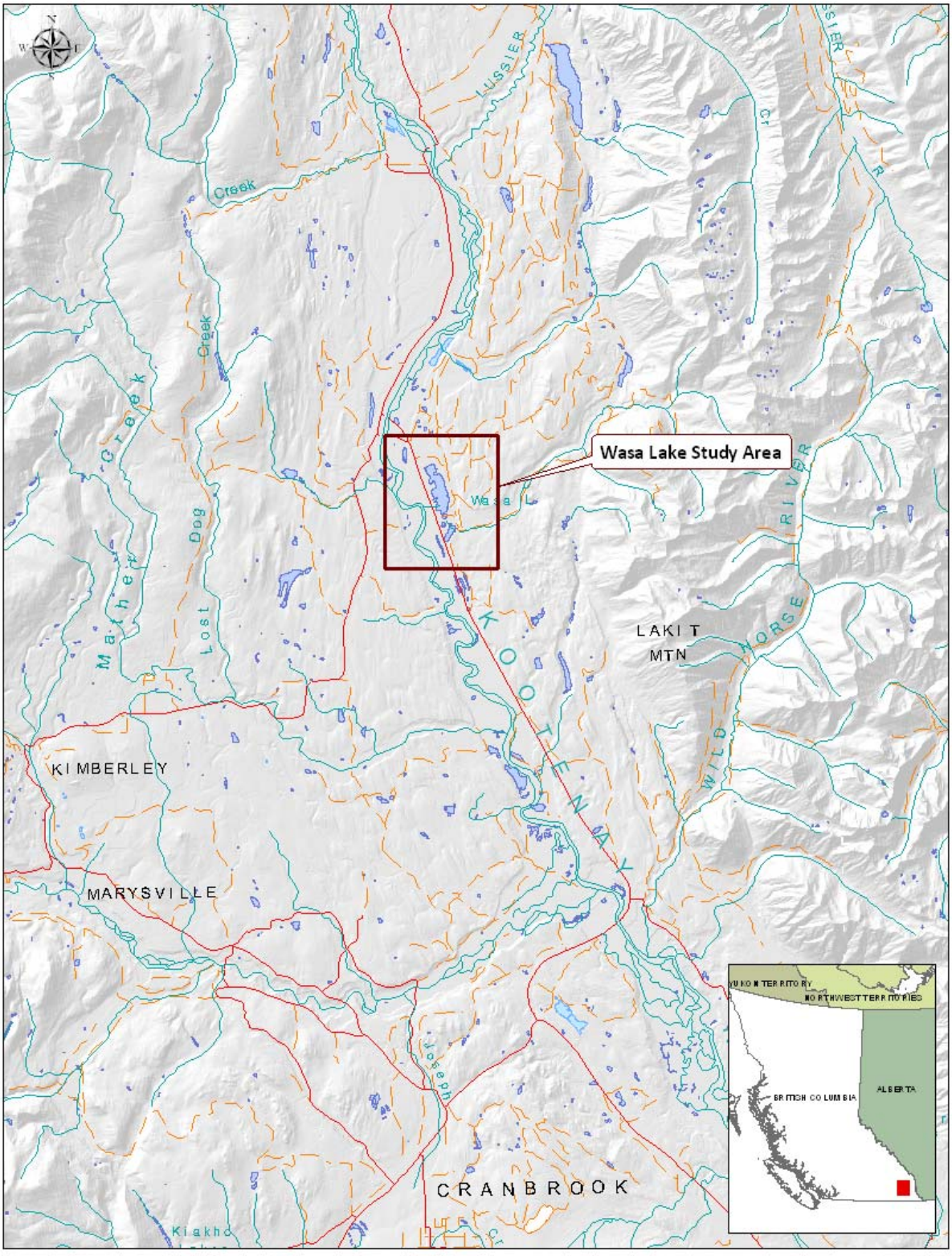
Parameter	Amount
Elevation	772 m
Surface Area	105.5 ha
Drainage	12.15 km^2
Maximum Depth	13.1 m
Mean Depth	3.8 m
Average Width	400 m
Foreshore Perimeter	7.45 km

Wasa Lake is a kettle lake that formed through glacial fluvial processes (BC Lake Stewardship Society (BCLSS) and MoE 2008). A kettle lake results when ice breaks off a receding glacier and becomes buried by glacial outwash and then melts leaving a kettle hole (Wikipedia 2008). Wasa Lake does not have continuous inlet or outlet streams (BCLSS and MoE 2008). The lake is situated below the water table and the lake levels are thus largely governed by the levels of the neighbouring Kootenay River (Baker 1987 and McArthur 2005). Lake levels fluctuate annually as a result of this hydrogeology. Water level averages for the period of 1996-2006 (WLLID 2008) indicate that lake levels alter by approximately 2 metres (7 feet) between the winter low period and the summer high period in July.

Athough limited, there are ephemeral streams (which flow briefly) in and out of the lake. Hanson Creek, located on the west shore, is known to carry flow both into the lake from the Kootenay River (during river flood conditions) and to change direction and carry lake flows out to the river with receding river levels (McArthur 2005). From the orthophotos, the Hanson Creek channel appears undefined, once it crosses under the highway and nears the Kootenay River. Terrain Resources Inventory Mapping (TRIM) reveals that there are also two unnamed creeks situated on the east shores. The flow through these creeks is uncertain, since the drainage has been disturbed; they appear to only likely provide some ephemeral flow from the mountain side during run-off periods. Lewis Creek, located at the south end of the lake, is also a tributary providing run-off flows. This creek also appears to have been highly disturbed, particularly as it nears Wasa Lake; however, the 2008 orthophotos reveal tributary outlet features, indicating that flow does enter the lake from Lewis Creek, at least during periods of spring runoff.

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

Figure 5 Overview Map of Wasa Lake Study Area



3.1.1 Water Quality

This brief summary of water quality conditions has been obtained from BCLSS and MoE (2008). The measure of time that inflow replaces the lake water volume, also known as 'flushing rate', is unknown for Wasa Lake; however, considering that there is no permanent inflow or outflow from the lake, the flushing rate is likely low. This could be a significant factor to the lake's water quality, since it suggests that the lake is susceptible to becoming more productive with time (eutrophication), as nutrients entering the lake do not get moved through very quickly. However, Wasa Lake was not determined to be eutrophic, based on water quality sampling conducted between 2003 and 2006. According to the phosphorous levels during this period, the lake is oligotrophic, meaning that it has low productivity, which is typical of clear water with low nutrient levels, sparse plant life and low fish production. The secchi depth and nitrogen levels indicated that the lake is more mesotrophic, meaning that it is more productive than an oligotrophic lake, but less so than a eutrophic lake.

LAKE PRODUCTIVITY

Oligotrophic
(Low productivity, clear, low nutrient levels, low fish production)

⬇

Mesotrophic
(Intermediate between oligotrophic and eutrophic)

⬇

Eutrophic
(High productivity, high nutrient levels, abundant plant life)

Lakes naturally become more eutrophic with time, as they age. Since Wasa Lake is naturally filtered by the surrounding sand/gravel deposits, it would be expected that euthrophication would be a slow process (Bisset pers.com.). However, since it does not receive flushing flows and anthropogenic activities are highly concentrated around it, Wasa Lake could be susceptible to accelerated aging causing negative impacts (Bisset pers. com.). This could be further accelerated with global warming, further justifying that a cautious approach to development be instilled.

Wasa Lake is known to be a warm lake. Monthly data in 2005 showed that water temperatures were around 15 ^{o}C in May and gradually climbed to a maximum of nearing 23 ^{o}C by August.

3.1.2 Plants

Wasa Lake occurs in the Kootenay Dry Hot Ponderosa Pine biogeoclimatic zone variant (PPdh2) (Meidinger and Pojar 1991). The variant is characterised by ponderosa pine (*Pinus ponderosa*) trees, up to 950 m in elevation with a mix of rough fescue (*Festuca scabrella*) and bluebunch wheatgrass (*Pseudoroegneria spicata*) with various flowering plants, including silky lupine (*Lupinus sericeus*), and round-leaved alumroot (*Heuchera cylindrical*) and other flowering plants (Grasslands Conservation Council of BC 2009). Mature stands are typically open forest savannahs, although extensive in-growth has occurred. Grasslands are found throughout the zone, though they too have been degraded through forest encroachment, overgrazing and recreational activities. The zone is fire-maintained, with historical fire-return intervals of 20 years or less (Rocky Mountain Trench Ecosystem Restoration Steering Committee 2006). Fire suppression over the past 60-plus years has contributed to both in-growth and encroachment.

The orthophoto delineation of Wasa Lake's foreshore identified six natural, coarse-level plant communities around Wasa Lake: coniferous forest, deciduous forest, high shrub, low shrub, grasslands, lawn and wetlands (Appendix C). In-growth and grassland degradation are identified as known management issues for Wasa Lake Provincial Park and a restoration plan has been drafted (MoE 2003).

Sensitive Plant Species

The BC Conservation Data Centre (BC CDC) sensitive species listings (Table 8) indicates that the Wasa Lake area is known to contain several sensitive plant species, including those that are red or blue listed and either provincially designated as critically imperiled (S1), imperiled (S2) or vulnerable (S3) (BC CDC 2008a). Lacustrine (associated with lakes) and palustrine (associated with wetlands) plants have been specifically identified in this table, since these would most likely be associated with the foreshore environment.

Table 8 Lacustrine and palustrine associated vascular plant species at risk that may occur in the Wasa Lake area.

Common Name	Scientific Name	Global Rank[1]	Prov Rank[1]	BC CDC[2]	Notes
rivergrass	*Scolochloa festucacea*	G5	S2	Red	Known from Larsen Lake and near Grasmere
slender wedgegrass	*Sphenopholis intermedia*	G5	S3	Blue	Waters edge plant known from Edwards Lake near Grasmere
obscure cryptantha	*Cryptantha ambigua*	G4	S3	Blue	Known from Butte
wild licorice	*Glycyrrhiza lepidota*	G5	S2	Red	One location in BC - Tie Lake on limey, gravelly soil
mountain sneezeweed	*Helenium autumnale* var. *grandiflorum*	G5	S2S3	Blue	Known from Wasa, beside water
western St. John's-wort	*Hypericum scouleri* ssp. *nortoniae*	G5	S2S3	Blue	Most CDC locations in west Kootenay
sweet-marsh butterweed	*Senecio hydrophiloides*	G4G5	S1	Red	Known from Flathead and Grand Forks

[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; **NR = not ranked.** A **numeric range rank** (e.g., S3S4) is used to indicate the range of uncertainty in the status of a species. Source: NatureServe (2008)

[2] BC CDC: British Columbia Conservation Data Centre (provincial element ranking organization). **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.

Sensitive Ecological Communities

Most ecological communities found in the PPdh2 are red-listed by the BC CDC (Table 9). Wells et al. (2004) examined the occurrence of various fine-scale ecosystems throughout the East Kootenay and assessed how well each is represented with respect to occurrence, management regime, protected land status and forestry activities. Their study was conducted primarily for the East Kootenay Conservation Program to identify target ecosystems and specific areas with significant conservation value. Most land at low elevations in the East Kootenay trench is private land and is often of significant conservation value.

Table 9. Ecological communities at risk found in the Ponderosa Pine Kootenay dry hot biogeoclimatic subzone variant (PPdh2)*.

English Name	Scientific Name	Global Rank	Prov Rank	BC CDC
rough fescue - bluebunch wheatgrass	*Festuca campestris - Pseudoroegneria spicata*	G4	S2	Red
ponderosa pine - trembling aspen / prairie rose	*Pinus ponderosa - Populus tremuloides / Rosa woodsii*	GNR	S1	Red
ponderosa pine / bluebunch wheatgrass - silky lupine	*Pinus ponderosa / Pseudoroegneria spicata - Lupinus sericeus*	GNR	S2	Red
black cottonwood / common snowberry - roses	*Populus balsamifera* ssp. *trichocarpa / Symphoricarpos albus - Rosa spp.*	GNR	S1S2	Red
bluebunch wheatgrass - junegrass	*Pseudoroegneria spicata - Koeleria macrantha*	G2	S2	Red
antelope-brush / bluebunch wheatgrass	*Purshia tridentata / Pseudoroegneria spicata*	G3	S2	Red

*Note: Not all of these ecological communities necessarily occur in the Wasa Lake area. Source: BC Conservation Data Centre. For ranking definitions and codes, see Table 8

Using predictive ecosystem mapping (PEM), Wells et al. (2004) identified three potential ecosystems around Wasa Lake. Most land was identified as Subxeric – submesic (Douglas-fir, ponderosa pine, bunchgrass; PPdh2/01 site series). This ecosystem has some of the lowest conservation representation in the region: 36.4% occurs on private land, only 0.7% in protected areas. It includes the driest forested sites in the region which were historically subjected to frequent low-intensity fires.

Short reaches of the foreshore were predicted to be “Subhygric PPdh2 (PPdh2/03 site series)” (Wells et al. 2004). These are wetter areas, where creeks flow into (east shore, one location in Wasa Lake Provincial Park, the other on private land) or out of (west shore in Wasa Lake Provincial Park) Wasa Lake characterized by ponderosa pine / Douglas-fir forest stands with understory of rose (*Rosa* spp.), bluegrass (*Poa* spp.) and pinegrass (*Calamagrostis rubescens*). There is little shrub component to this ecosystem type.

One location near the outlet on the west shore, within Wasa Lake Provincial Park, was identified to potentially be a very rare hygric (fluvial riparian) site within the PPdh2 (PPdh2/04 site series; Wells et al. 2004). This site series is dominated by open black cottonwood (*Populus balsamifera*) and hybrid white spruce (*Picea glauca x engelmannii*) and Doulgas-fir stands; with a greater shrub component to the understory.

Whether these last two ecosystems are actually present is unknown; since no ground-truthing has been done and hydric sites were not always predicted accurately (Ketcheson et al. 2002; Thomae et al 2002 in Wells et al. 2004). Less than 1% of both these ecosystems occurrences in the East Kootenay are within protected areas, most of which is likely Wasa Lake Provincial Park.

Grasslands

Grasslands are one of Canada's most endangered ecosystems (Fish and Wildlife Compensation Program 2008) and BC’s grasslands are known to be home to over 30 percent of the species at risk in the province (Grasslands Conservation Council of BC 2009). Making up less than one percent of British Columbia, grasslands account for over 30% of the province’s rare and endangered species (Grasslands Conservation Council of BC 2009). Remaining grasslands have been heavily altered by livestock grazing, off-road recreation, invasive exotic plants and encroachment of adjacent

forests. A northern extension of Great Basin grasslands in the United States and different from the prairie grasslands east of the Rocky Mountains, the species found in BC Grasslands are largely at their northern range limit and uniquely adapted to an often harsh environment. In the East Kootenays, there are 20 red-listed and an additional 20 blue-listed vascular plant species and six red-listed plant communities (Grasslands Conservation Council of BC 2009). However, not all of these occur at Wasa and/or they do not necessarily occur in close association with lacustrine or palustrine ecosystems.

Wasa Lake Provincial Park was designated primarily "to protect the remnant open forest, grassland and riparian ecosystems of the East Kootenay Trench" (MoE 2003). The park is situated in four separate blocks around the lake, totaling 144 ha. Although the park has areas within it designated as natural environment, other areas are managed for intensive recreation. Key attributes protected by the park are as follows (MoE 2003):

- The park provides 4% of the protected area representation to the East Kootenay Trench Ecosection, which is under-represented (0.68%) province-wide;
- It also contributes to protecting the very poorly represented PPdh2 subzone/variant biogeoclimatic zone, which only has 0.18% protected province-wide.
- A special feature of the park is the natural sand dunes riparian habitat and the endangered grassland ecosystem.

The park plan further identified that non-native invasive plants (e.g., diffuse knapweed [C*entaurea diffusa*]), forest in-growth, the lack of natural fire and the expansion of recreational activities into endangered ecosystems are management issues threatening the park landscapes (MoE 2003). These values and features do not necessarily stop at the park boundary. The orthophoto delineation for this project revealed that grassland habitats are found on adjacent private properties surrounding the lake.

Wildlife Trees

As a veteran tree deteriorates, it can support up to 80 wildlife species, or 15% of the province's birds, mammals and amphibians (BC Wildlife Tree Committee 2009). Wildlife trees provide many kinds of critical habitats including nest cavities and platforms, nurseries, dens, roosts, hunting perches, foraging sites and display stations (Backhouse 1993). Loss of this habitat is a concern for many dependant wildlife species and the most effective wildlife management practices is to retain wildlife trees (Wildlife Stewardship Program 2006). Vertebrate species known to the Wasa Lake area that are cavity nesters and that would thus utilize wildlife trees include: Lewis' Woodpecker (*Melanerpes lewis*) and several other woodpeckers, Saw-whet owl (*Aegolius acadicus*), Northern Pygmy-owl (*Glaucidium gnoma*), chickadees (*Parus* spp.), nuthatches (*Sitta* spp.), bluebirds (*Sialia* spp.) northern flying squirrel (*Glaucomys sabrinus*), red squirrels (*Tamiasciurus hudsonicus*). Wildlife trees located along foreshore, riparian habitats, deciduous patches, gullies and ravines are known to be used the most (Backhouse 1993).

Few high value wildlife trees were found around Wasa Lake (Appendix F). High value wildlife trees take a long time to generate so maintaining those present is the preferred management option. Wide diameter trees are best and these are often centuries old. Dead trees are often removed for either aesthetic or safety reasons, as well as firewood collection. The current mountain pine beetle outbreak may result in the death of mature ponderosa pine trees around Wasa Lake.

