Arrow Lakes (Reservoir)
Foreshore Integrated Management Planning

Photo: Nakusp – Kootenay Rockies Tourism (https://www.kootenayrockies.com/partner/nakusp/)

Prepared For:
Living Lakes Canada and Project Partners

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EXECUTIVE SUMMARY

The desire to live and recreate in the Kootenay Region of British Columbia (BC), combined with the generally positive economic climate, has resulted in rapid population growth and urban development. Lake foreshore (or shoreline) residential development pressures (both permanent and seasonal) have especially increased. This development inevitably impacts the natural foreshore environment. Unfortunately, these impacts can diminish the natural values that draw people to live and recreate along the foreshore in the first place. Living Lakes Canada (LLC) has funded this Foreshore Integrated Management Plan (FIMP) through Fisheries and Oceans Canada (DFO) Nature Fund for Aquatic Species at Risk (SAR) Program. The objective of preparing a FIMP is to aid long-term lakeshore planning to protect high value fish and wildlife habitat values. The Arrow Lakes (more appropriately, and herein the Arrow Reservoir) is located between Revelstoke and Castlegar in the West Kootenay area. The FIMP study area is the section from Hugh Keenleyside Dam upstream to Arrowhead/Shelter Bay. The northernmost section extending upstream to Revelstoke (or the Revelstoke Reach) was not included. This study area includes an approximate 425 km of shoreline, which has been broken into 185 continuous segments as part of this study.

In addition to development pressure from settlement and regional growth, the Arrow Reservoir has experienced several other impacts. The most notable being the installation of dams and hydro facilities on the Columbia River, which have impacted fish and wildlife habitat in profound ways. Of these, the two dams most proximal to the project are: 1) the Hugh Keenleyside Dam, which was installed in 1968 and is located at the downstream end of the study area near Castlegar; and, 2) the Revelstoke Dam completed in 1973, located 5 km north of Revelstoke, outside the study area. Both dams influence water levels and preclude fish migratory access on the Columbia system. Other impacts in the watershed include forestry and agriculture. The study does not specifically address these cumulative impacts. Rather, it recognizes that maintaining a healthy shoreline is an important foundation to protect the fish and wildlife residing amongst the many pressures. Further, in this case, a natural shoreline is considered in a post flood scenario. This means that reference to a “natural” shoreline is based upon anthropogenic disturbances that have occurred to the natural shoreline ecosystems, from the full pool elevation of the reservoir. It is important for readers to understand the intent of this document and how it should be used, where many fisheries and wildlife studies on the reservoir focus on operational impacts. This assessment is focused on land use planning around the reservoir shoreline and is intended to help better manage residual habitats that remain, post flood.

FIMP is a framework intended to help governments, landowners, and nonprofit organizations understand lake foreshore habitat values and the potential ecological risks from proposed shore altering activities. The resulting information is used to help make land use planning decisions regarding foreshore development and conservation. The methods used are standardized to provide a consistent framework for assessing proposed shoreline development. One of the many benefits of the standardized process is that data from future surveys can be used to determine the rate of loss of natural shoreline. This rate of loss

understanding can help identify improvements to better manage natural foreshore values into the future. The FIMP methods have been developed to provide a habitat overview, recognizing that the budgets available are finite. Detailed assessments and planning are an integral part of the urban development process and must be incorporated at later phases of project planning, as necessitated by any existing legislation or permitting processes.

The following three standard FIMP steps were completed during this study (Schleppe et al. 2021):

1. Foreshore Inventory and Mapping (FIM) was first conducted and involved the collection of standardized field data from a boat viewing the shoreline. These data were supplemented with other available ecological datasets originating from a variety of sources (e.g., SAR Management Plans, BC Conservation Data Center, etc.). The foreshore was defined as the area from the deeper edge of the littoral region of the lake (i.e., where the start of pelagic region begins) to an area up to 50 m past the high-water mark (HWM) into the upland/riparian zone. Within this area, the following was counted, catalogued, and described: land use (e.g., residential development), modifications (e.g., retaining walls, docks, marinas), and biophysical attributes (e.g., riparian vegetation cover, substrates, large woody debris, and aquatic vegetation).
2. Shoreline habitat sensitivities were then determined using a ranking index called the Foreshore Habitat Sensitivity Index (FHSI). The index used FIM and other data to rank shoreline habitat value for fish, wildlife and ecosystems. The index was intended to "flag" areas of the greatest ecological sensitivity to change from urbanization. As part of the FHSI, the most sensitive habitats were identified as Zones of Sensitivity (ZOS).
3. The Foreshore Development Guide (FDG) was prepared to identify risks posed by different shore altering activities, to inform land use decisions. The FDG was intended to help mitigate or reduce the potential for negative effects to sensitive habitats owing to urban developments and identify areas for conservation (e.g., ZOS).

Overall, the FIM data revealed that 87% (440,241 m) of the shoreline was in a natural condition, while the remaining 13% (67,241 m) was disturbed. Disturbed areas were defined as an area altered by some form of anthropogenic activity/installation, such as commercial, industrial, or residential development. Associated pertinent FIM findings are as follows:

- Of the land uses, the Natural Areas land (areas of Crown Land not contained within a standard legal parcel) use was the most prevalent, extending along 66% of the shoreline. This was generally comprised of forested areas on steep terrain with limited or no road access to the shoreline. Rural Residential areas followed, representing 22% of the shoreline. A large proportion of these Natural and Rural Residential areas remained undisturbed, at 98% and 75% respectively).
- Of the given shore types, Rocky and Gravel shores were the most prevalent, occurring along 42% and 34% of the shoreline, respectively. Disturbance on these shore types was the greatest, with 7% and 23% of each disturbed, respectively. These areas are where

disturbance occurred the most, with 58% of the total shoreline disturbance occurring on Gravel and 23% on Rocky Shores. These shore types were generally associated with lower gradient areas that were easily accessible for land development. Stream Mouth and Wetland shore types, although present, were only present on a small proportion of the lake (4% each). These shore types provided some of the highest value habitats for fish and wildlife. Disturbance was evident within 14% of Stream Mouth and 7% of Wetland habitats, and efforts should be made to restore and preserve these and other high value areas moving forward.