We recommend that a Wildlife Tree Assessment be completed for the foreshore. Options should be explored for maintaining as many of these trees as safely possible. It is recognized that this is a sensitive subject, given that there has historically been losses of life at Wasa Lake resulting from fallen tree(s) (Bisset pers. comm.). The Wildlife Tree Assessment should be ongoing for any trees protected, to help ensure public safety.

Aquatic Plants

As provided by BCLSS and MoE (2008), aquatic plants play an important role in the lifecycle of aquatic insects, provide food and shelter from predators for young fish and also provide food for waterfowl, beavers and muskrats. Aquatic plant species identified in Wasa Lake include (BCLSS and MoE 2008): *Carex* spp. (sedges), *Menyanthes trifoliate* (bog-bean or bugbean), *Nuphar polysepaulum* (yellow pond lily), *Potemogeton* (pond weeds, 2 species), *Potentilla palustris* (marsh cinquefoil) and *Ranunculus* spp. (buttercups, 3 species).

3.1.3 Fish

The Fish Inventory Summary System (FISS; MoE 2008) identifies that a diversity of fish species have been known to utlilize Wasa Lake. These species are listed in Table 10.

Table 10. Fish species historically recorded at Wasa Lake and Hanson Creek (MoE 2008)

Species	Scientific Name	Management Classification*	Reference Date	Stocking Data
Burbot	*Lota lota*	Wild indigenous[2]	1952	N/A
Lake Chub	*Couesius plumbeus*	Wild indigenous[1,2]	1983	N/A
Largescale sucker	*Catostomus macrocheilus*	Wild indigenous[1,2]	1983, 1960, 1952	N/A
Northern pikeminnow	*Ptychocheilus oregonensis*	Wild indigenous[2]	1983, 1960, 1952	N/A
Peamouth chub	*Mylocheilus caurinus*	Wild indigenous[2]	1960, 1952	N/A
Largemouth bass	*Micropterus salmoides*	Wild naturalized[2]	1990, 1960, 1956	N/A
Yellow perch	*Perca flavescens*	Wild naturalized[1,2]	1990, 1960,	N/A
Eastern brook trout	*Salvelinus fontinales*	Hatchery[1,2]	1983	2055 and 293 count (no dates)
Rainbow trout	*Oncorhynchus mykiss*	Hatchery[1,2]	1995, 1960	Oregon-1960 & 1995; 188 count (no date)
Threespine stickleback	*Gasterosteus aculeatus*	ID questioned-coastal species[2]	1952	N/A

*Sample location denoted as follows: [1] Hanson Creek, [2] Wasa Lake.
Resource Inventory Committee (1994) and McPhail (2007) were used to designate wild indigenous and wild naturalized species.

The fish species list indicates that five wild indigenous fish species historically inhabited the lake. These include: burbot, lake chub, largescale sucker, northern pikeminnow and peamouth chub. Burbot and peamouth chub, however, have not been reported since 1960. Lack of suitable habitat, in particular a connection to tributary flow with gravels substrates for spawning, is likely the limiting factor for many potential native fish species (such as burbot, peamouth chub and salmonid species). Lake chub, largecale sucker and northern pikeminnow; however, can spawn along lake margins and are thus more suited to Wasa Lake's habitat conditions (McPhail 2007). There have also been anecdotal accounts of bull trout in the lake, in the past; however the lake is not typical habitat for this species and these may have only accessed the lake from the Kootenay during high flows (Bisset pers. com.).

The FISS data also reports four non-native species in the lake – largemouth bass, yellow perch, rainbow trout and brook trout. Eastern brook trout and rainbow trout were hatchery stocked and being diploids, are capable of reproducing; however, it is unlikely that suitable habitat is available for spawning. Largemouth bass and yellow perch, however, have successfully established in the lake (i.e. Holmes pers. comm. and Tepper pers. comm.). These species are highly suited to the habitat conditions available. For example, they do not depend on tributary flows for spawning, and instead typically seek out littoral areas with vegetation or submerged woody debris (Thorpe 1977 and McPhail 2007). Juveniles and adults are also associated with weed beds and are suited to warm water conditions, with largemouth bass typically remaining in lake shallows until temperatures exceed 27^{o}C and perch until temperatures exceed 20^{o}C (McPhail 2007).

Current inventories of species presence and abundance are thus not known. Overall, MoE has not been stocking or managing Wasa Lake in recent years due to the presence of perch and bass, which usually have negative impacts on native species (Tepper pers. comm.). Largemouth bass, in particular are known to be efficient predators capable of eliminating native species (McPhail 2007). It is important to recognize that these species are sought by recreational fishers throughout the year (Bisset pers. comm.). They also are likely not having a large impact on native populations, since the native populations are suspected to be naturally limited (or extirpated from) in the lake. Although bass and perch are not native to the area, as a result their recreational value, agencies should consider including them in future management planning. This would include protecting important habitats and preventing spread to other areas through education. Duck Lake, near Creston, is one example of a lake that is managed for non-native fish species (Holmes pers. comm.). Another management option could be to perhaps remove these non-native species from the lake

According to TRIM mapping, Lewis Creek, located at the lake's south end, at one time flowed directly into Wasa Lake. As a likely result of land disturbances, Lewis Creek does not have an open channel to the lake; however, the 2008 orthophotos do provide a clear indication that the creek's flow is entering the lake, likely through a culvert under the road concentrating overland and/or subsurface flow. The fish values of this creek are worth mentioning because of the proximity to the lake. In addition to nearly all species listed in Wasa Lake, Lewis Creek is also reported to have: westslope cutthroat trout (*Oncorhynchus clarkii lewisi*), redside shiners (*Richardsonius balteatus*), sculpin (*Cottus* spp.) bull trout (*Salvelinus confluentus*) and pumpkinseed (*Lepomis gibbosus*) (MoE 2008). All of these other than pumpkinseeds would be considered native species to the area.

3.1.4 Wildlife Species

We searched BC's Conservation Data Centre's (2008a) online Species and Ecosystem Explorer for terrestrial species at-risk associated with lacustrine (lake) and palustrine (wetland) habitat associations (Table 11). 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. Relevant known information relating to habitat use is summarized for each species. Wasa Lake and the sloughs south of the lake are commonly viewed by local naturalists and reliable records exist of species that occur there, birds in particular (*See* Appendix E). A discussion for these listed species and others has been provided below.

Table 11 Lacustrine and palustrine associated animal species at risk that may occur in the Wasa Lake area.

Common name	Global Rank[1]	Prov Rank[1]	BC CDC[1]	COSEWIC	SARA Schedule
Pronghorn Clubtail	G5	S2S3	Blue	not assessed	na
Twelve-spotted Skimmer	G5	S3	Blue	not assessed	na
Western Grebe	G5	S1S2	Red	not assessed[2]	na
Great Blue Heron	G5	S3S4	Blue	not assessed	na
American White Pelican	G3	S1	Red	Not at risk	na
American Avocet	G5	S2	Red	not assessed	na
Common Nighthawk	G5	S4	Yellow	Threatened	not listed[3]
Lewis' Woodpecker	G4	S2	Red	Special Concern	Schedule 1[4]
Barn Swallow	G5	S3S4	Blue	not assessed[5]	na
Badger	G5	S1	Red	Endangered	Schedule 1[4]
Western Toad	G4	S4	Yellow	Special Concern	Schedule 1[4]
Rubber Boa	G5	S4	Yellow	Special Concern	Schedule 1[4]

Column acronyms: BC CDC: British Columbia Conservation Data Centre (provincial); COSEWIC: Committee on the Status of Endangered Wildlife in Canada (federal); SARA: Species at Risk Act (federal).

[1] For ranking definitions and codes see Table 8

[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.

Pronghorn Clubtail, *Gomphus graslinellus*

This blue-listed dragonfly was first observed from Wasa Lake in 1998 (Cannings et al. 2000). Initially, red-listed, it was down-listed to blue when additional occurrences were found throughout the Okanagan. Pronghorn clubtails have also been observed at Surveyor's Lake (Kikomun Creek Provincial Park; Nicholson pers. comm.); these locations are the only known occurrences in British Columbia east of Christina Lake.

Proghorn clubtails are closely associated with foreshore habitats. The larvae burrow in sand and silt of wave-washed shores, and then metamorphose slightly back from the water's edge. Adults often bask on beaches and clearings near water. Their recorded flight dates (when adults are present) range from 3 June to 20 July (Cannings et al. 2000). For management considerations, Cannings et al. (2000) note that "Marina developments, pollution from power boats and popular swimming beaches all have potential impact on larval survival."

Twelve-spotted Skimmer, *Libellula pulchella*

Libellulid dragonflies are most common around marshy lakeshores with calcareous soils. Eggs are oviposted directly into the water, preferably around submerged vegetation. The larvae are more aquatic than the pronghorn clubtail, living on muddy lake bottoms (Cannings et al. 2000). The blue-listed twelve-spotted skimmer is known from Bummer's Flats and a few other ponds in the East Kootenays, but not Wasa Lake itself (Cannings et al. 2000).

Western Grebe, *Aechmophorus occidentalis*

Western Grebes are large waterfowl who migrate through the East Kootenays, primarily in late April and early May. They are colonial nesters, with colonies near Creston and Salmon Arm. In migration they can form very large flocks (over 100 individuals) and make regular stops at 'staging lakes' to rest and feed for several days before moving on. While staging, they feed on small fish and aquatic invertebrates, while generally avoiding areas with human activity (Burger 1997). Western Grebes

are known to stage on Wasa Lake in late April to early May, staying for up to a week and may be found foraging close to shore. Western grebe diet is predominantly small fish, but also includes aquatic insects and crustaceans (Burger 1997).

Great Blue Heron, *Ardea herodias herodias*

Herons are regularly observed foraging at Wasa Lake and in sloughs and wetlands in the area. There are two Great Blue Heron nesting colonies close to Wasa Lake. One is Saugum Lake, southeast of Wasa Lake, which was last active in 2002. Another colony between Highway 93/95 and the Kootenay River, immediately west of Wasa was active, but unsuccessful in 2007 (Machmer 2008).

Herons stalk prey in shallow waters with abundant small fish (Butler 1992). Maintaining the integrity and wetland characteristics of foraging areas, such as Wasa Lake, that are close to nest colonies is especially important (Machmer and Steeger 2003). Management actions that ensure prey availability are therefore essential.

American White Pelican, *Pelecanus erythrorhynchos*

The American White Pelican is one of only four species formally listed as Endangered under the provincial *Wildlife Amendment Act*, and subject to protections under this legislation. In the East Kootenay, the pelican is an occasional migrant, staging on lakes and sloughs in late April to early May. The only known breeding colony in BC is at Stum Lake in the Fraser Plateau (BC Conservation Data Centre 2008b). There are numerous colonies on lakes in the prairies and aspen parklands east of the Rocky Mountains. Pelicans are occasionally observed on the sloughs south of Wasa and likely use the lake on occasion too.

Shorebirds

Numerous shorebird species stage on mudflats and beaches of Wasa Lake and surrounding sloughs and wetlands during spring and fall migrations (Appendix E). Spring migration occurs, approximately, from mid-April to mid-May, and south-bound fall migration occurs in mid-August to early September. Birds are found primarily on sand / mud beach and shallow water areas where they forage for aquatic invertebrates. Birds may spend up to a week in the area, depending on the weather. Shorebirds are typically small to medium-sized birds that may occur alone (e.g. Semi-palmated Plovers, dowitchers) or in large flocks. Red-listed American Avocet (*Recurvirostra americana*) is an occasional migrant in the East Kootenay and known to nest near Creston.

Common Nighthawk, *Chordeiles minor*

The Common Nighthawk was recently listed by COSEWIC as Threatened (COSEWIC 2007). The species is undergoing extended consultation for addition to Schedule 1 under *The Species at Risk Act*. A decision is expected in spring of 2009 (Canadian Wildlife Service 2008). Critical habitat (as defined by SARA) has not yet been designated.

Nighthawks are known in the Wasa area, arriving in late May to early June (Campbell et al. 1990). Nests are built directly on the ground in wide array of habitats including: beaches, pasture, open forest, lakeshores, gravel roads, river banks, railways, airports and flat gravel rooftops. (COSEWIC 2007 and references therein). Incubation lasts 16 to 20 days and nestlings remain in or near the nest until late August (COSEWIC 2007 and references therein). Large flocks of nighthawks congregate post-fledging prior to southward migration in late summer. Most nighthawks have migrated south by mid-September.

There is a low probability of nighthawks nesting on the Wasa Lake foreshore; however, they may nest in the area. As aerial insectivores, they may feed on air-borne insects which have emerged from aquatic larvae and as a federally listed species, they merit discussion and management concern.

Lewis' Woodpecker, *Melanerpes lewis*

Lewis' Woodpecker is a migratory bird present in the East Kootenays from late April until early September (Cooper et al. 1998). They excavate cavities in large dead or decaying trees in open ponderosa pine forests, open riparian woodlands and recently burned forests (Cooper et al. 1998). Fire appears to play a key role in the creation and maintenance of Lewis' Woodpecker nesting habitat (Cooper and Beauchesne 2000; Cooper and Gillies 2000). A reliable source of insects for food is also necessary.

Suitable nesting and foraging habitat exists for Lewis' Woodpecker immediately adjacent to Wasa Lake and they are historically documented in Wasa, TaTa Creek and Skookumchuk Prairie (Cooper et al. 1998). However, in 2007 the closest active nest was at Bummer's Flats and previously used (and still apparently suitable) nest sites were abandoned (Beauchesne and Cooper 2007).

Swallows

Several species of swallow are known in the Wasa Lake area (Table 12; Campbell et al. 1997). Only Barn Swallows are provincially blue listed (BC Conservation Data Centre 2008a) and will soon be assessed by COSEWIC. However, most swallows have suffered major declines across North America. For example, Bank Swallows have had statistically significant annual declines of 7.5% from 1986 – 2006 in Canada, based on breeding bird survey data (McCracken 2008). Lacustrine habitats are an important aspect to swallow ecology, as they regularly forage over lakes, hunting aerial insects which hatch from aquatic larvae.

Raptors

Several raptor species occur in the Wasa Lake area, including Bald Eagle (*Haliaeetus leucocephalus*) and Osprey (*Pandion haliaetus*). Other possible species nesting nearby include Cooper's Hawk (*Accipiter cooperii*), Sharp-shinned Hawk (*Accipiter striatus*), Red-tailed Hawk (*Buteo jamaicensis*), Merlin (*Falco columbarius*) and American Kestrel (*Falco sparverius*). Most of these species build large, highly visible stick nests in trees or atop human-constructed poles (e.g. power lines). Golden eagles (*Aquila chrysaetos*) are regularly observed during spring and fall migration (Bisset pers. comm.). Rough-legged hawks (*Buteo lagopus*) are regularly observed over-wintering in the area, though not necessarily along the Wasa Lake foreshore.

Table 12 Swallow species known or likely to occur at Wasa Lake, BC, the type of nest each constructs and characteristics of breeding colony. Source: Campbell et al. (1997).

Swallow species	*Nest type*	*Colonies*
Barn, *Hirundo rustica*	Open cup mud nest usually built on human structures	Loosely colonial
Cliff, *H. pyrrhonota*	Enclosed mud nest on cliff faces or human structures	Highly colonial
Bank, *Riparia riparia*	Excavates burrows in bank / cliff faces of silt, clay or sand with very specific soil stability requirements.	Highly colonial
Tree, *Tachycineta bicolor*	Cavity nester – trees, cavities, crevices, rarely on vertical faces	Primarily solitary
Violet-Green, *T. thalassina*	Primarily cavity nester, occasionally on cliffs; highly adaptable	Primarily solitary, but will form substantial colonies.
Northern Rough-winged, *Stelgidopteryx serripennis*	Burrows in banks, occasionally in cliff crevices. Rarely excavates its own burrow, relying on Bank Swallows and kingfishers.	Primarily solitary, occasionally colonial, sometimes associated with Bank Swallows

Bald Eagle nesting begins in April, with young usually fledged by late July (Campbell et al. 1990). Ospreys arrive soon after the lake is ice-free, with nesting beginning in late April. Young are fledged by late July (Campbell et al. 1990). The other raptors listed above have similar nesting periods, but are not necessarily associated with foreshore or riparian habitats.

Bald Eagles and Osprey are known to nest in the area. A Bald Eagle pair has a nest on the east shore of Cameron Slough, located just beyond the south end of the lake (Machmer 2008), and are regularly observed around Wasa Lake proper. Bald Eagles are both hunters and scavengers, often feeding on dead fish at the lake shore. Ospreys also nest nearby (though not necessarily adjacent to water) and regularly feed on live fish from Wasa Lake. Both these species are highly visible, recognizable to most residents and visitors and likely highly valued.

Raptor nests are relatively easy to locate: the nests are large, the adult birds are conspicuous and, except for incubation, they are noisy and often aggressively defended. As with most birds, raptors are protected by the *Wildlife Act* (s.34) and sub-section 34(b) provides year-round protection to nests of Bald Eagle, Osprey and selected others, regardless of whether the nest is active.