- There were several modifications present. Of those with the highest counts, docks were the most abundant at 210, followed by gravel and concrete boat launches (189), retaining walls (103), and groynes (97). The 14 boat basins were notable with many in wetland habitat where dredging likely occurred to create them. There were also four marinas. Of the lineal modifications along the shoreline, substrate modification was the most apparent occurring along 7% (36,007 m) of the shoreline, followed by erosion protection (2.8% or 14,259 m). Other lineal modifications included road (2.4%), retaining walls (0.7%), and rail (0.9%) that were directly impacting foreshore values.

The FHSI identified numerous high value habitats around Arrow Reservoir for SAR, provincially and regionally sensitive species, and for maintaining general biodiversity. Criteria included:

- Standard FIMP biophysical data.
- Fisheries ZOS data: critical habitat for White Sturgeon, high value Burbot habitat, salmonid streams, juvenile rearing, and migration corridor/staging areas.
- Wildlife ZOS data: critical habitat for bank Swallows, Caribou, and Whitebark Pine; BC Red and Blue listed observations, Wildlife Habitat Areas for Grizzly Bear, Old Growth Management Areas, raptor nests, bat sites, and emergent vegetation areas.

The environmental values of these habitats were described (e.g., such as what made the critical White Sturgeon habitat important) based upon publicly available information found from previous studies conducted by agencies such as BC Hydro. A rationale for inclusion of these habitat values has been provided to help users understand the importance of these habitats and why these specific areas require protection from land alteration or disturbance.

The FHSI identified that 15.6% of shoreline had a Very High Ecological Rank, and 28.3% of the shoreline had a High Rank, which translates to approximately 79,758 and 143,886m, respectively. Almost all Wetlands and Stream Mouth shore types were included in these ranks, as well as other locations where important fish or wildlife habitat features were identified. Areas of higher value tended to have more overlapping habitats of importance. For instance, stream mouths of salmonid streams typically had high juvenile rearing values, extensive emergent aquatic vegetation, and other features such as raptors nests. Sites that had no identifiable habitats of importance generally tended to have a lower overall shoreline value when compared to areas with many overlapping habitat values.

Areas ranked as Moderate accounted for 42.8% of the shoreline or 217,923m. These areas occurred in locations that had fewer overlapping ZOS or were areas with important ZOS that were impacted by development. These areas were represented by all land use types, except for "Other" which was shoreline that is typically so modified it is unrecognizable or doesn't fit a specific natural shoreline type (e.g., some of the area around Hugh Keenleyside dam).

Areas of Low and Very Low Ecological Rank occurred along 13.3% or along 67,649 m of shoreline. These areas occurred predominantly in areas of increased development intensity, and entirely included the Shore Type. Low ranked areas were also scattered across the other land uses to at least a small degree. Areas with more intense development often lose many of the habitat values that were originally present, highlighting the importance of protection of natural areas in any development process.

The Arrow Reservoir has not seen the same development pressures of other more highly developed lakes in the region (such as Kootenay or Windermere lakes). Nonetheless, development has occurred, and more is anticipated as the area grows in popularity for recreational use. This report, and the shoreline habitat values it identifies, are thus intended to help with land use planning that should precede future development.

Recommendations have been presented to help all levels of government utilize these findings and move towards more sustainable urban development practices. Recommendations were categorized by type, and include measures to address cumulative impacts, restoration, and other planning related needs.

The FDG presents recommendations and tools to aid in identification and planning so high value environments and ZOS are conserved during development (see Appendix C).

ACRONYMS

FIMP Methods	Meaning
CDC	Conservation Data Center
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DFO	Fisheries and Oceans Canada
CMN	Community Mapping Network
EKILMP	East Kootenay Integrated Lake Management Partnership
FDG	Foreshore Development Guide
FHSI	Foreshore Habitat Sensitivity Index
FHSI Category	Foreshore Habitat Sensitivity Index Category
FHSI Criteria or Criterion	Foreshore Habitat Sensitivity Index Criteria
FHSI Ecological Rank	Foreshore Habitat Sensitivity Index Ecological Rank or output
FIM	Foreshore Inventory and Mapping
FIMP	Foreshore Integrated Management Planning
FRPA	Forest and Range Protection Act (BC)
GIS	Geographic Information Systems
GPS	Geographic Positioning System
HWM	High Water Mark
LLC	Living Lakes Canada
LWD	Large Woody Debris
MoF	Ministry of Forests (BC)
QEP	Qualified Environmental Professional
SARA	*Species at Risk Act* (federal)
TEK	Traditional Ecological Knowledge
WHA	Wildlife Habitat Area (BC designation under FRPA)
ZOS	Zone of Sensitivity

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1.0 INTRODUCTION

Living Lakes Canada (LLC) is part of a global network of over 130 non-governmental organizations that facilitates collaboration in education, monitoring, restoration, and policy development initiatives for the long-term protection of Canada's lakes, rivers, wetlands, and watersheds. LLC has a mandate to help Canadians understand, adapt, and mitigate the impacts of climate change on water quality and quantity, biodiversity and healthy human communities through grassroots water stewardship activities. LLC helps bridge the gap between science and action to foster and normalize citizen-based water stewardship. Declines in lakeshore conditions are occurring globally, and LLC funded this shoreline mapping project through Fisheries and Oceans Canada (DFO) Canada Nature Fund for Aquatic Species at Risk (CNFASAR) Program to help aid better long-term lakeshore planning and protect aquatic Species at Risk (SAR) in the Kootenay Region of British Columbia (BC).

LLC has contracted the team of Ecoscape Environmental Consultants Ltd (Ecoscape) and Lotic Environmental Ltd (Lotic Environmental) to complete Foreshore Integrated Management Planning (FIMP) on the Arrow Lakes Reservoir (Project). The Project involved using the recently revised FIMP methods (Schleppe et al. 2021).

1.1 Foreshore significance and development pressures

The desire to live and recreate in the Kootenay Region of BC, combined with the generally positive economic climate in BC and Alberta, has resulted in rapid population growth and development. This growth has increased the value of all property, and in particular waterfront property for recreational or permanent residences. As a result, commercial and residential development pressures have increased along lake foreshores (or shorelines).