Badger, *Taxidea taxus jeffersonii*

Badgers are mid-sized fossorial carnivores. Traditionally considered an upland species, research in the East Kootenay (Newhouse and Kinley 2001) has found badgers to maintain exceptionally large home ranges (males average 70 km^2) which suggests they must regularly encounter foreshore areas. In the East Kootenay, badgers' primarily prey on Columbia ground squirrels (*Spermophilous columbianus*), but will feed on a variety of species including aquatic species, including spawning fish (e.g. suckers; Newhouse and Kinley 2001; Messick 1987).

Fine scale habitat associations include glaciofluvial, fine sandy-loam textured and well-drained soils on south-facing slopes (Apps et al. 2002). Numerous sightings of badgers and burrows have been documented in and around Wasa Lake, including the provincial park day-use area on the east shore near the campground (Kinley pers. comm.). Apps et al. (2002) rate the area at a coarse scale as 'better' and 'best' badger habitat. Figure 6 provides further support of badger habitat use and suitability in the Wasa Lake area by depicting data synthesized by the FWCP (2008) of badger sightings between 1968 and 2002, tracked movements obtained during radio telemetry studies from 1996-2005 and habitat suitability analysis results. Updated badger habitat modeling is in progress but not yet available (Kinley pers. comm.).

Amphibians

At some point in their life cycle, all amphibians require a reliable water source. Most require at least a moist environment for much of their lifespan and are incapable of surviving in hot, dry environments. As such, the upland forests and grasslands around Wasa Lake are not particularly hospitable to amphibians and residents report that amphibians have not been abundant in the area for the past 30 years or more (Ohanjanian 2000). An amphibian survey of Wasa Lake in 2000 (Ohanjanian 2000) found the only amphibian species present to be western toad (*Bufo boreas*). This species is federally listed as a species of "Special Concern", but not considered at risk provincially (Table 11). Only 2 individual toads were observed, a recently metamorphosed toadlet in the south bay of Wasa Lake and one adult on Wasa Lake Drive near Birch Rd. Ohanjanian (2000) suggested that the "exceedingly low" numbers of both amphibians and aquatic insects suggest "this ecosystem is not functioning well." Other amphibian species that may be expected to be in the Wasa Lake area include: Columbia spotted frog (*Rana luteiventris*), Pacific treefrog (*Hyla regilla*) and long toed salamander (*Ambystoma macrodactylum*). Red-listed and federally endangered northern leopard frogs (*Rana pipiens*) were re-introduced to Bummer's Flats south of Wasa in 2003. There are no known historic records of them at Wasa Lake proper and the lake is not currently a priority site for future re-introductions (Adama pers. comm.).

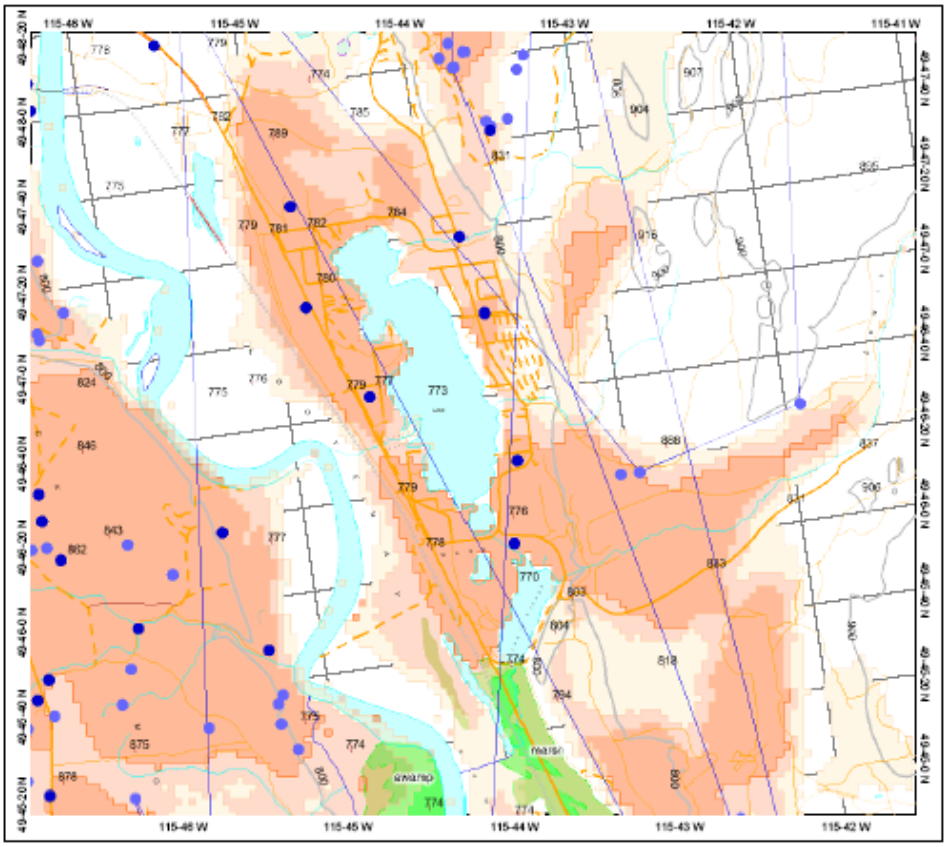


Figure 6. Wasa Lake area badger sightings (dark blue dots), radio telemetry (light blue lines and dots) and habitat suitability (shaded area; with darkest salmon colour representing high suitability, light pink is medium and yellow is low). Source: FWCP 2008.

Snakes

The only snake listed 'at-risk' that may possibly occur in the Wasa Lake area is the rubber boa (*Charina bottae*). Rubber boas inhabit a wide variety of habitats, including riparian, grassland and montane forest areas (COSEWIC 2003 and references therein). They spend up to 25% of their time underground (St. Clair 1999) and seem to require coarse woody debris or other similar structures as protective and thermoregulatory cover. While there are no known records of rubber boas from Wasa Lake, they do occur in the East Kootenay region (BC Conservation Data Centre 2008a).

Other snake species known from the East Kootenays also have close associations with wetland and wet habitats (e.g. western terrestrial garter snake (*Thamnophis elegans*) and common (or red-sided) garter snake, *T. sirtalis*). In cold climates such as this, snakes are often limited by access to hibernacula for over-wintering. Best management practices (BMPs) for garter snakes in BC (Ovaska et al. 2004) recommend access to wetland foraging areas. Maintaining good herbaceous cover in the foreshore area is very important for western terrestrial garter snakes who, despite their name, are very aquatic and seldom found far from water (The Reptiles of BC 2008).

3.2 Physical Data Summary from 2008 Field Reviews

In total, 7,454 m of foreshore was surveyed and divided into 10 contiguous segments. The segments ranged in length from 202 m to 1281 m. GIS maps showing segment locations and key segment information are provided in Appendix B, the database of all physical findings are provided in Appendix F and detailed descriptions of each segments are located in Appendix G. Natural vs. disturbed areas, land use, foreshore type, modifications along the foreshore and level of impact are reviewed in detail in order to provide an inventory of the foreshore condition.

Land Use and Disturbance vs. Natural

Land uses on areas adjacent to the foreshore of Wasa Lake are residential (66%) and park (34%). Segment 1 is the only anomaly, since approximately 25% of its foreshore is designated as a regional park (Crown Land Use); however, in this study this entire segment was considered residential, because the regional park section was a narrow band and it has been impacted by adjacent residential land uses including beach grooming, dock placement and dredging.

Overall, results indicate that more than half (60% or 4,492 m) of the foreshore is disturbed and that 40% (2,963 m) is in a natural condition (Table 13). The extents of natural and disturbed foreshore for each segment as well as the associated land use are depicted in Figure 7. Using these findings, it has been calculated that the shoreline is made up of approximately 6% residential land which is in a natural condition, 54% residential land which is disturbed, 28% natural park land and 6% disturbed park land.

Table 13. Wasa Lake shoreline condition (natural vs. disturbed) and land use summary.

Foreshore		Length (m)	% of total
Total Shoreline	Natural	2963	40%
	Disturbed	4492	60%
Land Use Summary	Residential	4900	66%
	Park	2554	34%
Shoreline Condition by Land Use	Natural Residential	886	12%
	Disturbed Residential	4013	54%
	Natural Park	2076	28%
	Disturbed Park	479	6%
Total Foreshore		7454	100%

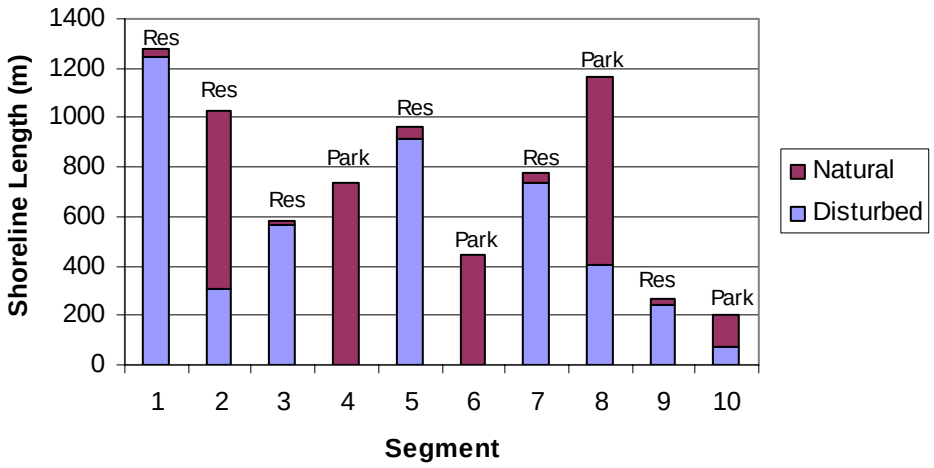


Figure 7. Extent (m) of natural and disturbed shoreline and associated land use (Res. = Residential, Park = Provincial Park) for each segment.

A total of 82%, or 4013/4900 m of the residential shoreline length has been calculated as being disturbed. The one exception is Segment 2, located at the north end of the lake, which has approximately 70% of it's foreshore in a natural condition, despite being classified as residential land (typed as both semi-rural residential and residential in the local RDEK bylaw (2007)). Development is likely limited in this segment by floodplain restrictions.

Of the four park properties, Segments 4 and 6, located on the west side of the lake, are completely intact, while Segments 8 and 10, located on the south and east side of the lake, have been disturbed along approximately 35% of their respective lengths. Although disturbances observed will be discussed in later sections; the disturbances in the park properties are a result of management for recreational uses (e.g., beach access, beach grooming).

Shore Type

The foreshore of Wasa Lake is diverse containing sand/cobble beach, vegetated, sand beach, wetland, 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 8. The foreshore is dominated by the sand/cobble shore type which is sand beach at the high end of the shoreline and cobble beach at the lower end (2648 m or 36%). Vegetated and sand beach shore types also make up substantial lengths of the shore (2169 m and 1897 m) respectively, while wetland and stream mouth shore types make up the smallest lengths of foreshore (703 m and 37 m respectively). Figure 9 provides detail on how these shore types are distributed within each segment.

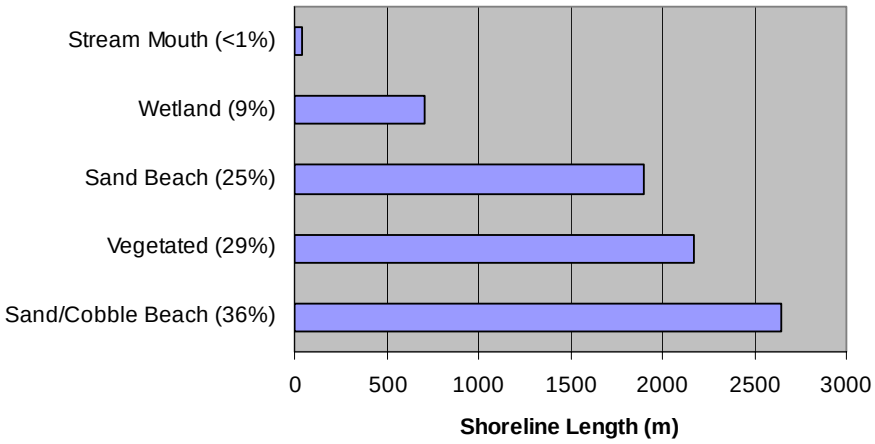


Figure 8. Total length (m) and percentage (%) of each Shore Type along Wasa Lake.

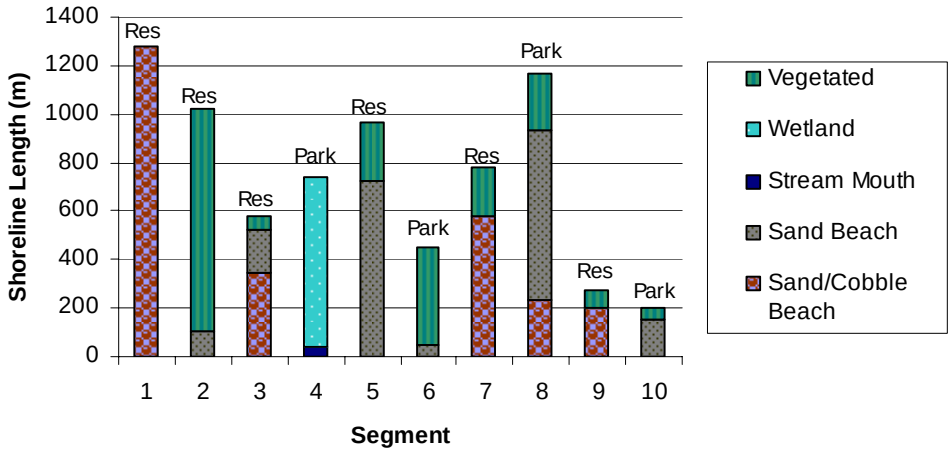


Figure 9. Shore Type and extent (m) for each segment along the foreshore of Wasa Lake.

Some additional observations from the field review relating to the shore type findings are as follows:

- The Sand/Cobble Beach Shore Type was not evident during high water levels, but at low water levels appeared prevalent in many segments around the lake (Figure 10). This was considered an important shore type to distinguish, particularly because many, but not all, of the areas where the Sand Beach Shore Type were found, were anticipated to likely have been the result of extensive beach grooming (sand placement) primarily for recreational purposes. The placement of sand appeared in both park and residential segments and will be discussed in the following section.

Figure 10. Segment 1, showing extensive sandy beach at high water, however, this area was extensively covered with cobble substrate at lower water levels.

- Although Segment 6 was classified as a Vegetated Shore Type, substantial sections of cobble were identified along the shoreline at low water levels, and at high water levels (as evidenced through the orthophotos) (Figure 11). In this location, there were two overlapping shore types and it was decided that the intact vegetation along the shoreline was the significant feature for classification.

Figure 11. Cobble shoreline following the base of the Vegetated shore type of Segment 6.

- Grassland areas and open forests with grassland understory were observed in several segments around the lake, including Segments 2, 8, 9 and 10. These included open ponderosa pine forest containing a grassy understory (e.g., Segments 8 and 10) as well as grassy fields without the mature conifers (Segment 2). Segment 9 also had sections of grassland which had not yet been impacted by development. These were classified in with the Vegetated Shore Types. Appendix C provides the orthophoto delineation completed by Terrasaurus, delineates grassland features around the lake.

Figure 12. Ponderosa pine open forest in the riparian and upland areas of Segment 8.

Foreshore Modifications

Shoreline modifications along Wasa Lake included retaining walls, docks, groynes, boat launches, road access points and beach grooming/sand placement. Riparian and upland vegetation removal were other anthropogenic modifications; these will be discussed separately below in their own section. From Figure 13, it is evident that the greatest numbers of structures were docks (84). There were three each of retaining walls, groynes and boat launches. Road access points accounted for ten modifications along the foreshore; however, many of these were included in the boat launch count. The figure also provides the percent of foreshore estimated to have experienced beach grooming, which involves mass removal of vegetation and/or sand placement, in parentheses, for each segment.

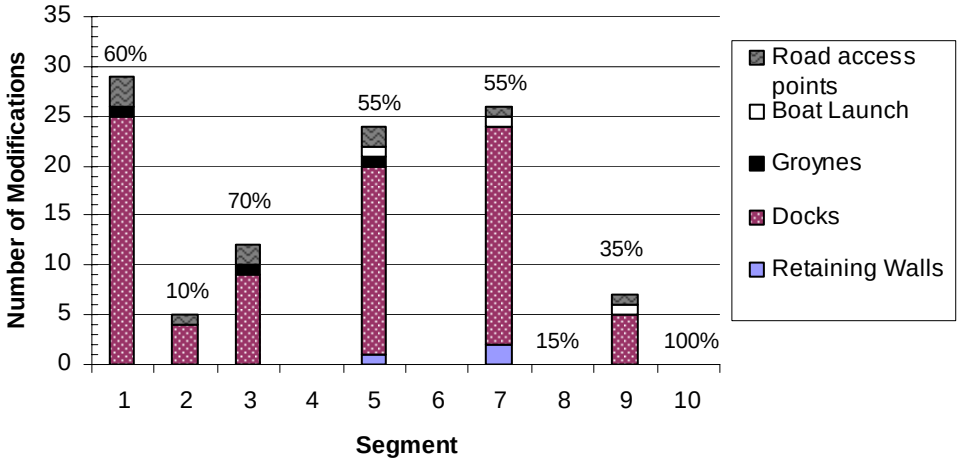


Figure 13. Segment modifications, and in parentheses, estimated percentage of segment length that has had beach grooming at Wasa Lake.