To date, development on Arrow Reservoir has not been quite as extensive as some other lakes (such as Kootenay or Windermere lakes). This is likely due to its more isolated setting, as well as its considerable drawdown zone, making it not quite as favourable as other unregulated lakes closer to larger centers. However, development pressures are mounting, particularly as other lake areas get overpopulated and built out (e.g., in the Shuswap, Okanagan, and Kootenay Lake), resulting in higher prices for waterfront land. Typically, these developments are single-family homes. Due to greater affluence or borrowing ability, new larger buildings are often constructed to replace historically smaller lakefront cabins. The total footprint area is also often expanded to include a greater number and/or larger size of outbuildings and other shoreline modifications (e.g., marinas, groynes, retaining walls and docks). These developments inevitably impact the natural foreshore environment through removal of riparian and aquatic vegetation. Unfortunately, these impacts can diminish the natural values that draw people to live and recreate along the foreshore in the first place. Ultimately, the goal should be to maintain a balance between anthropogenic and natural values to the benefit of all residents and species that rely upon the lake. Most

importantly, development in high valued habitats should be avoided or remain at a low density.

The foreshore is ecologically significant because it is the transitional community between aquatic and terrestrial habitats. This area provides a high diversity of habitat types for fish and wildlife such as aquatic vegetation, deep and shallow lake edges, stream mouths, wetlands, and riparian vegetation. The foreshore also serves many beneficial ecological functions such as providing foraging, nesting and rearing areas for aquatic and terrestrial fauna; buffering the watercourse from contaminants; and maintaining bank stability (e.g., DFO 1992). Even though there are several legislative mechanisms in place to help protect the foreshore (e.g., *Federal Fisheries Act*, *BC Water Sustainability Act*, Local Government Official Community Plans, etc.), anthropogenic pressures often result in incremental losses leading to habitat fragmentation and degradation. These impacts can reduce the ability of a lake to provide habitat necessary to sustain healthy populations of fish, wildlife, and ecosystems.

As a result of ongoing urban development pressures and evidence of degradation, Foreshore Inventory and Mapping (FIM) was implemented in BC, starting in 2004 by the Community Mapping Network and Regional District Central Okanagan (see Schleppe et al. [2019] for a summary of methodological development). In 2020, the methods were updated, and the assessment framework was renamed Foreshore Integrated Management Planning or "FIMP". Although the name has changed, the primary objective of the FIMP process remains to identify environmental values of importance and provide land-use planning guidelines to reduce impacts on high value areas. The science-based methods were developed with input from all levels of government (federal, provincial, regional, and municipal), Indigenous Peoples, lake stewardship groups and professional consultants. The intent is that the outputs, including those specific to Arrow Reservoir, receive support from these groups and are relied upon during development planning.

In addition to development pressure, other large-scale activities in the watershed include dams and hydroelectric operations, logging, mining, and agriculture. Further, the lakes are not sheltered from climate change impacts. These impacts have generally been considered in this report in a broad sense. There is a long and complex history of significant effort to understand and manage the impacts of these activities to meet a balance and maintain the high valued fish and wildlife resources throughout the watershed.

1.2 General geography

The Arrow Reservoir is located in the southern interior of BC, in the West Kootenay Region. The lakes are located between the communities of Castlegar (south end) and Revelstoke (north end), in the valley between the Monashee (west) and Selkirk (east) mountains ranges.

The lakes are gazetted as the Upper Arrow Lake and Lower Arrow Lake, but now are more accurately referred to as the Arrow Reservoir, given dam installations (see below). The lakes are widenings of the Columbia River. The two lakes were originally 30 km apart; however, upon installation of the Hugh Keenleyside Dam, the lakes became one long 230 km reservoir (Sebastian et al. 2000). At low water, the two lakes remain distinct, connected by a fast-moving section known as The Narrows.

Revelstoke and Castlegar are the largest cities along the shoreline, with populations of just under 8,500 each (Statistics Canada 2022). Nakusp is the third largest community, with a population of 1,589. There are many other smaller communities bordering the shoreline (e.g., Beaton, Shelter Bay, St Leon, Shoreholme, Arrow Park, East Arrow Park, Burton, Fauquier, and Edgewood). There are also three ferry crossings: at the north end between Galena Bay and Shelter Bay, between Needles and Fauquier, and in the south between West and East Arrow Park. Several tributaries flow into the lakes. The main body of the Arrow Lakes ranges from being ~ 4.5 km wide (in the north near St Leon and Shelter Bay) to being less than 1 km wide in the Narrows. Mountain sides are primarily forested and rise steeply to elevations as high as 2,300 m above sea level.

In addition to environmental impacts from foreshore development that are documented in this study, Arrow Reservoir has also experienced pressures related to other industrial activities. Most notably, the installation and operation of the dams on the Columbia River have impacted aquatic habitats. Other uses along the shoreline include many forestry based operations that process, sort, store, and move logs within and around the reservoir (e.g., log yards).

1.3 Study area

The upstream end of the FIMP study area starts at the historic Upper Arrow Lake upstream confluence of the Columbia River, as marked by (and includes) Arrowhead/Shelter Bay and Beaton Arm. The study area extends south to the Hugh Keenleyside Dam in Castlegar, a lineal centerline distance of 200 km (Figure 1).

The Revelstoke Reach extending upstream from Arrowhead/Shelter Bay to Revelstoke was not included in this project. This area is more closely associated with former riverine habitat and has very different habitat values when compared to the areas that were historically lakes. It is acknowledged that ‘The Narrows’, between the former Upper and Lower Arrow Lakes are more similar to the Revelstoke Reach.

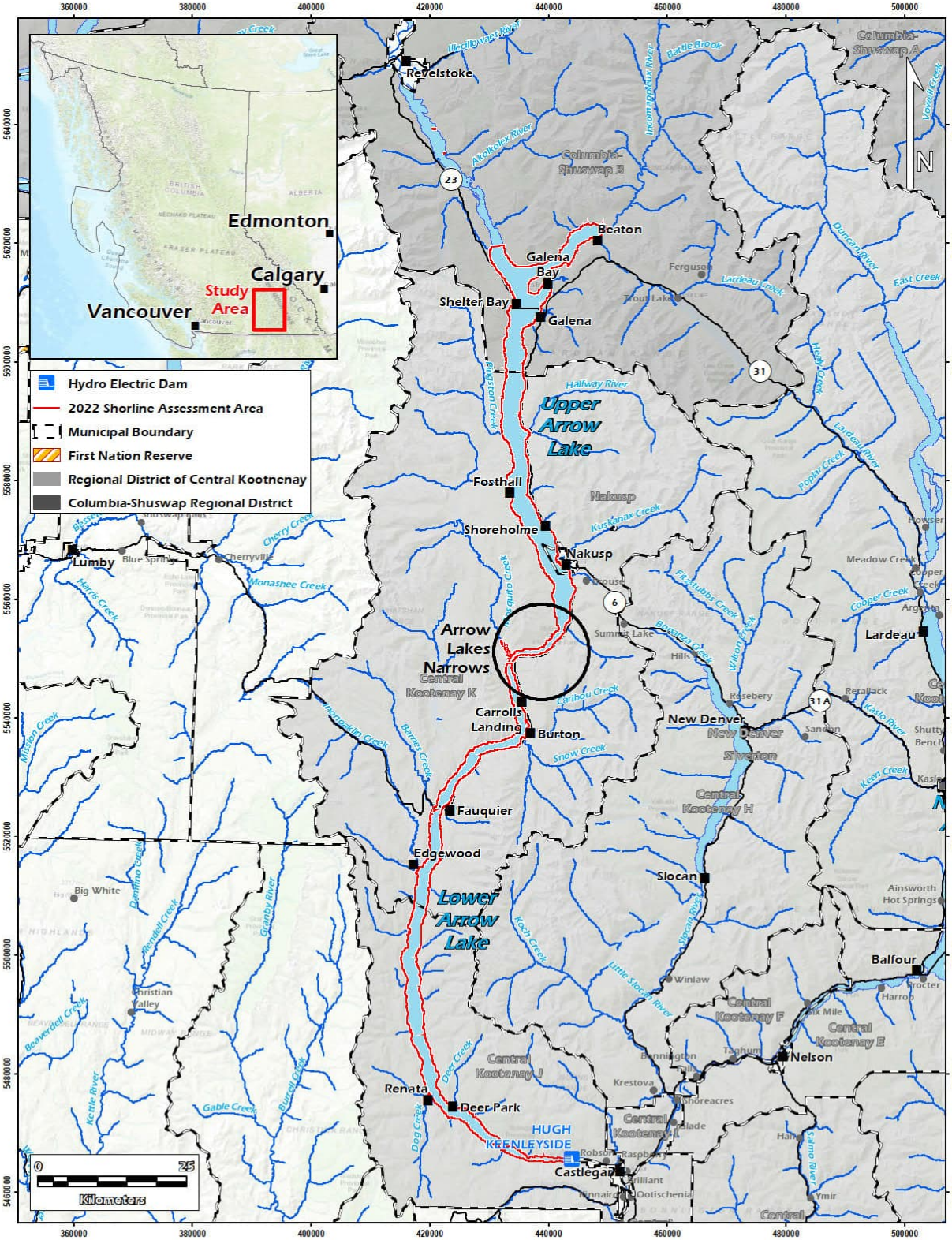


Figure 1. Arrow Lakes Study Area

1.4 Dams and hydroelectric facilities on Columbia River that impact the Arrow Lakes

The installation of dams and hydroelectric facilities on the Columbia River had significant, permanent changes to areas relied upon by fish and wildlife as habitat in the Arrow Lakes study area, acknowledging that humans also rely upon these same habitats. A brief overview is provided here for the historical context of major changes seen in the watershed that have occurred to date. Recognizing the resilience of fish and wildlife to these operational water management impacts is an important starting point to help protect the high value habitats that remain. It is recognized that this summary is fish centric, given the literature reviewed. Additional fish and wildlife impacts are presented in Section 4.0.

Prior to any dam installation on the Columbia River, the Upper Columbia River was accessible to anadromous salmon species, with Sockeye, Chinook and Steelhead ascending through the Arrow Lakes (Sebastian et al. 2000). These migratory runs completely ceased with construction of the Grand Coulee Dam in the late 1930s (Sebastian et al. 2000).

1.4.1 The Columbia River Treaty and the Columbia River Water Use Plan:

The Columbia River Treaty came into force in 1964 and is an international agreement between Canada and the United States to develop and operate three storage facilities in BC to regulate flows on the Columbia and Kootenay rivers (BC Hydro 2007). The primary objective of the Treaty is to optimize flood control and power generation in both countries, for which Canada is compensated (Canadian Columbia River Forum 2008). Under the terms of the Treaty, BC Hydro built and now operates 15.5 million acre-feet (MAF) of storage at the Mica (7.0 MAF), Hugh Keenleyside (7.1 MAF), and Duncan (1.4 MAF) facilities (BC Hydro 2007). There is no specified termination date for the Treaty; however, the earliest the Treaty may be terminated by either party is 2024, provided notice is given 10 years prior (Columbia River Water Use Plan Consultative Committee 2005). The United States and Canada are currently in negotiations to modernize the Treaty.

The Columbia River Projects Water Use Plan (WUP) defines how the water control facilities will be operated and was developed following a multi-stakeholder consultative planning process (Columbia River Water Use Plan Consultative Committee 2005). The WUP was reviewed by provincial and federal agencies and accepted by the provincial Comptroller of Water Rights (Columbia River Water Use Plan Consultative Committee 2005).

1.4.2 Hugh Keenleyside facility

Hugh Keenleyside Dam (formerly known as the High Arrow Dam) spans the Columbia River 8 km upstream of Castlegar and was completed in 1968 (Columbia Basin Institute no date). The dam was installed by BC Hydro to regulate the flow of the Columbia River and end the annual threat of flood damage in BC, Washington and Oregon under the Columbia River Treaty (Canadian Columbia River Forum 2008). The facility consists of an earth fill dam, a

concrete dam, four spillways, eight low-level outlets (ports) and a navigation lock (Columbia River WUP Consultative Committee 2005). The original facility was not constructed to have power generating capacity. However, the Arrow Lakes Generating Station was installed in 2002, immediately downstream of the Hugh Keenleyside Dam, under a joint venture between the Columbia Power Corporation and Columbia Basin Trust (Columbia Power Corp. 2022 and Columbia River WUP Consultative Committee 2005).