Considering all segments, 36% of the total foreshore length was estimated to have been beach groomed. Substantial beach grooming (>50%) has occurred in the residential Segments 1, 3, 5 and 7, and the park-Segment 10. Figure 14 provides beach grooming examples from sites in Segments 1 and 5. The photos clearly depict the “grooming line”, showing the contrast of the sandy or unvegetated beaches up against the vegetative features of the neighbouring shoreline, which in the case of the left photo is a park in a natural state (Segment 4). Maintaining a natural vegetative cover is preferable, and this has been done in some cases, while allowing for recreational use of the beach (Figure 15). In this photo, the dock has been placed at the low water mark and the vegetation and substrates higher on the shoreline were left intact.

Figure 14. Examples of beach grooming: vegetation has been removed and sand has been placed along the shoreline of Segment 5 (left), and vegetation has simply been mowed in Segment 1 (right),

Figure 15. Example of dock attached to the shore at the low water mark where beach grooming was not evident in Segment 7.

The number of docks per kilometer of shoreline was calculated since docks, along with beach grooming, were the prevalent modifications observed (Figure 16). The greatest dock densities were found in Segment 7 (28 docks/km). High dock densities were also seen at Segments 1 and 5 (both 20 docks/km), Segment 9 (19 docks/km) and 3 (16 docks/km).

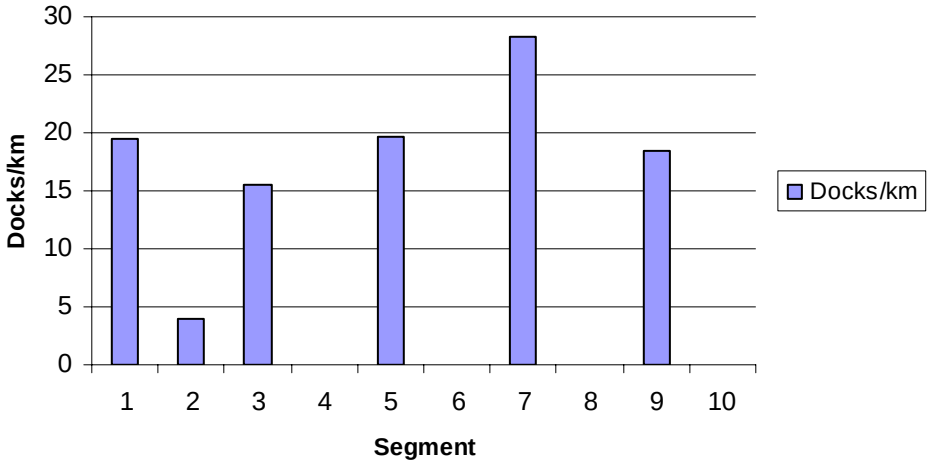


Figure 16. Number of docks per kilometer for each of the shoreline segments.

Although, not part of the database, dredging was another modification observed at a few locations around the lake (Segments 1 and 3). Figure 17 depicts a location on Segment 1, which has been dredged in order to allow access up from the shoreline to a dock. This dredging, consequently, appears to have occurred on Crown Land zoned as P-2 Parks and Open Space (RDEK 2002).

Figure 17. Example of area that was dredged in order to allow access to a dock in Segment 1.

Aquatic Vegetation

The orthophoto delineation data set created by Terrasaurus was updated in ArcGIS to identify aquatic vegetation evident at low water levels (Appendix C). Species identification was not completed, but this aquatic vegetation appeared to mainly be grasses and herbs, as shown above in Figure 17. A small area of emergent bulrush and cattail vegetation was also identified on the northern shore of the provincial park in Segment 4 (Figure 18). The majority of the aquatic vegetation was likely submerged during higher water levels and they would have become emergent with lowering water levels. This vegetation is anticipated to be beneficial in many ways by providing: bank stability, a filtering agent for nutrients and potential toxins, habitat for fish and wildlife, and foraging opportunities (either directly or through related invertebrate production).

Figure 18. Isolated location of bulrush and cattail evident along Segment 4

Percentage of shoreline length with aquatic vegetation is provided in Figure 19. Since modifications to the substrates (such as placement of sand and vegetation removal) would have an impact on natural shoreline vegetation, the extent of substrate modified was also depicted. From this data, it is evident that generally where substrate modifications have been low, aquatic vegetation was high, such as in Segments 2, 4, and 9. It appears that as the degree of substrate modification increased, the aquatic vegetation became less. The total shoreline length with aquatic vegetation was estimated to be 52%.

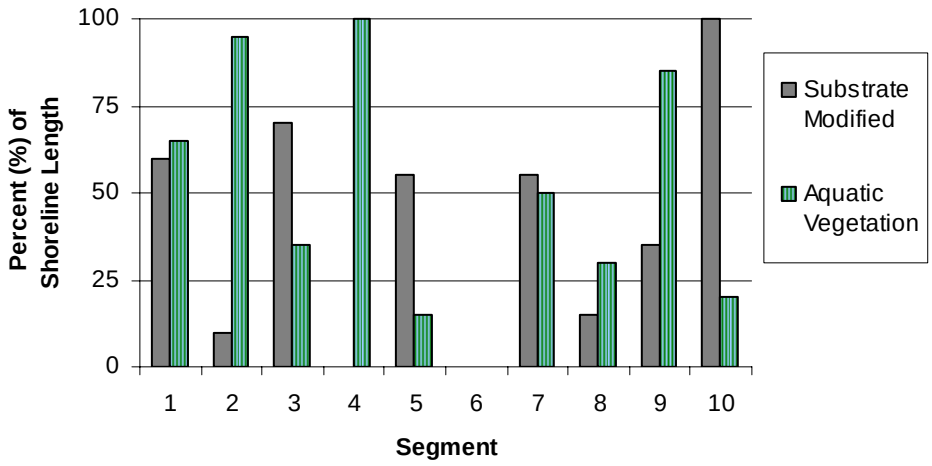


Figure 19. Percent of shoreline length with modified substrates and aquatic vegetation.

Riparian and Upland Vegetation

The FIM database reveals that the riparian and upland areas have also experienced anthropogenic disturbances. Although the extent of vegetation disturbance has not been quantified, the segment details reveal similar results as for aquatic vegetation, where residential development has generally resulted in vegetation loss. For instance, Segments 1, 3, 5, 7, 8, 9 and 10 all had moderate to high levels of disturbance and riparian vegetation data which reported mainly exposed soils with some sparse coverage with herbs/grasses. Meanwhile, the less disturbed (Segment 2) and natural segments (Segments 4 and 6) all had abundant riparian vegetation coverage with herbs/grasses or wetland vegetation. There were also few riparian veteran trees or snags observed.

Similarly, upland vegetation, which was assessed to a distance of approximately 45 m, appeared to be impacted by the residential land uses which often included some degree of landscaping and clearing activity. Generally the upland of the less disturbed segments had higher coverage with the mature Ponderosa Pine / grassland vegetation and less lawn. This will be further depicted in the following section.

Summary of Foreshore Modification Impacts

Modifications appear to be converting the physical nature of the lake to sand beach from more diverse shore types such as vegetated and sand/cobble. Figure 20 provides an overview of properties along a part of Segment 3, which exemplify how modifications such as landscaping and beach grooming appear to have impacted the natural shoreline. In this photo, the properties on the north and south ends are evidenced to have been landscaped, beach groomed and have had other modifications (i.e., docks and possible dredging). On these properties, many of the natural features are no longer visible. The central property, however, showed minimal impacts on the shoreline, since it was setback and had limited modifications. As a result, the central property showed extensive area with riparian vegetation (grassland) and aquatic vegetation and cobble substrate in the littoral area. The sand placement on the beach (beach grooming) of the outlying properties appeared to result in loss of natural vegetative and structural features, which are important for biodiversity, aesthetics and water quality. It is important to note that in some locations, (e.g., Segment 6 which is unmodified) some features such as aquatic vegetation, do not exist naturally, as a result of shoreline morphology. An orthophoto review of features for neighbouring, unimpacted properties tends to identify what the natural conditions of a segment once were. This assessment was qualitative, and a thorough quantitative analysis of these relationships was not completed under this project.

Figure 20. Overview of properties along Segment 3, showing area where the natural shoreline features were kept intact (low impact area) against adjacent properties where development has substantively altered the shoreline.

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. Figure 14 provides a summary of the LoI ratings for Wasa Lake, and reveals that 52% (3,876 m) of the foreshore was determined to have a High LoI, 32% (2,392 m) a Medium LoI, and 16% (1,187 m) a Low LoI. The Segments 1, 3, 5, 7, and 9 were rated as High LoI and as indicated in earlier results included all the residential segments other than Segment 2, which has not been fully developed. The Moderate LoI includes Segment 2, and the Provincial Park Segments 8 and 10 that are highly used for recreational activities and have subsequently had some degree of beach grooming and vegetation alteration. The Low LoI Segments were only those Provincial Park Segments 4 and 6, which appear to have been set aside for biodiversity and protection of habitat. Photos of segments representing each of these LoIs at Wasa Lake are provided in Figures 21 - 23.

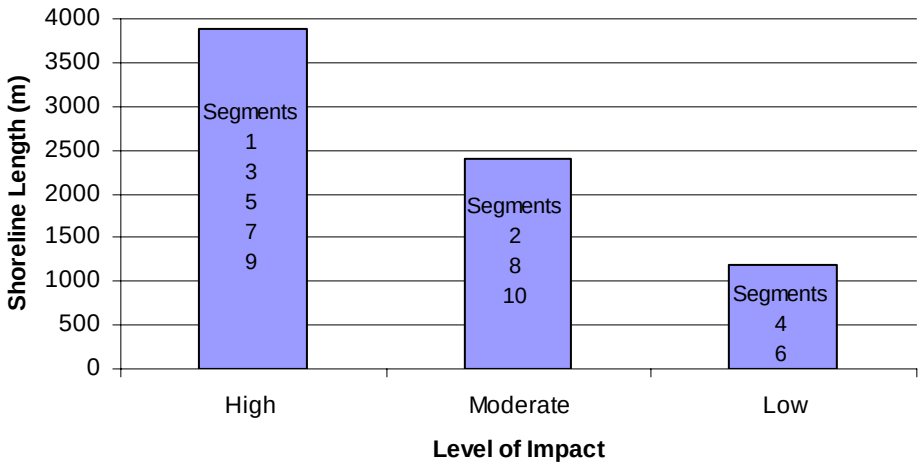


Figure 21. Segment level of impact (LoI) rating (High = >40%, Moderate = 10-40% and Low = <10%) and total shoreline length (m) attributed to each of the LOI ratings.

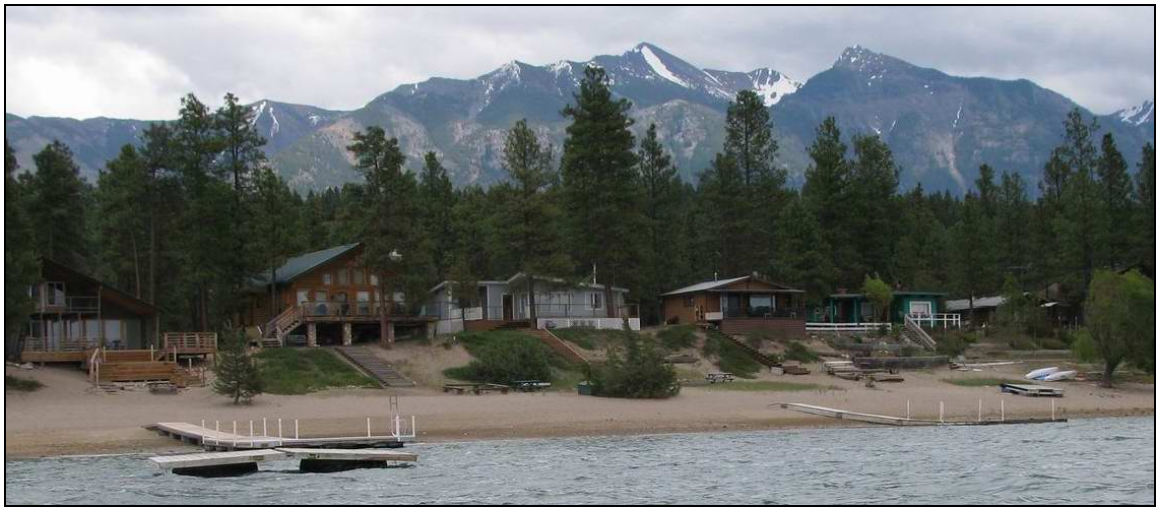


Figure 22. High Level of Impact example (Segment 1), showing how development has impacted most of the shoreline.

Figure 23. Moderate Level of Impact example (Segment 2), showing how development has impacted approximately 30% of the shoreline.

Figure 24. Low Level of Impact example (Segment 4), where the wetland shoreline features are undisturbed and protected as a Provincial Park.

3.4 Orthophoto Delineation Statistics

Key foreshore and upland features around Wasa Lake were delineated by Terrasaurus using the July 2008 orthophoto's and results are mapped in Appendix C. Delineation occurred to a distance of approximately 100 m upland from the low water mark and included eight vegetative features ranging from coniferous through to wetlands as well as roads, trails and man-made structures. Interior professionals conducted the field inspection of Wasa Lake in December with the Terrasaurus delineation product in hand. From this inspection, it appeared that the delineation and mapping was quite accurate and true to on the ground conditions. Interior updated the GIS data set by digitizing the extent of aquatic vegetation evident at low water levels. A spatial analysis was also completed, summarizing the orthophoto results by segment and is provided in Appendix H. Table 14, below, provides summary statistics for the whole delineated lake perimeter area.

Table 14. Summary of orthophoto delineation statistics for the Wasa Lake riparian and upland area.

Foreshore Class	Total Area	
	m	%
Coniferous	134,929	18
Deciduous	1,983	<1
Aquatic Vegetation	56,909	7
Grassland	264,328	34
Lawn	36,277	5
Man-made structure	40,184	5
Mixed forest	25,421	3
Road (paved)	47,151	6
Road (unpaved)	16,689	2
Sand	61,104	8
Sand/Grass	37,483	5
Shrub (high)	17,373	2
Shrub (low)	16,230	2
Stream	2,272	<1
Trail	3,265	<1
Wetlands	7,442	1
Grand Total (m^2)	*769,042*	100

From this table it is evident that considering foreshore, riparian and upland areas, grassland accounts for the highest vegetative coverage (34%), followed by coniferous forest (18%). The remaining parameters account for 10% or less coverage. The riparian and upland vegetation information in the FIM database (Appendix F) was improved (i.e. greater detail provided) using the orthophoto delineation results for each segment.

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 along the foreshore. 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, in their Foreshore Inventory and Mapping report for Central Okanagan Lake (RDCO 2005), provided the following synopsis of difficulties faced with providing protection to the foreshore:

> *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. These challenges often lead to further frustration by landowners, developers, and government staff alike. Foreshore ecosystems continue to be the subject of development pressure, which further compromises ecosystem function. The lack of comprehensive information on foreshore ecosystem relationships makes foreshore management difficult.*

Wasa Lake has experienced many of these management issues, particularly in relation to protection of habitat and related enforcement by governing bodies (*See* Introduction). The two reported examples point to violations of the *BC Water Act* following the addition of sand to the beach area, which resulted in foreshore degradation and no imposed penalties (West Coast Environmental Law 2007). WLLID would like to see improved regulatory management aimed at foreshore protection (Ashmore pers. com). 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 species dependant on the foreshore of Wasa Lake and examples of human-induced alterations to the foreshore.

4.1 State of Wasa 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 2001).

The literature review of environmental values identified that the foreshore (and adjacent upland areas) of Wasa 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: seven plant species, two invertebrate species (dragonflies), seven bird species and one mammal. As well, there are potentially three sensitive grassland and open forest ecosystems in the area. Maintaining functioning habitats for these species is considered important both now and into the future. McArthur (2005) supported this by outlining that climate change models suggest that the sloughs, located at the south end of the lake, will be compromised due to reduced flow, affecting wildlife resources and increasing the importance of available habitat at Wasa Lake. He predicted that Wasa Lake may not be as greatly influenced by climate change, since it receives its water from

the Kootenay River, whereas the snowmelt from Lewis Creek contributes to the water levels in the sloughs.

The physical analysis of Wasa Lake's foreshore revealed that the lake levels are dynamic (high in the spring/summer and low in the fall/winter) affecting the visible habitat along the shoreline. The most prevalent shore type observed was the sand beach (high end of shoreline) /cobble beach (low end of shoreline) (36%). Vegetated and sand beach shore types also covered substantial areas (29% and 25%, respectively); while wetland and stream mouth shore types were minimal (9% and <1%, respectively). Aquatic vegetation was observed along the upper end of approximately 52% of the shoreline. The aquatic vegetation was composed of mainly grasses which were submerged during high water periods and emerged/on dry ground during lower water periods. The vegetation of natural or less disturbed shoreline areas was herbs/grasses, and for many segments, these transitioned to ponderosa pine/grassland ecosystems through the riparian and upland zones.

Over half (60%) of the lake's foreshore area was found to be disturbed through anthropogenic alterations. The alterations were mainly the result of residential land use activities (54%), while some of the disturbances were associated with park areas managed for recreational uses (6%). In the littoral zone (waters edge to where sunlight could penetrate) and the shoreline zone (water's edge), the most prevalent modifications were dock placement and beach grooming (conversion to sand beach through sand placement and/or removal of shoreline vegetation). Higher up the foreshore, disturbances to the riparian and upland vegetation areas included conversion to lawns and other landscaping activities which often resulted in only patches of natural vegetation on properties.