The Hugh Keenleyside Dam caused water to rise 12 m above natural levels, transforming the Upper and lower Arrow lakes into the Arrow Reservoir (Canadian Columbia River Forum 2008). This had far-reaching impacts. For example, two thirds of the arable land in the valley was lost, and approximately 2,000 people subsequently needed to be relocated (Canadian Columbia River Forum 2008). The increased water levels inundated high-quality fish spawning and rearing habitat in tributaries. The total stream habitat losses were estimated to be 203 km (Thorley 2008), and about 90% of this by area was low-gradient, high-quality habitat (Fish and Wildlife Compensation Program (FWCP) 2019). This equated to a loss of approximately 20% of the Kokanee spawning habitat in tributary streams, not counting the unaccounted losses in The Narrows (Andrusak 1969, Sebastian et al. 2000). Cumulatively, these impacts are considered significant.

1.4.3 Mica facility

The second impact on the Arrow Lakes was the Mica Dam and generating station, located 137 km north of Revelstoke. This facility was also built under the terms of the Columbia River Treaty and is operated by BC Hydro (Canadian Columbia River Forum 2008). The facility was completed in 1973 and now consists of an earth fill dam, outlet works and a chute spillway (Columbia River WUP Consultative Committee 2005). The Mica generating station was installed in 1977, with four of the six generating units initially installed (BC Hydro 2016). In 2016, the two remaining units, Mica 5 and 6, were installed (BC Hydro 2016).

Kinbasket Reservoir was formed by this dam (Columbia River WUP Consultative Committee 2005). The Mica dam blocked migratory fish access to potentially hundreds of kilometers of river and stream habitat upstream of the reservoir to spawn and rear (Bassett et al. 2022; Sebastian et al. 2000). The Mica Dam also caused long-term changes in light penetration and nutrients in the lentic habitat of Arrow Lakes Reservoir (Bassett et al. 2022).

1.4.4 Revelstoke facility

The third major impact on Arrow Lakes was construction of the Revelstoke Dam and associated facility. The dam is situated at the upstream end of the Arrow Lakes, 5 km north of Revelstoke, and is operated by BC Hydro. The facility was completed in 1984 and consists of an earth fill wing dam and a concrete gravity main dam (Columbia River WUP Consultative Committee 2005). The main dam includes the power intakes with steel

penstocks and spillway facilities (Columbia River WUP Consultative Committee 2005). The powerhouse originally had four operating units, with space to install two additional units (Columbia River WUP Consultative Committee 2005). Unit 5 was brought online in 2010, and Unit 6 was postponed indefinitely because BC Hydro's Integrated Resource Plan is not forecasting a need over the next 20 years (BC Hydro 2020, BC Hydro 2023). Although the Revelstoke Dam facility is not covered directly under the Columbia River Treaty, it may be called upon by the Treaty to provide flood control (Columbia River WUP Consultative Committee 2005).

The Revelstoke Dam construction resulted in the formation of the Revelstoke Reservoir. It is fed largely by the flow discharged from the Mica facility, with additional local inflow (Columbia River WUP Consultative Committee 2005). Following installation, 30-50% of fish spawning habitat upstream of the dam was estimated to be lost, with an estimated 500,000 Kokanee, 1000 Rainbow Trout and 4,000 Bull Trout spawners, all of Arrow origin, believed to be blocked at the dam (Martin 1976, Lindsay 1977, and Paish 1974). This dam also caused long-term changes in light penetration and nutrients in the lentic habitat of Arrow Lakes Reservoir (Bassett et al. 2022).

1.4.5 Other dams

Two other dams are located within the watershed. The Whatshan Dam is a hydroelectric facility that diverts water from Whatshan Lake to Arrow Lake in a different location from its original outlet. The Whatshan River flows directly into the Arrow Lakes, just north of the Needles-Fauquier Ferry (Wikipedia 2022b). There is also private run-of-river hydro project on Fosthall Creek, near Nakusp. The impacts of these facilities are not discussed here, as their influence on fish and wildlife were either presumed to be encapsulated with the impacts of the other facilities described above, or the impacts incurred were outside of the project area.

1.4.6 Ongoing impacts from dam operations

The terms and conditions authorized under the BC *Water Act* for the beneficial use of water at the Columbia River hydroelectric facilities are set out in the Columbia River Projects WUP (BC Hydro 2007). The Columbia River Projects WUP also identified several soft constraints to balance the wildlife, recreation, fisheries, culture and heritage, shoreline conditions, and power generation interests on the reservoir (BC Hydro 2007). Given the nature of this FIMP study, only very generalized information is provided here, and the Columbia Rivers Projects WUP should be reviewed for detailed information. Further, it should be noted that reference to "natural" condition infers areas that were natural, post flooding of the reservoir, that have not experienced further anthropogenic impacts. It is acknowledged that all shores of the reservoir have been altered by creation of the operational facility. The intent of this study is to provide a summary of lake wide habitat values at or around the reservoir full pool elevation to better aid land use decision processes (e.g., local

government decisions, public dissemination of available habitat data, etc.) for activities above the full pool elevation of the reservoir.

The Arrow Reservoir is licensed to operate between the normal full pool elevation of 440.1 m and minimum pool elevation of 418.6 m (BC Hydro 2007). The maximum allowable vertical fluctuation between full pool and full drawdown is thus 21.5 m. The Arrow Reservoir is subjected to marked daily fluctuations in flow and seasonal variations in water depth from hydro operations, especially in the upper reaches (Robichaud et al. 2014; Figure 2). From the spring of 2021 through spring of 2022, water levels changed 13 m between the summer (high) and winter (low). This change was consistent with documented historic records of average seasonal changes (e.g., 12 m from 1984 to 2008, and 10.5 m from 2009-2013 [Hawes et al. 2014]). These changes have the potential to influence the environmental conditions for fish and wildlife inhabiting the drawdown zone.

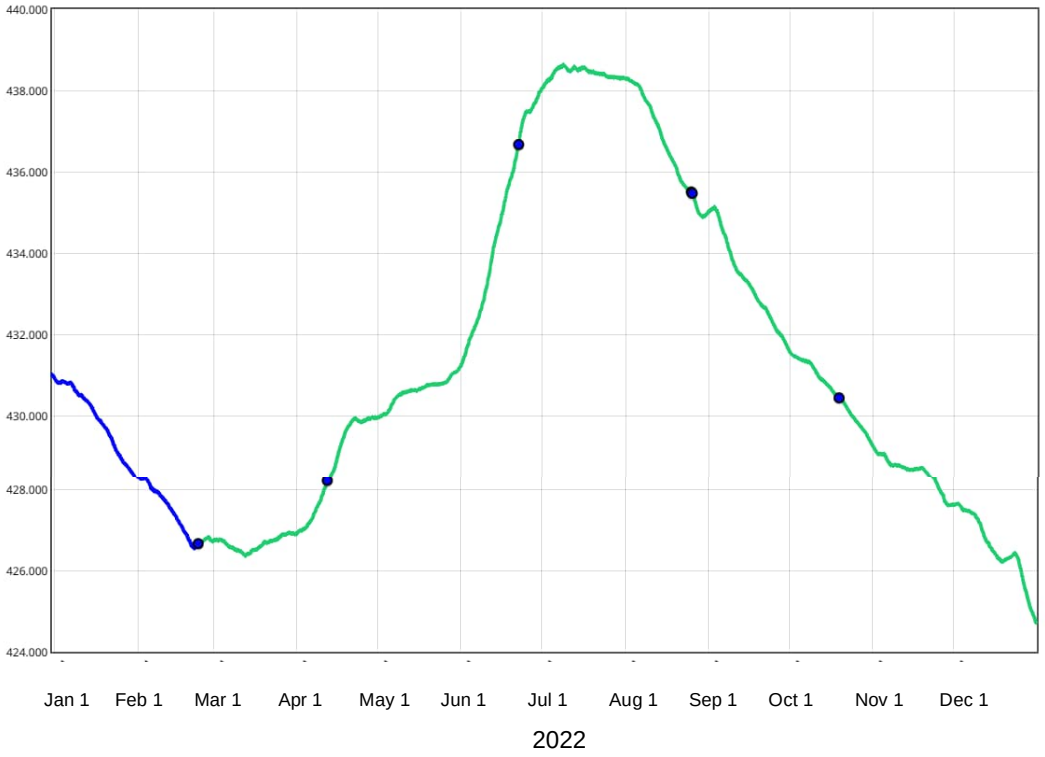


Figure 2. Arrow Reservoir at Nakusp water levels (m), January 1 – December 31, 2022 (Station 08NE104, Environment Canada 2023).

In accordance with the Columbia River Projects WUP, BC Hydro is required to monitor impacts associated with the facilities (Columbia River WUP Consultative Committee 2005 and BC Hydro 2007). The monitoring program was set out to study key uncertainties to enable improved operating decisions (BC Hydro 2007). Implementation of several of the monitoring programs and works are conditional on the results and outcomes of other

monitoring programs or feasibility studies (BC Hydro 2007). Additionally, Arrow Lakes Reservoir has its own Operations Management WUP, as per the Columbia River Order under the BC *Water Act,* dated January 26, 2007 (BC Hydro 2021). Through these plans, several monitoring and enhancement programs have been undertaken to assess and address environmental impacts both within and immediately upstream of this project's study area. These have been summarized in Section 4.0.

In addition to affecting fish and wildlife inhabiting the drawdown zone, the changing water levels impact recreational activities. Boaters need to be aware of changing water levels in the reservoir throughout the year due to dam operations. The Hugh Keenleyside dam is equipped with a navigation lock, which is available at no charge.

1.5 White Sturgeon – Species at Risk

The Upper Columbia River Population of White Sturgeon is an endangered species both federally under the Species at Risk Act (SARA; Schedule 1[1]) and Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and provincially. As described in the White Sturgeon Recovery Strategy (DFO 2014):

> *This population historically had access from the ocean to Columbia Lake in the upper Columbia River. This population has been affected by several anthropogenic impacts, but the main influence on aquatic habitat has been the construction of large mainstem dams and subsequent river regulation. Impacts likely first occurred in 1942 with the completion of Grand Coulee Dam downstream of the Canada-U.S. border. This dam resulted in the loss of anadromous salmon returns to the upper Columbia River, which were likely a main source of prey for White Sturgeon. The construction of Hugh Keenleyside (1968) and Mica (1973) dams further fragmented and altered habitat.*
>
> *The Arrow Lakes Reservoir population is distinct within the Upper Columbia and extends from the Revelstoke Dam downstream to the Hugh Keenleyside Dam. White Sturgeon abundance here is substantially lower than elsewhere in the Upper Columbia. Radio-tagged sturgeon have been observed to overwinter at Beaton Flats and several move during spring and summer upstream to Revelstoke or into Beaton Arm near the confluence with the Incomappleux River. The total estimated population abundance in the Arrow Lakes Reservoir is 52 wild fish greater than 40 cm total length (Golder 2006). Failure of juveniles to recruit into the population is ongoing, with mainly older adults present. This skewed age structure is insufficient to support a self-sustaining population.*

[1] Schedule 1 is the official federal list of wildlife species at risk, which receive legal protection under SARA.

Risks to the Upper Columbia White Sturgeon population were identified and are related to dam installations and operations, as well as other developments/activities. The high and moderate risks on this population are as follows (DFO 2014):

High risk:

- *Loss of habitat quality and quantity - associated with flow regulation (e.g., affecting geomorphology, depth, velocity, substrate), as well as gravel and sand extraction; upland, foreshore, floodplain and estuary use and development, including bank protection, dyking and infilling, and other in-channel works.*
- *Habitat fragmentation – caused by impassable dams and inadequate flows or water level changes.*
- *Altered hydrograph components - related to flow regulation, flow diversion, and anthropogenic activities causing climate change.*
- *Change in ecological community (predation/competition) – caused by flow regulation, species introductions and movements, fishing effects, habitat alteration, and anthropogenic activities causing climate change.*

Moderate:

- *Pollution - sources include industrial inputs (pulp mill effluents, various wastewater, and smelting effluents), municipal and domestic sanitary and storm sewage, non-point source urban runoff, point source agricultural discharges and chemical over-sprays, and non-point source agricultural runoff.*
- *Fishing and industrial – fishing concerns include poaching, recreational catch-and-release, scientific inquiry and monitoring, aboriginal and commercial net fisheries, and by-catch in the aboriginal and recreational fisheries. Industrial effects include interactions with industrial facilities or operations, including equipment at hydro-electric facilities (turbines, draft tubes, locks).*
- *Reduced turbidity - may be related to flow regulation and stream channelization, which can influence water clarity.*
- *Altered thermal regime - affected by flow regulation and anthropogenic activities causing climate change.*
- *Reduced or altered food supply (including fishing of white sturgeon prey base) - affected by commercial, Aboriginal, and recreational fishing; upland, foreshore, floodplain and estuary development; dams (fragmentation and hydrograph changes); and anthropogenic activities causing climate change.*

Monitoring works completed by BC Hydro to better understand the effects of water management operations (i.e., dams and their operations) on White Sturgeon and other fish and wildlife species are provided in Section 4.0, including efforts for recovery.

1.6 Climate change

Although outside of the scope of this study, the effects of climate change on the health of aquatic and terrestrial habitats are also to be considered during foreshore planning. Any shoreline development that creates newly subdivided lots on natural areas will inevitably result in loss of green space such as mature forest, contributing to climate related impacts. Like shoreline losses, these individual impacts are small in and of themselves, but add up cumulatively. For this reason, avoiding densification processes, such as subdivision or rezoning, along the shoreline is extremely important for both habitat related reasons and those associated with climate change.

Climate change also has the potential to result in alterations to the hydrologic regime. In the Upper Columbia Basin, the predicted changes typically result in higher winter flows, earlier snowmelt, elevated peak flows, and lower summer flows (Carver 2022). Maintaining natural habitats help with an ecosystem's resilience to these changes, particularly when hydrologic regimes are expected to change.

1.7 Foreshore Integrated Management Planning Framework

FIMP is intended to help governments, landowners, and nonprofit organizations understand lake foreshore habitat values and the potential ecological risks from proposed shore altering activities (Schleppe et al. 2021). The outputs are used to help make decisions regarding foreshore development and conservation. The methods are standardized to provide a consistent framework for shoreline development reviews. One of the many benefits of the standardized process is that if data from previous surveys are available, the rate of loss of natural shoreline can be determined. Understanding rates of loss on any lake is important to better manage the shoreline. The methods have been developed to provide an overview of ecological values of the shoreline, recognizing that budgets available are usually finite. These data and analytical results are primarily intended to aid land use planning, and they may not identify site specific habitats of importance. Detailed assessments and planning are integral for individual developments planned and must be incorporated as necessitated by regulatory requirements, conservation strategies, etc.

The FIMP process follows three general steps (Schleppe et al. 2021):

1. Shoreline inventory and mapping is conducted following the FIM protocols. FIM consists of collection of standardized field data, which are supplemented with available ecological datasets originating for a variety of sources (e.g., Species at Risk Management Plans, Official Community Plans, etc.).

2. Shoreline habitat sensitivities are determined using a ranking index called the Foreshore Habitat Sensitivity Index (FHSI). The index is a simple, cost-effective method to approximate shoreline values collected from numerous datasets and is developed using assessments, inventories, and professional opinions. The index is intended to act as a "flagging" tool to identify areas of greatest sensitivity to change from urbanization.
3. The Foreshore Development Guide (FDG) is prepared to identify risks posed by different shore altering activities, to inform land use decisions. The FDG is intended to help mitigate or reduce the potential for negative effects to sensitive habitats owing to urban developments.

1.8 FIMP during regulatory reviews

The shoreline areas of Arrow Reservoir are managed by numerous federal, provincial, regional, local agencies and Indigenous Peoples. Each governing agency/regulator has certain activities that they are responsible for managing, as specified by legislation (e.g., acts, regulations, bylaws and policies, and legal precedents; Table 1). For instance, the Federal government is responsible for managing fish and their habitats, species at risk, and navigation; the Province of BC manages all areas in and around lake (or stream) water bodies; regional and local governments review land use activities on properties within their jurisdictional areas; and Indigenous Peoples review land use activities on properties within traditional territory. The FIMP outputs (FDG maps in particular), have proven to provide reviewers with a clear, consistent, and coordinated management strategy to protect high value shoreline environmental values during the development review process. Key regulatory requirements triggered by foreshore development proposals are summarized below, while a full listing of other potential requirements is provided in the FDG. Despite regulatory requirements, there are still documented impacts resulting from shoreline urbanization, inferring the need for more stringent requirements to maintain ecological values.

Table 1. Summary of Arrow Reservoir governing agencies.

Level	Agency	Applicable Legislation
Federal	Fisheries and Oceans Canada (DFO)	*Federal Fisheries Act*, *Species At Risk Act*, *Navigation Protection Act*
Provincial	Ministry of Forests Ministry of Environment and Climate Change Strategy	*Water Sustainability Act*, *BC Park Act*
Regional	Regional District of Central Kootenay Columbia – Shuswap Regional District	*Local Government Act* - Official Community Plan and associated bylaws
Local	City of Nakusp	*Local Government Act*- Official Community Plan and associated bylaws
First Nation	Ktunaxa Nation Council, Secwepemc / Shuswap Nation Tribal Council, and Syilx / Okanagan Nation Alliance (Province of BC 2023a)	Official Community Plan and associated bylaws, provincial or federal referrals on land and resource decisions that could impact their treaty rights or aboriginal interests.

1.8.1 Federal government

For projects near fish bearing waterbodies, the Federal *Fisheries Act* requires Project Reviews to ensure works adjacent to or within watercourses do not result in the harmful alteration, disruption, or destruction of fish habitat (HADD). Where a HADD may occur, an Authorization from DFO is required that clearly demonstrates that avoidance, mitigation and appropriate compensation or offsetting measures are in place. Also, because the lake and shoreline have identified Critical Habitat for several species (Sturgeon, Caribou, Bank Swallow, and Whitebark Pine [Section 4.0]), the *Species at Risk Act* (SARA) is also applicable in some areas.