As was found at Okanagan Lake (RDCO 2005) and Windermere Lake (McPherson and Michel 2007), foreshore modifications along Wasa Lake tend to be similar for adjacent properties throughout the study area, especially in residential areas. Neighbours typically conduct similar activities that impact the foreshore (Coopper pers. comm.) This was particularly evident at Wasa Lake, where for instance, placement of a dock and beach grooming were typical of many residential and properties. These activities pose a special challenge to management groups such as WLLID and regulatory agencies when dealing with precedence, consistency, and the manner in which development and redevelopment are viewed and managed.

In the High LoI segments (Segments 1, 3, 5, 7, and 9), dock densities ranged from 16 docks/km to 28 docks per km. These densities are considered quite high. In comparison, a similar study on Windermere Lake found the highest dock density to be 12 docks/km for a highly developed segment (McPherson and Michel 2007). Docks along the lakeshore, particularly in high densities, have the potential to degrade sensitive freshwater habitats by changing the lakebed and water column, shading vegetation, introducing pollutants from motors and causing damage from boat propellers (MoE 2006). Construction of docks may also cause sediment and contaminants to enter the water column where they may interfere with rearing fish and insects, plants and algae. The Best Management Practices for Small Boat Moorage (MoE 2006) provide guidelines to ensure proposed docks protect water quality and aquatic shoreline habitat.

Beach grooming at Wasa Lake was estimated to have occurred along 36% of the shoreline and appeared to impact the shoreline diversity through a reduction of riparian, shoreline and aquatic vegetation and cobble substrates in the littoral zone. Fisheries and Oceans assessments completed on Kootenay Lake which compared fish use over various substrates (fines, cobbles, boulder and large woody debris/macrophyte) provided additional insight to effects of altering the substrate habitat (MacDonald pers. comm.). The fish species observed during the Fisheries and Oceans study were kokanee, rainbow trout, whitefish and non salmonids (sculpins, suckers and redside shiners). In reviewing fish utilization at a site where a portion of the cobble substrate was groomed to make a sandy beach with the cobbles piled into a small groin, fish abundance was found to be greater over the cobble and groin structures; as well, non-salmonids showed the greatest diversity in species, lifestage and habitat use over the cobble substrate. The results also revealed that abundance and diversity of fish was low at the altered site compared with sites with natural complex habitats. Fisheries and Oceans have developed Beach Grooming Guidelines for Kootenay Lake

and other lakes deemed appropriate (Fisheries and Oceans 2003). Examples of provisions provided within the Beach Grooming Guidelines are that: beach grooming could only occur in areas of fine or boulder substrates and not cobble, large woody debris or macrophyte (aquatic vegetation) substrates; beach grooming may be allowed on only a small proportion of the frontage (e.g. 10%) as long as habitat features are added to the remaining area; and that the natural substrates are to be loosely sidecast to adjacent non-groomed area and not placed over cobble, large woody debris or macrophyte substrates.

Provincial and federal agencies have worked together to develop other policies to protect and improve foreshore environments. The 'Shore Primer' produced by Fisheries and Oceans (2008) is one such valuable guide available to the public, which outlines foreshore values and suggested development approaches. Suggestions for landowners provided in this guide that relate to modifications observed at Wasa 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.
- Do not cover the area with sand - as the sand erodes, it will smother spawning areas, bury invertebrates (e.g., mayflies, club tail dragonflies) in their burrows and cover 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.

The simplest way to keep the littoral zone functioning is to leave it as natural as possible. A few good examples may initiate a trend of leaving the foreshore more natural, and of designing modifications in a more environmentally sensitive manner. Residents need to be made aware that many of 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.

4.2 Foreshore Protection and Restoration

Agencies that supported this study, including WLLID, have indicated that protection of biodiversity, water quality and aesthetic values of Wasa Lake are important. There is strong desire to promote sustainable development along Wasa Lake and develop a lake management plan (LMP). The WLLID should be consistent with management approaches of the EKILMP on other lake's in the East Kootenays, (e.g., Shoreline Management Guidelines for Fish and Wildlife Habitats and the development of the LMP for Windermere Lake), to facilitate consistent lake management.

In the draft Windermere Lake Shoreline Management Guidelines EKILMP (EKILMP 2008), the lake was divided into four colour zones based on fish and/or wildlife habitat values and sensitivities determined through quantitative and qualitative analysis in the fish and wildlife habitat assessment

(completed by McPherson and Hlushak 2008). In summary, these zones were defined by the following:

Red Shoreline - Very High or High Current Ecological Values (determined through quantitative analysis of habitat features) that overlap with Key Habitat Areas (determined by qualitative mapping of known high value habitat areas). These areas were recommended to be designated for conservation use.

Orange Shoreline - Key Habitat Areas.

Yellow Shoreline – Very High and High Current Ecological Values.

Grey Shoreline – Moderate, Low and Very Low Current Ecological Values.

Risk ratings were attributed to disturbance activities for each of the zones. Examples of risks identified at Windermere Lake for modifications found at Wasa Lake are as follows:

- **Docks** were rated as Not Acceptable and High for the two high value zones and Low for the two lower value zones, however, the risk would be elevated to High for these zones if a species at risk was identified;
- **Erosion protection** (vertical wall or retaining wall) was rated as Not Acceptable for the very high zone, High for the two intermediate zones and Low for the lowest value zone;
- **Aquatic vegetation removal** was rated as either was rated as Not Acceptable for the two highest value zones and High for the lower value zones.
- **Upland Vegetation Removal** was rated as either was rated as Not Acceptable for the highest value zones and High for the lower value zones.
- **Groynes** were rated as Not Acceptable in the conservation areas and High for all other zones;
- **Dredging** was rated as Not Acceptable for all zones.
- **Beach creation (above and below the high water mark)** was rated as Not Acceptable for the highest value zones and High for the lower value zones.

Using EKILMP (2008) as a guideline, many foreshore modifications undertaken at Wasa Lake (including dredging, beach creation, upland and aquatic vegetation removal) would be seen by the EKILMP to be either **not acceptable** or **high risk** regardless of the fish and habitat values and colour zone determination. The activities determined to **not be acceptable** are known to have significant negative impacts to fish and wildlife habitats and are extremely difficult or impossible to mitigate or compensate; therefore, applications for these activities would not be considered by referral agencies. **High risk activities** are known to have significant challenges relating to providing adequate mitigation or compensation to address loss of fish and/or wildlife habitat values. **Low Risk activities** could be incorporated along the foreshore with minimal impacts on fish and wildlife habitat values if planned according to Provincial and Federal agency Best Management Practices and Regional Operating Statements. Establishment of these guidelines at Wasa Lake would greatly benefit fish and wildlife values. Completing a detailed fish and wildlife habitat assessment and having the colour zones determined for Wasa Lake would provide a valuable management tool; however, in absence of this, if even the moderate and lowest value shore zone risks were attributed to foreshore areas abutting residential lands (unprotected areas), sizeable protection of fish and wildlife values would ensue.

There is concern that regulatory agencies may not have managed disturbances as strictly at Wasa Lake as elsewhere, because the native fish values are not high and the Federal *Fisheries Act* has generally not been invoked. Managing the lake for its sport fishery (e.g. Duck Lake near Creston; P. Holmes pers. comm.) may help to maintain habitat values. The B.C. *Water Act,* however, should be enforced more routinely in order to ensure environmental foreshore values are considered.

Despite the many foreshore impacts revealed by this project, a substantial portion of the study area remains undisturbed (40%). Twenty eight percent of the foreshore that is undisturbed is located in the Wasa Lake Provincial Park. It is important to protect the ecological integrity of the currently natural park areas (Segments 4 and 6 in particular) from recreational activities in perpetuity and this appears to be the management objective (Figure 25; MoE 2003). Segments 8 and 10 are also in the Provincial Park and do show higher recreational development and associated modifications. Efforts should be made to minimize further disturbance in these areas and restoration opportunities could be explored.

Figure 25. Signage minimizing recreation impacts inside the bay of Segment 6.

Approximately 12% of the undisturbed foreshore is located in residential land use areas, with Segment 2 containing the largest length of natural shoreline (717 m representing 81% of undisturbed residential area). Segment 2 is mainly vegetated shoreline containing a diversity of vegetation types including: sand/grass, grassland, low-shrub, deciduous and coniferous components (Figure 26). New development here may be limited by floodplain construction regulations, since this is a low lying semi-wetland area. It would be valuable to protect the natural components of this segment for fish and wildlife habitat.

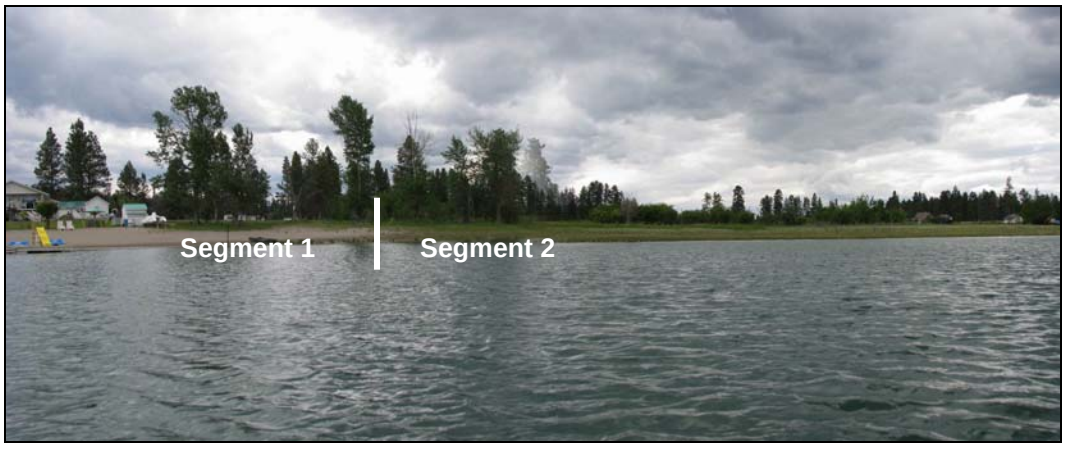


Figure 26. Undeveloped vegetated shore type in Segment 2, located at the south end of Wasa Lake.

Restoration opportunities should be sought along the foreshore of the remaining residential lands that are considered disturbed. As an example, consider the removal of foreshore modifications (e.g., docks) and allow the natural vegetative processes to prevail along the crown land/park area

near the southern end of Segment 1. Land owners here need to be aware that foreshore development (e.g., dredging or beach grooming) can not occur on Crown Land, without prior approval. Further habitat disturbance along the residential properties around the lake that remain natural or semi-natural should also be curtailed, if possible.

It is important to have 'conservation' be a goal for the remaining intact ecosystems that exist along Wasa Lake. 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). 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). Challenges are especially formidable when dealing with foreshore protection issues in areas where long-term visions have not been established (RDCO 2005), such as Wasa Lake, which does not yet have an official plan to guide development. Along Okanagan Lake, most parks are geared toward recreation and unimpeded public access, making it difficult to provide protection to natural features and ecosystems (RDCO 2005).

Clearly defined principles and associated policies/strategies will help guide future decisions and promote a coordinated approach to foreshore management among regulatory agencies. These principles and policies are key to establishing a regional vision and common goals while considering provincial and federal government interests (RDCO 2005). In summary, the RDCO (2005) provides the following valuable advice on subsequent efforts and refinement of planning tools:

> *Subsequent efforts should be concentrated on protecting critical habitats using tools available in the planning environment, such as regional policies, foreshore plans, and foreshore development guidelines. These tools should all be examined and updated to include science-based policy direction for conservation planning. This direction should be intent on achieving a higher quality of development that preserves the integrity of upland areas and maintains environmental attributes of the foreshore while facilitating human requirements. 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.*

5 Conclusions

The results of this inventory are intended to increase the effectiveness and coordination of foreshore management activities at Wasa Lake, leading to improved ecosystem structure and function and integration of human use with environmental protection. Specifically, this study will help identify where significant impacts have and have not occurred in order to provide information that guides decisions on future works, areas requiring protection, and suitable areas for enhancement (Coopper 2007). In making decisions about future works, the intention is to use what is already disturbed or of low value to continue to allow sustainable development (Coopper pers. com.), while providing protection to undisturbed critical habitat areas.

In order to adequately address foreshore protection issues, it is important to examine the way residents and stewards view foreshore ecosystems (RDCO 2005). The key to protection is our ability to recognize and acknowledge our influence on these systems and the role they play in the lake's health and vitality (Battelle 2001). Preservation of these ecosystems is critical in maintaining the environmental, social, and economic values that have drawn people to the East Kootenay Region.

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 for Wasa Lake. Due to their relevance, the following recommendations are based largely on these reports.

Decisions regarding the management of the Wasa 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 (RDCO 2005). Based on the current state of the foreshore, measures should be taken to conserve areas that contribute to maintaining and restoring sensitive foreshore ecosystems and to preserving the ecological integrity of Wasa 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 Wasa Lake are as follows:

Action #1. Conduct additional inventories to determine sensitive species and habitats associated with the foreshore.

- Identify critical habitat areas for species through further analysis and future addition to the project database.
- 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 provincially listed “at risk or sensitive” species or ecosystems are present.
- Complete a Wildlife Tree Assessment for the foreshore and have all wildlife trees be protected 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.
- Rate habitat conditions that would allow for re-introduction of extirpated species (e.g., northern leopard frogs and painted turtles).

Action #2. Identify and protect critical and natural areas

- Protect undeveloped areas adjacent to the foreshore. This is especially important when dealing with ecosystems that are threatened or endangered.
- 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.
- Pursue agreements between local governments and provincial agencies about foreshore management. For instance, utilize successful strategies employed by the EKILMP for coordinated management of Windermere Lake.
- Restrict marinas, boat launches, high horsepower boats/jet skis, and foreshore modifications in sensitive and significant habitat areas.

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, such as dredging, sand placement or vegetation removal.
- 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. Such guidelines should be developed in conjunction with senior government agencies to ensure consistency with regulatory requirements and resource management objectives.

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

- Set objectives, which consider shore type and disturbance level for the management of Wasa Lake.
- Address specific zoning of the foreshore of Wasa Lake.
- 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.
- Consider lakeshore development guidelines being developed elsewhere (e.g., Windermere Lake).
- Link foreshore activities to upland portions of the watershed.
- Determine if there would be a benefit in calculating the carrying capacity (the impact of foreshore modifications and activities on shore zone ecosystems). If so, obtain necessary foreshore data to determine carrying capacity. The carrying capacity of a lake 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). Although not easily measured, carrying capacity may be useful in assessing cumulative loss of foreshore habitats resulting from human disturbance (RDCO 2005).
- On a small lake significant damage can occur to shorelines because of high horsepower boats/jet skis – consideration should strongly be given to a horsepower restriction (Bisset pers .com).

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.
- A further mechanism for educating people, beyond the WLLID, might be through the Wasa Cottager's Association, Wasa Lions and BC Parks.

Action #8. Continue monitoring water quality

- Continue to monitor Wasa Lake's water quality, in cooperation with MoE.

7 References

Apps C.D., N.J. Newhouse and T.A. Kinley. 2002. Habitat associations of American badgers in southeastern British Columbia. Canadian Journal of Zoology. 80:1228-1239.

Backhouse F. 1993. Wildlife Tree Management in British Columbia. An initiative of the Wildlife Tree Committee of BC. Government of Canada and Province of BC.

Baker R. 1987. Wasa Lake. Water Management Branch Report. *In* BC Lake Stewardship Society and Ministry of Environment 2008.

Batelle Marine Sciences Laboratory et al. 2001. *Reconnaissance Assessment of the State of the Nearshore Ecosytem: Eastern Shore of Puget Sound, Including Vashon and Maury Islands* (WRIAs 8 and 9). King County. *In* RDCO 2005.

BC Conservation Data Centre. 2008a. BC Species and Ecosystems Explorer. B.C. Ministry of Environment. Victoria, BC. Available: http://a100.gov.bc.ca/pub/eswp/ (accessed Dec 17, 2008).

BC Conservation Data Centre. 2008b. Species Summary: *Pelecanus erythrorhynchos*. B.C. Ministry of Environment. Victoria, BC. Available: http://a100.gov.bc.ca/pub/eswp/ (accessed Dec 17, 2008).

BC Lakes Stewardship Society (BCLSS) and British Columbia Ministry of Environment (MoE). 2008. Wasa Lake 2004-2006 - The Importance of Wasa Lake and its Watersheds. BC lake stewardship and monitoring program.

BC Ministry of Agriculture and Lands. 2009. Foreshore and Aquatic Crown Land Ownership in British Columbia. Available: http://www.agf.gov.bc.ca/clad/tenure_programs/programs/privatemoorage/index.html#foreshore/ (accessed Feb 4, 2009).

BC Wildlife Tree Committee. 2009. BC Ministry of Forests and Range. Available: http://www.for.gov.bc.ca/hfp/values/wildlife/WLT/index.htm (accessed: January 8, 2009).

Beauchesne S.M. and J.M. Cooper. 2007. Lewis's Woodpecker (*Melanerpes lewis*) survey in the East Kootenay Trench, British Columbia 2007. Technical report to Canadian Wildlife Service, Delta, BC.

Burger A.E. 1997. Status of the Western Grebe in British Columbia. B.C. Ministry of Environment, Lands and Parks, Wildlife. Branch. Working Rep. WR-87. 40pp.

Butler R.W. 1992. Great Blue Heron. In The birds of North America No. 25. A. Poole, P. Stettenheim, and F. Gill (editors). Philadelphia: Acad. Nat. Sci., Philadelphia, PN., and Am. Ornith. Union, Washington, D.C.

Campbell R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser and M.C.E. McNall. 1990. The Birds of British Columbia, Vol. 2, Nonpasserines: Diurnal Birds of Prey through Woodpeckers. Royal B.C. Mus. in association with Environ. Can., Can. Wildl. Serv. 636pp.

Campbell R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, M.C.E. McNall and G.E.J. Smith. 1997. The Birds of British Columbia, Vol. 3, Passerines: Flycatchers through Vireos. Royal B.C. Mus. in association with Environ. Can., Can. Wildl. Serv. 693pp.

Canadian Wildlife Service. 2008. Consultation on Amending the List of Species under the *Species at Risk Act*: Terrestrial Species, January 2008. Environment Canada, Ottawa, ON. Available: http://www.sararegistry.gc.ca/virtual_sara/files/public/cd_specieslisting_terrestrial_0208_e.pdf

Cannings R.A., S.G. Cannings and L. Ramsay. 2000. The Dragonflies of the Columbia Basin, British Columbia. Royal B.C. Mus. 287pp. Available: http://www.livinglandscapes.bc.ca/cbasin/www_dragon/toc.html

Cooper, J.M., C. Siddle and G. Davidson. 1998. Status of the Lewis's Woodpecker (*Melanerpes lewis*) in British Columbia. B.C. Ministry of Environment, Lands and Parks, Wildlife Branch. Working Report WR-91. 34pp.

Cooper J.M. and C. Gillies. 2000. Breeding Distribution of the Lewis's Woodpecker in the East Kootenay Trench in Relation to Fire History. Pp. 423-428 *in* L.M. Darling, ed. 2000. Proc. Conf. on the Biology and Manage. Species and Habitats at Risk, Kamloops, B.C., 15-19 Feb., 1999. Vol. 1; B.C. Ministry of Environment, Lands and Parks, Victoria, BC, and University College of the Cariboo, Kamloops, BC. 490pp.

Cooper J.M. and S. Beauchesne. 2000. Inventory of Lewis's Woodpecker Breeding Population and Habitat in the East Kootenay. B.C. Ministry of Environment, Lands and Parks, Wildlife Branch, Victoria, BC. Wildlife Working Rep. No. WR-100. 30pp.

COSEWIC. 2003. COSEWIC assessment and status report on the rubber boa *Charina bottae* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 14 pp.

COSEWIC. 2007. COSEWIC assessment and status report on the Common Nighthawk *chordeiles minor* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, ON. Vi + 25 pp. Available: http://www.sararegistry.gc.ca/document/default_e.cfm?documentID=1393

East Kootenay Integrated Lake Management Partnership (EKILMP). 2009. Windermere Lake Shoreline Management Guidelines for Fish and Wildlife Habitats. Draft. Report completed in cooperation with S. McPherson and D. Hlushak, Interior Reforestation Co. Ltd.

East Kootenay Integrated Lake Management Partnership (EKILMP). 2006. Terms of Reference to the East Kootenay Integrated lake Management Partnership. Draft Version 1.2 (December 19, 2006).

Engel S. 1990. Ecosystem Responses to Growth and Control of Submerged Macrophytes: a Literature Review. Wisconsin Department of Natural Resources, Technical Bulletin 170, Madison. *In* Radomski and Goeman 2001.

Fish and Wildlife Compensation Program (FWCP). 2008. Columbia Basin Fish and Wildlife Compensation Program Biodiversity Atlas Project. Website http://www.biodiversityatlas.org/index.php. Accessed November, 2008.

Fisheries and Oceans Canada. 2008. The Shore Primer- A Cottager's Guide to a Healthy Waterfront. Ontario Edition. Burlington, Ontario.

Fisheries and Oceans Canada. 2003. Beach Grooming Guidelines – Lake Environments in the Columbia Basin. Nelson, BC.

Grasslands Conservation Council of BC. 2009. website. Available: www.bcgrasslands.org. (accessed January 7, 2009).

Lindsay A.R., S.S. Gillum and M.V. Meyer. 2002. Influence of Lakeshore Development on Breeding Bird Communities in a Mixed Northern Forest. Biological Conservation. 107, 1-11.

Machmer M.M. 2008. Great Blue Heron and Bald Eagle inventory and stewardship in the Columbia Basin (2007-2008). Columbia Basin Fish and Wildlife Compensation Program. Nelson, B.C. 34pp.

Machmer M.M. and C. Steeger. 2003. Breeding inventory and habitat assessment of Great Blue Herons in the Columbia River Basin. Columbia Basin Fish and Wildlife Compensation Program. Nelson, B.C. 28pp.

Mason B. and R. Knight. 2001. *Sensitive Habitat Inventory and Mapping*. Community Mapping Network. Vancouver BC. 315pp+viii. M. Johannes, editor.

McArthur R. 2005. Drought Planning for the Wasa Area. McArthur Consulting. *In* BC Lake Stewardship Society and Ministry of Environment 2008.

McCracken J. 2008. Are aerial insectivores being 'bugged out'? Bird Watch Canada. Winter 2008. pp 4-7. available: http://www.bsc-eoc.org/download/BWCwi08.pdf

McPhail J.D. 2007. The Freshwater Fishes of British Columbia. Published by the University of Alberta Press, Edmonton, Alberta.

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

McPherson S. and D Michel. 2007. Windermere Lake Foreshore Inventory and Mapping. Consultant report prepared for the East Kootenay Integrated Lake Management Partnership. Prepared by Interior Reforestation Co. Ltd., Cranbrook, BC.

Meidinger D. and J. Pojar. 1991. Ecosystems of British Columbia. British Columbia Ministry of Forests. 330 pp.

Messick J.P. 1987. North American badger. In Wild furbearer management and conservation in North America. Edited by M. Novak, J.A. Baker, M.E. Obbard, and B. Malloch. Ontario Trappers Association, and Ontario Ministry of Natural Resources, Toronto. pp. 586–597.

Ministry of Environment (MoE). 2008. Fisheries Inventory Summary System (FISS) -Data Query - Accessed December 2008. Province of British Columbia.

Ministry of Environment. 2006. Best Management Practices for Small Boat Moorage on Lakes. Environmental Stewardship Division, Province of British Columbia.

Ministry of Environment (MoE). 2003. Wasa Lake Provincial Park – Purpose Statement and Zoning Plan. Province of British Columbia.

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: December 17, 2008).

Newhouse N.J. and Kinley T.A. 2001. Ecology of badgers near a range limit in British Columbia. Columbia Basin Fish and Wildlife Compensation Program, Nelson, and Parks Canada, Radium Hot Springs, B.C.

Ohanjanian, I.A. (Penny). 2000. Wasa Lake Provincial Park amphibian survey. Technical report to BC Parks. Wasa, BC.

Ovaska K., S. Lennart, C. Engelstoft, L. Matthias, E. Wind and J. MacGarvie. 2004. Best Management Practices for Amphibians and Reptiles in Urban and Rural Environments in British Columbia. Ministry of Water Land and Air Protection, Ecosystems Standards and Planning, Biodiversity Branch. Available: http://www.env.gov.bc.ca/wld/BMP/herptile/HerptileBMP_final.pdf

Radomski P. and T.J. Goeman. 2001. Consequences of Human Lakeshore Development on Emergent and Floating-Leaf Vegetation Abundance. North American Journal of Fisheries Management. Vol 21:46-61.

Regional District of Central Okanagan (RDCO). 2005. Central Okanagan Lake Foreshore Inventory and Mapping. Planning Services Department. 91 pp.

Regional District of East Kootenay. 2007. Wasa - Ta-Ta Creek – Skookumchuck – Sheep Creek Land Use Bylaw No. 1625.

Rocky Mountain Trench Ecosystem Restoration Steering Committee. 2006. Blueprint for action: Fire-maintained Ecosystem Restoration in BC's Rocky Mountain Trench. Available: http://www.trenchsociety.com/setup/content/Blueprint_for_Action_2006.pdf

St. Clair, R.C. 1999. Identifying critical habitats for a vulnerable snake species, the rubber boa. Report to Columbia Basin Fish and Wildlife Compensation Program. Nelson, BC.

Schindler D.E., S.I. Geib and M.R. Williams. 2000. Patterns of Fish Growth Along a Residential Development Gradient in Northern Temperate Lakes. Ecosystems, 3, pp 229-237.

The Reptiles of British Columbia. 2008. http://www.bcreptiles.ca Site maintained by Thompson Rivers University and B.C. Ministry of Environment. (accessed October, 2008).

Thorpe J.E. 1977. Morphology, Physiology, Behavior, and Ecology of *Perca fluviatilus* L. and *Perca flavenscens* (Mitchill). J. Fish. Res. Board Can. 34: 1504-1514. *In* McPhail 2007.

Wasa Lake Land Improvement District. 2008. Water Level Data for Wasa Lake and Kootenay River, 1996-2006.

Wells R.W., D. Haag, T. Braumandl, G. Bradfield and A. Moy. 2004. Ecosystem Representation in the East Kootenay Conservation Program Study Area. Technical report for Tembec, Inc., Cranbrook, BC and Canfor, Ltd., Radium Hot Springs, BC.

West Coast Environmental Law. 2007. No Response. A Survey of Environmental Law Enforcement and Compliance in BC. Vancouver BC.

Wikipedia. Accessed December 2008. Kettle (Landform) http://en.wikipedia.org/wiki/Kettle_(geology).

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Nicholson D. Naturalist. Cranbrook, BC.

Tepper H. 2008. Fish Biologist. Ministry of Environment, Cranbrook, BC.

Appendix A. Key to the Field Headings in the Wasa 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.
Video Time	Lists time according to the video tape for the segment
Dominant Shore Type	Dominant shore type for the segment based on shore type percentages.
Slope	Foreshore slope type
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 / Bluff Shore Type	Approximate percentage of segment which is occupied by Cliff/Bluff shore type (CL/B).
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).
Vegetated Shore type	Approximate percentage of segment which is occupied by a Vegetated shore type (VS).
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).
Sand Beach (high) / Cobble Beach (low) Shore Type	Approximate percentage of segment which is occupied by the shore type containing a mix of Sand Beach (along the high water shoreline) and Cobble Beach (along the low water shoreline). Coded as SB/CB.
Stream Mouth Shore Type	Approximate percentage of segment which is occupied by Stream Mouth shore type (SM).
Grassland Shore Type	Approximate percentage of segment which is occupied by Grassland shore type (Gr)
Residential	Percentage of segment occupied by residential land use (Res)
Commercial	Percentage of segment occupied by commercial land use (Com)
Rural	Percentage of segment occupied by rural land use (Rur)
Agricultural	Percentage of segment occupied by agricultural land use (Ag)
Park	Percentage of segment occupied by park land use (P)
Industrial	Percentage of segment occupied by industrial land use (Ind)
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
Floating Veg (%)	Percentages shoreline length with floating 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.
Upland Forest Class	Land cover classes (i.e. based on % crown cover and dominant vegetation). *See* Riparian Class for field key options.
Upland Forest Stage	Structural Stage of the dominant native vegetation in the upland area. *See* Riparian Stage for field key options.
Upland Shore Cover	Percentage of the upland area that is occupied by natural vegetation. *See* Riparian Shore Cover for field key options.
Upland Band Width	Number of metres of upland area reviewed (up from the riparian area).
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)
Attached Docks	Number of docks attached to the shore per segment
Floating Docks	Number of floating docks in the lake, situated in open water away from the shoreline
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.
Substrate Modified	Identify if the substrate at the high water mark has been modified.
Percent Substrate Modified	Percentage of substrates modified in relation to segment length.
Modification Comment	Comments regarding modifications.
General Comments	Additional comments regarding observations in the segment

Appendix B. Foreshore Summary Map

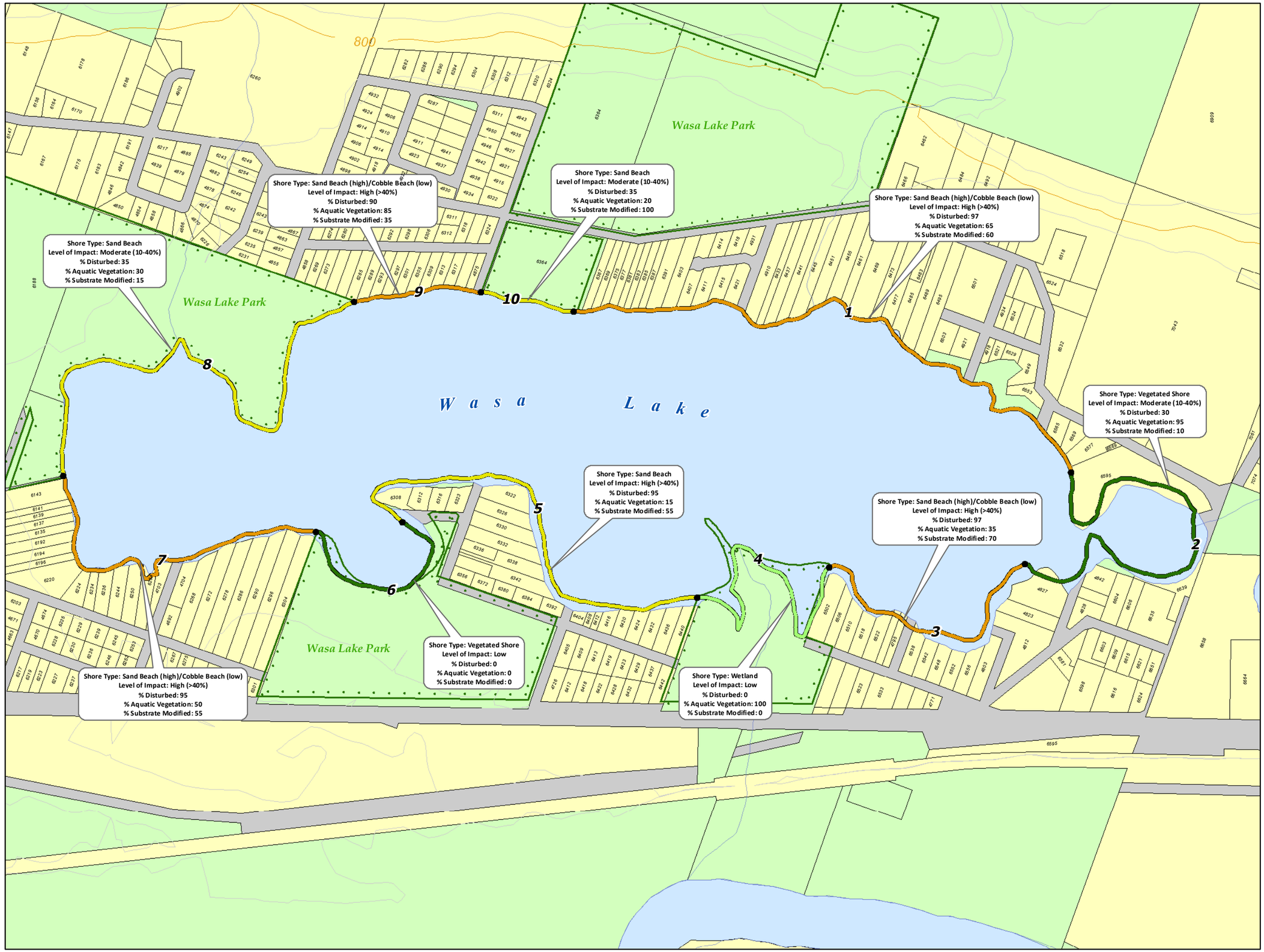
WASA LAKE FORESHORE INVENTORY AND MAPPING

Appendix B: Foreshore Inventory Map

Map 1 of 1
Date: 2009.01.08
Scale: 1:7,500

0 100 200 300 Meters

Fisheries and Oceans Canada
- Pacific Region



Legend

Dominant Shore Type
- Sand Beach
- Sand Beach (high)/Cobble Beach (low)
- Vegetated Shore
- Wetland

Features
- Segment Break
- Legal Boundaries
- Crown Land (Default)
- Private Lands
- Roads/Access
- Water
- Park/Protected Area
- Rivers
- Contour (Index)
- Contour (Intermediate)

Data Sources

Regional District Base Map and Legal Plans: Regional District of East Kootenay
Transportation, Stream, Lake: TRIM
Parks/Protected Areas: GeoBC, Province of BC
Shoreline Segments: Digitized from TRIM Lake data

Map Information

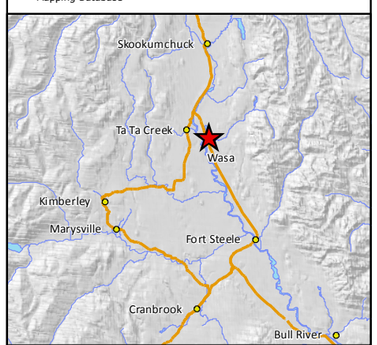
Map Projection: UTM 11
Map Datum: NAD 1983
Contour Interval: 20 m
Issue Date: 01.09.2008

Cartographic Information

Created By: D.Hlushak
Reviewed By: S.McPherson
IR File: 08WASA6A\
WasaLake_FIM.mxd

Note:

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



Digital Mapping By:

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Appendix C. Orthophoto Delineation Map

WASA LAKE FORESHORE INVENTORY AND MAPPING

Appendix C: Orthophoto Delineation Map
Wasa Lake - North

Map 1 of 2
Date: 2009.01.08
Scale: 1:4,000

0 50 100 150 Meters

Fisheries and Oceans Canada
- Pacific Region

Legend

- Contour (Index)
- Contour (Intermediate)
- Legal Boundaries
- Segment Break

Shoreline Classification

- Emergent Vegetation
- Man-made Structure
- Coniferous
- Deciduous
- Grassland
- Shrub (low)
- Shrub (high)
- Lake
- Stream
- Lawn
- Mixed Forest
- Road (paved)
- Road (unpaved)
- Trail
- Sand
- Sand/Grass
- Wetlands

Wasa Lake

1 5 6 7 8 9 10

Data Sources

Regional District Base Map and Legal Plans: Regional District of East Kootenay
Transportation, Stream, Lake: TRIM
Shoreline Classification: Terrasaurus
Aquatic Vegetation Digitization: Interior Reforestation Co Ltd

Map Information

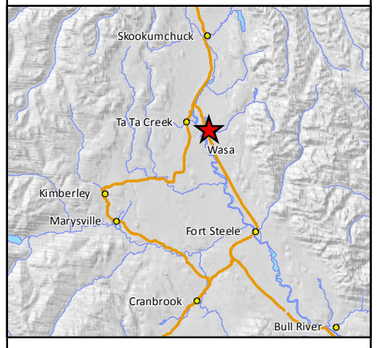
Map Projection: UTM 11
Map Datum: NAD 1983
Contour Interval: 20 m
Issue Date: 01.09.2008

Cartographic Information

Created By: D.Hlushak
Reviewed By: S.McPherson
IR File: 08WASA6A\WasaLake_ShoreClass_N.mxd

Note:

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



Digital Mapping By:

INTERIOR REFORESTATION CO. LTD.
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WASA LAKE FORESHORE INVENTORY AND MAPPING

Appendix C: Orthophoto Delineation Map
Wasa Lake - South

Map 2 of 2
Date: 2009.01.08
Scale: 1:4,000

0 50 100 150 Meters

Fisheries and Oceans Canada
- Pacific Region

Legend

- Contour (Index)
- Contour (Intermediate)
- Legal Boundaries
- Segment Break

Shoreline Classification

- Emergent Vegetation
- Man-made Structure
- Coniferous
- Deciduous
- Grassland
- Shrub (low)
- Shrub (high)
- Lake
- Stream
- Lawn
- Mixed Forest
- Road (paved)
- Road (unpaved)
- Trail
- Sand
- Sand/Grass
- Wetlands

Data Sources

Regional District Base Map and Legal Plans: Regional District of East Kootenay
Transportation, Stream, Lake: TRIM
Shoreline Classification: Terrasaurus
Aquatic Vegetation Digitization: Interior Reforestation Co Ltd

Map Information

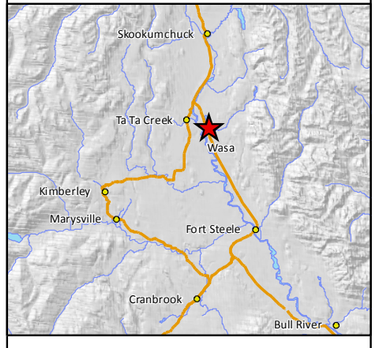
Map Projection: UTM 11
Map Datum: NAD 1983
Contour Interval: 20 m
Issue Date: 01.09.2008

Cartographic Information

Created By: D.Hlushak
Reviewed By: S.McPherson
IR File: 08WASA6A\WasaLake_ShoreClass_S.mxd

Note:

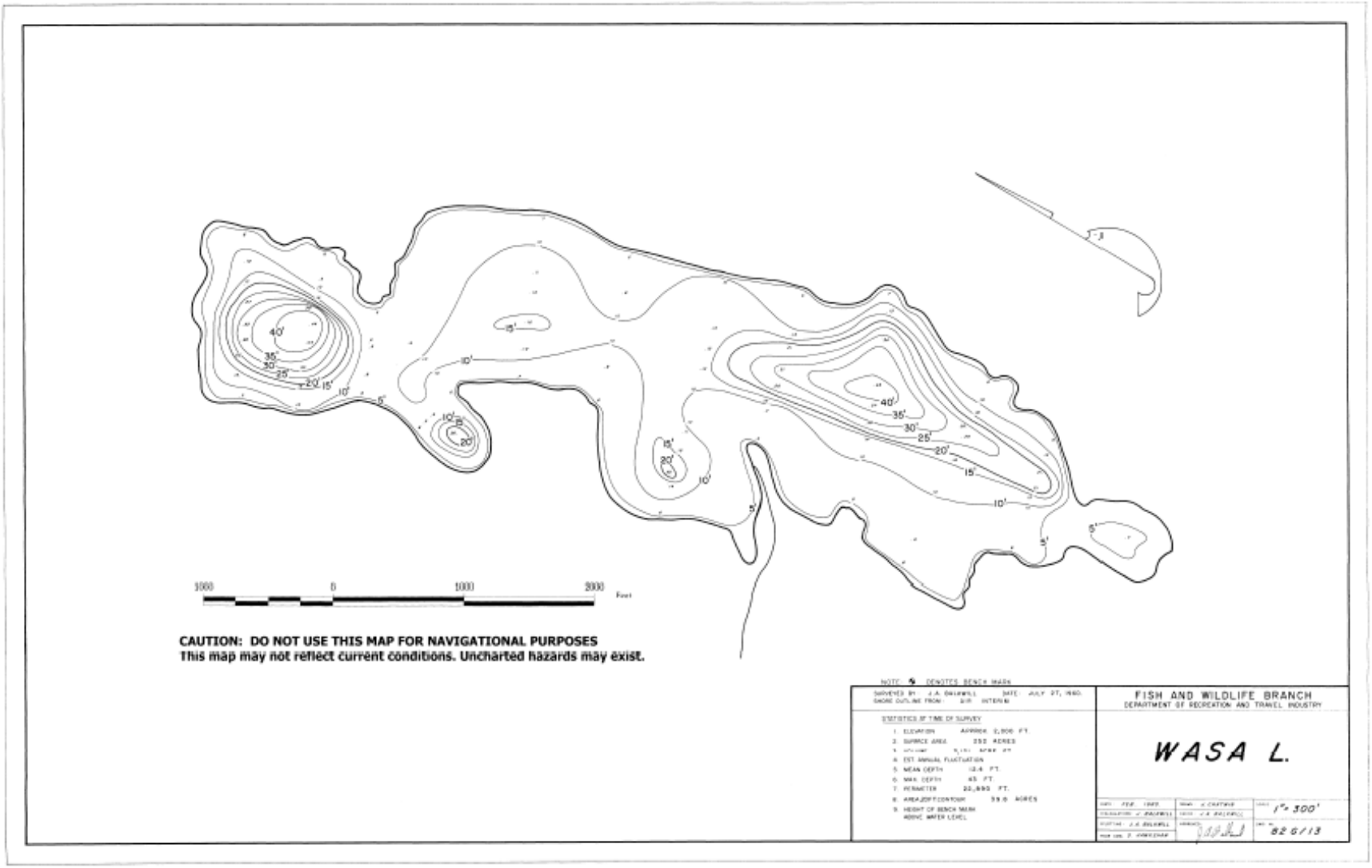
This map is used for illustrative purposes only and should be used in conjunction with the Wasa Lake Foreshore Inventory and Mapping Database



Digital Mapping By:

INTERIOR REFORESTATION CO. LTD.
Leadership In Natural Resource Management

Appendix D. Bathymetric Map of Wasa Lake



Appendix E. List of Waterfowl and Shorebirds Observed at or Near Wasa Lake.

List of 63 waterfowl and shorebird species observed at, or near, Wasa Lake. Species marked with an asterisk (*) have only been observed at the 'sloughs' south of the main lake. Sources: Nicholson (pers. comm.); Campbell et al. (1990; 1997); Nicholson et al. (2003).

Common Name	Scientific Name	Breeding Status[1]	Occurrence[2]
Common Loon	*Gavia immer*	breeds	common
Red-necked Grebe	*Podiceps grisegena*	breeds	common
Western Grebe	*Aechmophorus occidentalis*	non-breeder	uncommon
Eared Grebe	*Podiceps nigricollis*	breeds	uncommon
Horned Grebe	*Podiceps auritus*	breeds	uncommon
Pied-billed Grebe	*Podilymbus podiceps*	breeds	common
American White Pelican*	*Pelecanus erythrorhynchos*	non-breeder	occasional
American Bittern*	*Botaurus lentiginosus*	breeds	uncommon
Great Blue Heron	*Ardea Herodias*	breeds	common
Tundra Swan	*Cygnus columbianus*	non-breeder	uncommon
Trumpeter Swan	*Cygnus buccinators*	non-breeder	occasional
Snow Goose	*Chen caerulescens*	non-breeder	rare
Canada Goose	*Branta canadensis*	breeds	common
Wood Duck*	*Aix sponsa*	breeds	common
Mallard	*Anas platyrhynchos*	breeds	abundant
Northern Pintail	*Anas acuta*	breeds	common
Gadwall	*Anas strepera*	non-breeder	rare
American Wigeon	*Anas americana*	breeds	common - abundant
Eurasian Wigeon	*Anas penelope*	non-breeder	rare
Northern Shoveler	*Anas clypeata*	breeds	uncommon
Green-winged Teal	*Anas crecca*	breeds	common
Blue-winged Teal	*Anas discors*	breeds	common
Cinnamon Teal	*Anas cyanoptera*	breeds	common
Canvasback	*Aythya valisineria*	?	uncommon
Redhead Duck	*Aythya americana*	breeds	common
Ring-necked Duck	*Aythya collaris*	breeds	common
Greater Scaup	*Aythya marila*	non-breeder	uncommon
Lesser Scaup	*Aythya affinis*	non-breeder	common
Common Goldeneye	*Bucephala clangula*	breeds	common
Barrow's Goldeneye	*Bucephala islandica*	breeds	common
Bufflehead	*Bucephala albeola*	breeds	common
Ruddy Duck*	*Oxyura jamaicensis*	breeds	common
Common Merganser	*Mergus merganser*	breeds	common
Red-breasted Merganser	*Mergus serrator*	non-breeder	rare
Hooded Merganser*	*Lophodytes cucullatus*	breeds	uncommon
American Coot	*Fulica americana*	breeds	abundant
Sora*	*Porzana carolina*	breeds	uncommon
Virginia Rail*	*Rallus limicola*	probable breeder	rare
Black-bellied Plover	*Pluvialis squatarola*	non-breeder	rare

Common Name	Scientific Name	Breeding Status[1]	Occurrence[2]
Semipalmated Plover	*Charandrius semipalmatus*	non-breeder	rare
Killdeer	*Charandrius vociferous*	breeds	common
Black-necked Stilt	*Himantopus mexicanus*	non-breeder	occasional
American Avocet	*Recurvirostra americana*	non-breeder	rare
Greater Yellowlegs	*Tringa melanoleuca*	non-breeder	uncommon
Lesser Yellowlegs	*Tringa flavipes*	non-breeder	uncommon
Solitary Sandpiper	*Tringa solitaria*	breeds	uncommon
Spotted Sandpiper	*Actitis macularia*	breeds	common
Upland Sandpiper	*Bartramia longicauda*	non-breeder	occasional
Semipalmated Sandpiper	*Calidris pusilla*	non-breeder	occasional
Western Sandpiper	*Calidris mauri*	non-breeder	occasional
Least Sandpiper	*Calidris minutilla*	non-breeder	occasional
Baird's Sandpiper	*Calidris bairdii*	non-breeder	occasional
Pectoral Sandpiper*	*Calidris melanotos*	non-breeder	occasional
Long-billed Dowitcher	*Limnodromus scolopaceus*	non-breeder	occasional
Wilson's Snipe	*Gallinago gallinago*	breeds	common
Wilson's Phalarope	*Phalaropus tricolor*	breeds	rare
Red-necked Phalarope	*Phalaropus lobatus*	non-breeder	rare
Bonaparte's Gull	*Larus philadelphia*	non-breeder	uncommon
Ring-billed Gull	*Larus delawarensis*	non-breeder	uncommon
California Gull	*Larus californicus*	non-breeder	uncommon - rare
Herring Gull	*Larus argentatus*	non-breeder	uncommon
Common Tern	*Sterna hirundo*	non-breeder	occasional
Black Tern*	*Chlidonias niger*	breeds	common

[1] Breeding Status – species indicated as 'breeds' are known to breed in the East Kootenay, though not necessarily at Wasa Lake.

[2] Occurrence order: Abundant > Common > Uncommon > Rare > Occasional > Accidental

Appendix F. Wasa Lake Foreshore Inventory and Mapping Database

	GENERAL													SHORE TYPE (%)								LAND USE (%)						
Segment Number	Segment Length (m)	Photo Number	Video Time	Dominant Shore Type	Shore Type Code	Slope	Dominant Land Use	LU Code	Disturbed (%)	Natural (%)	Level of Impact	LOI Code	Livestock Access	Cliff/Bluff	Gravel Beach	Low Rocky Shore	Sand Beach (high) /Cobble Beach (low)	Sand Beach (year round)	Stream Mouth	Wetland	Vegetated	Residential	Commercial	Rural	Agriculture	Park	Crown	Industrial
1	1281.2	img 0814, 0815.jpg	21:52:15	Sand Beach (high)/Cobble Beach (low)	SB/CB	Bench	Residential	Res	97	3	High (>40%)	H	No	0	0	0	100	0	0	0	0	75	0	0	0	0	25	0
2	1024.2	img 0816, 0817.jpg	21:58:55	Vegetated Shore	VS	Bench	Residential	Res	30	70	Moderate (10-40%)	M	No	0	0	0	0	10	0	0	90	100	0	0	0	0	0	0
3	580.5	img 0818, 0819.jpg	21:59:	Sand Beach (high)/Cobble Beach (low)	SB/CB	Bench	Residential	Res	97	3	High (>40%)	H	No	0	0	0	60	30	0	0	10	100	0	0	0	0	0	0
4	740.0	img 0820, 0821.jpg	22:01:01	Wetland	W	Bench	Park	P	0	100	Low	L	No	0	0	0	0	0	5	95	0	0	0	0	0	100	0	0
5	966.5	img 0822, 0823.jpg	22:	Sand Beach	SB	Bench	Residential	Res	95	5	High (>40%)	H	No	0	0	0	0	75	0	0	25	100	0	0	0	0	0	0
6	446.8			Vegetated Shore	VS	Bench	Park	P	0	100	Low	L	No	0	0	0	0	10	0	0	90	0	0	0	0	100	0	0
7	777.4	img 0822, 0823.jpg	22:	Sand Beach (high)/Cobble Beach (low)	SB/CB	Bench	Residential	Res	95	5	High (>40%)	H	No	0	0	0	75	0	0	0	25	100	0	0	0	0	0	0
8	1165.8	img 0824, 0825.jpg	22:12:30	Sand Beach	SB	Bench	Park	P	35	65	Moderate (10-40%)	M	No	0	0	0	20	60	0	0	20	0	0	0	0	100	0	0
9	270.2	img 0826, 0827.jpg	22:17:53	Sand Beach (high)/Cobble Beach (low)	SB/CB	Bench	Residential	Res	90	10	High (>40%)	H	No	0	0	0	75	0	0	0	25	100	0	0	0	0	0	0
10	201.9	img 0828, 0829.jpg		Sand Beach	SB	Bench	Park	P	35	65	Moderate (10-40%)	M	No	0	0	0	0	75	0	0	25	0	0	0	0	100	0	0
	Jurisdictiction: Regional District of East Kootenays (RDEK)																											
	Field Review																											
	Date		**Crew**																									
	6/5/2008		BC Conservation Corps: Erica Heel, Brendan Guy, Erica Jenkins; Ministry of Environment: Peter Holmes																									
	12/10/2008		Interior Reforestation: Darcy Hlushak, Sherri McPherson																									

	SUBSTRATES - HIGH WATER LEVEL (%)						SUBSTRATES - LOW WATER LEVEL (%)							AQUATIC VEGETATION (% of Shorelength)		LITTORAL HABITAT				RIPARIAN VEGETATION								UPLAND VEGETATION			
Segment Number	Mud	Fines	Gravel	Cobble	Boulder	Bedrock	Mud	Fines	Gravel	Cobble	Boulder	Bedrock	Dominant substrate	Submergent, Emergent or Floating Veg.- High Water (June)	Emergent Veg-Low Water (Dec)	Littoral Zone Width	Littoral Zone Code	Spawning Habitat	LWD	Riparian Class	Riparian Stage (height dominant veg)	Riparian Cover (%)	Riparian Bandwidth (m)	Riparian Overhang (m)	Riparian Veteran	Riparian Snag	Riparian Comment	Upland Vegetation Class	Upland Veg. Stage (dominant veg)	Upland Veg. Cover (%)	Upland Bandwidth (m)
1	0	75	0	25	0	0	0	25	0	75	0	0	Cobble	0	65	Moderate (10-50m)	M	Unknown	No	Exposed soil and some herbs/grass	grass/herb	Sparse (<10%)	5	0	<5	<5	Sandy beach on shoreline, grasses in some areas	Mixed-landscaped, grassland & coniferous forest	grass/herb	Moderate (10-50%)	45
2	0	90	0	10	0	0	0	90	0	10	0	0	Fines	0	95	Moderate (10-50m)	M	Unknown	No	Herbs/grasses	grass/herb	Abundant (>50%)	5	0	No	<5		Mixed-mostly grassland with some coniferous forest	grass/herb	Moderate (10-50%)	45
3	0	100	0	0	0	0	0	50	0	50	0	0		0	35	Moderate (10-50m)	M	Unknown	No	Exposed soil with some herb/grass	Sparse	Sparse (<10%)	5	0	No	<5	Sandy beach on shoreline	Landscaped-w/ some grassland and coniferous	grass/herb	Moderate (10-50%)	45
4	0	100	0	0	0	0	0	100	0	0	0	0	Fines	0	100	Moderate (10-50m)	M	Unknown	No	Natural wetland	tall shrubs 2-10m	Abundant (>50%)	50	0	No	No	natural area	N/A			0
5	0	100	0	0	0	0	0	75	0	25	0	0	Fines	0	15	Wide (>50m)	W	Unknown	<5	Exposed soil with some herb/grass	Sparse	Sparse (<10%)	5	0	No	<5	sandy/grass beach	Landscaped-w/ some grassland and coniferous	grass/herb	Moderate (10-50%)	45
6	0	100	0	0	0	0	0	50	0	50	0	0		0	0	Moderate (10-50m)	M	Unknown	No	Herbs/grasses	grass/herb	Abundant (>50%)	5	0	Unknown	Unknown		Coniferous forest	mature forest	High (>50%)	45
7	0	100	0	0	0	0	0	25	0	75	0	0	Cobbles	0	50	Wide (>50m)	W	Unknown	<5	Exposed soil with some herb/grass	Sparse	Sparse (<10%)	5	0	No	<5		Landscaped-w/ some grassland and coniferous	mature forest	Moderate (10-50%)	45
8	0	100	0	0	0	0	0	70	0	30	0	0	Fines	0	30	Wide (>50m)	W	Unknown	No	Exposed soil with some herb/grass	grass/herb	Sparse (<10%)	5	0	No	<5	park - beginning section more groomed; small patch of deciduous before point; some evidence of landscaping	Coniferous and herbs/grass	mature forest and grass/herb	Moderate (10-50%)	45
9	0	100	0	0	0	0	0	10	0	90	0	0	Cobble	0	85	Wide (>50m)	W	Unknown	No	Exposed soil with some sand/grass	grass/herb	Sparse (<10%)	5	0	No	No		Landscaped w/ some grassland and coniferous	mature forest and grass/herb	Moderate (10-50%)	45
10	0	100	0	0	0	0	0	100	0	0	0	0	Fines	0	20	Wide (>50m)	W	Unknown	No	Exposed soil	Sparse	None	5	0	No	<5	sandy beach	Grassland and coniferous	mature forest and grass/herb	Moderate (10-50%)	45

		SHORELINE MODIFICATIONS																	
Segment Number	Upland Comment	Retaining Walls	Percent Retaining Wall	Retaining Wall Material	Retaining Wall Type	Attached Docks	Floating Docks	Total Docks	Docks/km	Groynes	Boat Launch	Railway	Road	Marine Railway	Marinas	Substrate Modified	Percent Substrate Modified	Modifications Comment	General Comments
1	Ponderosa pine, grass, landscaping around houses; scattered deciduous (aspen, cottonwood, poplar)	0	0			19	6	25	20	1	0	0	3 access points	0	0	Yes	60	beach grooming	Wide littoral shelf with cobbles at low water levels and sand above; cabins beside boat launch.
2	Ponderosa pine, cottonwoods, shrubs, poplar and grass/herb	0	0			4	0	4	4	0	0	0	1 acces point and road running along length of southern bay	0	0	Yes	10	beach grooming	Low vegetated shore, few cabins. Deer tracks in Dec.
3	mixed upland with ponderosa pine, poplar and willow	0	0			9	0	9	16	1	0	0	2 access points	0	0	Yes	70	grooming; groyne and dredging at northern-most property	cabins above sandy beach; cobbles predominant at low water levels. Deer tracks in Dec.
4	Tall shrubs and grasses	0	0			0	0	0	0	0	0	0	0	0	0	No	0		Wetland at lake outlet. Elk tracks, clay beach and dry stream in Dec.
5	Ponderosa pine around houses	1	5	Stonework	Discontinuous	15	4	19	20	1	1	0	2 access points, 1 is a boat launch	0	0	Yes	55	beach grooming	Cabins above sand, some veg in sand
6		0	0			0	0	0	0	0	0	0	0	0	0	No	0		
7		2	5	Stonework	Discontinuous	15	7	22	28	0	1	0	1 access point	0	0	Yes	55	beach grooming	cabins above sand, some veg in sand
8	Ponderosa pine and grass	0	0			0	0	0	0	0	0	0	No	0	0	Yes	15	beach grooming	
9	Ponderosa pine	0	0			3	2	5	19	0	1	0	1 access point	0	0	Yes	35	beach grooming	
10	Ponderosa pine	0	0			0	0	0	0	0	0	0	No	0	0	Yes	100	beach grooming	

Appendix G. Segment Descriptions

Segment Descriptions

Segment delineation proceeded clockwise around the lake, beginning at Segment 1 mid way along the east shore of the lake and ending at Segment 10. Segment locations are mapped in Appendix B. Summary descriptions and Level of Impact (LoI) of each Segment are provided below.

Segment 1 (1281 m) – LoI High

Segment 1 is the longest segment of all those delineated at Wasa Lake. This segment is located on the eastern shore and runs much of the length of the southern half of the lake. It is mostly (75%) comprised of residential land use; however, there is a narrow Crown Land section following the shoreline near the south end of the segment, occupying approximately 25% of the foreshore. This crown land portion is zoned as P-2 (park and open space) and has been disturbed by adjacent residential activities. This segment has been classified as a Sand Beach (high) / Cobble Beach (low) Shore Type, due to the predominance of sand along the shoreline at high water levels (June) and cobble at low water levels (December). This segment has been highly disturbed (approximately 97%) by lake front residences. During the low water period, aquatic vegetation was determined to extend along approximately 65% of the segment's length. The riparian vegetation just above the high water mark was sparse (<10% coverage) and where present, was mainly herbs/grass. Much of the upslope vegetation has been impacted by development and associated landscaping; however, the area was moderately vegetated with grassland and coniferous components. Additional shoreline modifications included: beach grooming (approx. 60%), 25 docks, 1 groyne and 3 road access points.

Segment 1 showing sand beach evident at high water levels and residential development. Photo: Holmes, June 2008.

Segment 2 (1024 m) – LoI Moderate

Segment 2 encompasses the southern end of the lake, including the shallow bay at the southern tip. Although the segment is all classified as a residential area in the local Land Use Bylaw, approximately 75% of the shoreline length appeared to be in a natural condition. Development may be limited by the low-lying nature of the area and resulting floodplain development restrictions. This segment has been classified as a Vegetated Shore due to the prominence of undisturbed emergent and riparian vegetation and moderate coverage in the upland area. A substantial portion of this segment was open grassland; however there was also some low shrub,

coniferous and deciduous components. In terms of modifications, this segment had four docks and a road built alongside the most southerly perimeter. A culvert under the road carries ephemeral flows into the lake from the Lewis Creek drainage area.

The edge of the sandy beach marks the end of Segment 1 (disturbed area) and beginning of Segment 2 (vegetated area). Photo: Holmes, June 2008.

Segment 2: Looking across the bay toward area of emergent vegetation (left) and view toward the west end of the segment (right). Photo: McPherson, Dec 2008.

Segment 3 (580 m) – LoI High

Segment 3 is located on the southwestern shore of the lake and has nearly all (97%) been disturbed by residential development. This segment was mostly (60%) Sand Beach (high) / Cobble Beach (low) Shore Type. Approximately 35% of the shoreline had aquatic vegetation along its lower littoral zone. The riparian area was mainly exposed soil with some sparse coverage with grasses. Although there has been considerable landscaping the upland area appeared to be moderately covered with grassland and coniferous components. Approximately 70% of the beach area has been disturbed by beach grooming modifications. Other modifications identified include: nine docks and one groyne/ dredging modification for boat access.

Segment 3 showing extensive sand placement along the shoreline and coniferous trees in the upland area.

Segment 4 (740 m) – Lol Low

Segment 4 was natural park land and is one of the four parcels of land falling under the Wasa Lake Provincial Park. This segment did not have any recreational related infrastructure. This segment was all Wetland Shore Type, but for a small component classified as Stream Mouth, which is the ephemeral, Hanson Creek which connects the lake to the Kootenay River floodplain. The substrates throughout the area were all fines with a high proportion being clays. Herbaceous grassy emergent aquatic vegetation was found along the entire length of this segment under low water conditions. Bulrush emergent vegetation was also found on the northern side of the point, which was unique to this segment. The low lying nature of this segment has resulted in a wide riparian width (50 m) compared to other segments which were estimated to be 5 m. This riparian area was vegetated with low and tall shrubs as well as wetland components.

Segment 4 showing wetland in June (left) and bulrush/emergent vegetation wetland plants near northern end in Dec. (right). Photos: Holmes, June 2008 and McPherson, Dec 2008.

Segment 5 (967 m) – LoI High

Segment 5 was mainly Sand Beach Shore Type (75%), with some Vegetated Shore areas. This segment has been largely disturbed by residential development (95%). The small undisturbed areas remain so, because development has been set-back leaving the shoreline in a fairly natural condition. Substantial lengths (approx. 55%) of this segment have been disturbed by beach grooming. Other modifications identified here include: 1 retaining wall, 19 docks, 1 groyne and 2 road access points (including 1 boat launch). These modifications have affected the vegetation in the area. For instance, emergent aquatic vegetation was determined to cover approximately 15% of the shoreline length, the riparian area was only sparsely covered with grassy components and grassland and conifers patches provided moderate coverage of the upland.

Segment 5 at the south end boundary with the park (left) and towards its northern end (right). Photos: Holmes, June 2008 and McPherson, Dec 2008.

Segment 5 shoreline area that has been left relatively intact, exhibited by emergent vegetation and cobble substrates below high water mark, along with grassland/coniferous mix of vegetation in riparian area. Photo: McPherson, Dec 2008.

Segment 6 (447 m) – LoI Low

Segment 6 is located on the western shore and is the second of four parcels protected under the Wasa Lake Provincial Park. This unique segment was undisturbed and had no recreational related infrastructure. It was mainly classified as a Vegetated Shore Type (90%), although there

were some Sand Beach areas. The riparian area was abundantly covered with grasses and the upland vegetation was coniferous forest. At low water levels, the substrates were assessed to vary throughout the segment, with sand predominating along the northern stretch, which gradually shifted to cobbles in the southern half. There were no shore alterations evident.

Segment 6 foreshore area showing grasses along the riparian area followed by conifers in the upland (top), cobble substrates along southern stretch (bottom left) and park signage protecting habitat (bottom right). Photo: McPherson, Dec. 2008.

Segment 7 (777 m) – LoI High

Segment 7, located on the northeastern shore, has been largely impacted (95%) by development. This segment was mainly composed of Sand Beach (high)/Cobble Beach (low) Shore Type. There was also some (approximately 25%) Vegetated shore type area, where coniferous and/or grassland vegetation has been left intact. Sand was the dominant substrate near the high water mark, while cobbles were dominant throughout near the low water levels. Shoreline modifications included: 2 retaining walls, 22 docks and 1 boat launch at the road access point. Beach grooming was estimated to have occurred along 55% of the shoreline. These modifications resulted in a sparsely vegetated riparian area and likely the absence of emergent vegetation along 50% of the shoreline. Upland vegetation was estimated to provide moderate coverage and was composed of grassland and coniferous components.

Segment 7, showing cobble substrates evident at low water levels and area where grasses have been maintained to the high water level. Photo: McPherson Dec. 2008.

Segment 7, showing property on left where some vegetation along the shore has been left intact and property on the right where beach grooming and retaining wall modifications have greatly altered the natural shoreline. Photo: Holmes, June 2008.

Segment 8 (1166 m) – LoI Moderate

Segment 8 is another parcel located in the Wasa Lake Provincial Park and is situated at the northern end of the lake. This segment was composed of mainly Sand Beach Shore Type (60%), although there were also Sand Beach (high)/Cobble Beach (low) and Vegetated Shore Types identified (20% each). Aquatic vegetation was estimated to extend along 30% of the shoreline. The riparian area was sparsely vegetated with grasses. The upland area was moderately vegetated with a natural open ponderosa pine and grassland landscape. This area has seen a moderate level of impact as a result of recreational infrastructure and associated landscaping (e.g. beach grooming and lawn establishment), which was concentrated near the northern point. Approximately 15% of the shoreline substrate was estimated to be modified by beach grooming activities.

Segment 8 showing the Sand Beach Shore Type and upland area composed of open ponderosa pine grassland.

Segment 9 (270 m) – LoI High

Segment 9 is located on the north east shore of the lake. It was highly impacted as a result of the residential land use along its shoreline. The houses are generally set-back on a bench located above the lake. Most (75%) of this segment has been classified as the Sand Beach (high)/Cobble Beach (low) Shore Type. There was some Vegetated Shore Type also identified (25%), which mainly represents areas where grassland riparian areas have been left intact. Aquatic vegetation was determined to extend along 85% of the shoreline. The riparian area was mainly composed of sand and as such, was sparsely vegetated. Much of the upland was landscaped; however, moderate coverage with mature coniferous forest and grassland remain. Beach grooming was estimated to have modified 35% of the substrate. Five docks, and a permanent (concrete) boat launch and associated groyne were also observed.

Segment 9: An example location where grass/herb vegetation has been maintained along the shoreline and of houses situated up on a bench (left) and boat launch/groyne structure at end of the segment (right). Photo: Holmes, June 2008.

Segment 10 (202 m) – LoI Moderate

Segment 10 is also a part of the Wasa Lake Provincial Park and is situated proximal to the campground. Out of the four park segments, this one has been developed for recreational purposes to the greatest extent. It had sand placement/beach grooming along its entire length and as a result, no riparian vegetation. However, a small area of emergent vegetation was evident; representing approximately 20% of the shoreline length, and the upland vegetation (mature ponderosa pine /open grassland) had been maintained to provide moderate coverage.

Segment 10 is a park developed for recreational purposes. The segment starts just to the south of the boat launch and includes the extensive beach area. Photo: Holmes, June 2008.

Appendix H. Orthophoto Delineation Statistics

Foreshore Class	Segment 1		Segment 2		Segment 3		Segment 4		Segment 5		Segment 6		Segment 7		Segment 8		Segment 9		Segment 10		Total Area	
	m	%	m	%	m	%	m	%	m	%	m	%	m	%	m	%	m	%	m	%	m	%
Coniferous	22,801	14	9,939	9	11,836	18	1,590	4	15,916	18	24,480	58	14,702	18	21,641	20	6,065	16	5,960	21	134,929	18
Deciduous	371	0	124	0	77	0	50	0	598	1		0	119	0	219	0	349	1	74	0	1,983	0
Aquatic Vegetation	16,448	10	16,999	15	3,319	5	8,131	19	1,260	1		0	3,561	4	3,063	3	3,078	8	1,052	4	56,909	7
Grassland	52,288	33	49,715	44	22,732	35	4,016	10	26,486	29	15,206	36	31,844	39	38,171	35	8,070	21	15,800	55	264,328	34
Lawn	9,071	6	4,819	4	5,422	8		0	9,516	11	10	0	2,459	3	16	0	4,965	13		0	36,277	5
Man-made structure	11,394	7	3,288	3	4,761	7		0	8,180	9	5	0	8,923	11	124	0	3,469	9	41	0	40,184	5
Mixed forest	9,781	6	486	0		0		0	5,443	6	804	2	1,754	2	5,877	5	1,277	3		0	25,421	3
Road (paved)	10,096	6	8,587	8	4,230	7		0	8,640	10		0	2,614	3	8,250	8	2,470	6	2,263	8	47,151	6
Road (unpaved)	4,848	3	1,882	2	1,239	2		0	1,364	2	84	0	5,520	7		0	1,753	5		0	16,689	2
Sand	13,460	8	5,204	5	5,839	9	2	0	3,901	4	137	0	6,111	8	19,099	18	4,576	12	2,774	10	61,104	8
Sand/Grass	5,813	4	8,657	8	3,161	5	192	0	8,166	9	1,325	3	2,938	4	4,786	4	2,026	5	420	1	37,483	5
Shrub (high)	2,012	1	92	0	123	0	10,541	25	268	0		0	164	0	4,040	4	134	0		0	17,373	2
Shrub (low)	434	0	2,963	3	644	1	8,829	21	435	0	394	1	116	0	2,364	2		0	51	0	16,230	2
Stream		0		0		0	2,272	5		0		0		0		0		0		0	2,272	0
Trail	630	0	1,091	1		0		0		0		0		0	1,259	1	34	0	250	1	3,265	0
Wetlands	449	0		0	684	1	6,309	15		0		0		0		0		0		0	7,442	1
Grand Total (m^2)	*159,897*	100	*113,847*	100	*64,066*	*100*	*41,932*	100	*90,171*	*100*	*42,445*	100	*80,824*	*100*	*108,909*	100	*38,266*	100	*28,685*	100	*769,042*	100

Appendix I. Digital Copy of the Wasa Lake FIM Report and Video Documentation