1.8.2 Provincial government

In BC, the foreshore is generally defined as the land between the high and low water mark. This area is considered provincial Crown Land (in almost all cases, with a few rare exceptions) and includes the permanently wetted lake area (Province of BC 2022b). The public retains the right to access Crown Land even if the upland is privately owned. Provincial authorization is required for any developments (e.g., installation of docks, and retaining walls) on this Crown Land. This includes, but is not limited to, obtaining *BC Lands Act* leases/licenses to occupy the land (i.e., to install a permanent structure) and/or

obtaining a BC *Water Sustainability Act* Approval or Notification for Works in and About a Stream.

The BC *Lands Act* also governs Crown Land, where upland property ownership abuts the Present Natural Boundary (PNB). The PNB is determined through a legal survey and is defined as (Province of BC 1996): *"The visible high-water mark (HWM) of any lake, river, stream or other body of water where the presence and action of the water are so common and usual, and so long continued in all ordinary years, as to mark on the soil of the bed of the body of water a character distinct from that of its banks, in vegetation, as well as in the nature of the soil itself*."

In the case of reservoirs operated by BC Hydro such as Arrow, land ownership and the concept of PNB are more complicated (see Surveyor General 1987 for clarification), where Present Natural Boundary still occurs at the original river or lake margin. Through their operating agreement(s), BC Hydro is allowed to flood the inundation areas of the reservoir within the operational constraints of the high and low water elevations defined in the license(s) for the system. A full comparison of PNB within the inundation areas of the reservoir littoral zone has not occurred as part of this study, nor has investigation into the varying BCH licenses or operational requirements that exist. Appropriate professionals should be contacted to better understand property ownership or other similar questions such as Present Natural Boundary, full pool, where is the HWM/full pool, etc. It is acknowledged here that all representations of property lines, high water mark, etc. made in this report are not to replace or be relied upon for the purposes of property delineation or BCH operationally allowed activities such as reservoir management and inundation limits or extents (i.e., our representation of HWM does not infer this is the exact location of areas BCH can inundate for example and is intended to merely represent the approximate location based upon available data).

On Arrow Reservoir, because of historic flooding, it is acknowledged that property ownership may be more complicated than an unregulated system, such as Shuswap Lake for example.

1.8.3 Regional districts

The Arrow Reservoir study area spans two regional districts, the Columbia-Shuswap Regional District (CSRD) and the Regional District of Central Kootenay (RDCK). These are broken out into the following areas (Figure 1):

- The north end of the study area, downstream to just past Shelter Bay is within the CSRD Area B.
- The central section downstream to just past Edgewood is within the RDCK Area K.
- The southernmost section (to Hugh Keenleyside Dam) is within the RDCK Area J.

In accordance with the *Local Government Act,* each jurisdictional area has its own land management policies as identified in their respective bylaws/policies/Official Community Plans (OCPs). Within the study area, the regional districts generally had few specific policies or bylaws (e.g., Development Permit Areas) aimed at protecting the sensitive foreshore environment (Table 2). The main policy offering environmental protection was in Area K, which requires an Environmentally Sensitive Residential Cluster Development Permit (ESRC DP) on residential properties. However, there was no direct mention of a QEP being required to provide an assessment of the development, and the DP area did not apply to other land use types (e.g., industrial, agriculture, commercial, institutional or parks), which too may have associated environmental risks.

There are examples of regional districts having DP requirements outside the study area. For example, in the RDCK electoral areas A, D and E on Kootenay Lake, DP areas are identified to be within 15 m or 30 m of the watercourse in the respective bylaws (RDCK 2013a, 2016, and 2013b). In the future, the RDCK's intention is to link the OCPs to the FIMP results throughout their region (N. Wight pers. comm. 2022). In the East Kootenay, the Regional District of East Kootenay (RDEK) has linked their DP areas to FIMP outputs. The Windermere Lake OCP for example, requires a DP when development is proposed within a 'red' or 'orange' zone (RDEK 2019) as identified in the original shoreline management guidelines (East Kootenay Integrated Lake Management partnership [EKILMP] et al. 2009). Similarly, the CSRD has a DPs related to both riparian protection[2] and sewerage systems within 100 m of Shuswap Lake to address water quality concerns and risks[3]. Also, most areas with the Lower Mainland, Vancouver Island, and the Okanagan / Shuswap regions have some form of DP requirement for lakefront or streamside developments. These have been established either through the Provincial Riparian Areas Protection Regulation, through their own bylaws or OCPs, or some combination thereof.

[2] https://www.csrd.bc.ca/DocumentCenter/View/706/Riparian-Areas-Regulation-RAR-Development-Permit-Area-PDF

[3] https://www.csrd.bc.ca/DocumentCenter/View/705/Lakes-100-Metre-Development-Permit-Area-PDF

Table 2. Summary of regional district and municipality bylaw requirements for Arrow Reservoir shoreline protection.

Jurisdict-ion	Electoral Area and Bylaw	Foreshore environmental development permit (DP)?	Bylaw Section reference: summary of DP (or other environmental related) requirements
CSRD	Electoral Area B - Zoning Bylaw No. 851 (CSRD 2022)	No Environmental Development Permit.	Section 5.2.1: Foreshore and Water Zone - permitted uses are listed, which include: • boat lift, dock, walkway and private mooring buoy - that are accessory to a permitted use on an adjacent waterfront. • livestock grazing, log dump, navigation and accessory uses to navigation, park and accessory uses to a park, passive recreation, public utility and swimming platform. Specifications for the above are provided (size, density, etc).

Jurisdict-ion	Electoral Area and Bylaw	Foreshore environmental development permit (DP)?	Bylaw Section reference: summary of DP (or other environmental related) requirements
RDCK	Electoral Area K - The Arrow Lakes Official Community Plan Bylaw No. 2022 and associated schedule (RDCK 2009).	Environmentally Sensitive Residential Cluster Development Permit (ESRC DP) area.	Section 19: The ESRC DP area is designated for protection of the natural environment, its ecosystems and biological diversity and the establishment of objectives for the form and character of intensive residential development. This DP area is comprised of all privately owned or leased lands designated as Community Residential (R1), Country Residential (R2) and Rural Residential (R3) on the associated map schedule. Ecological related guidelines: minimize impervious cover; retain existing vegetation, where possible; protect and enhance riparian areas, watercourses and sensitive ecosystems; and, retain common area green space. Section 7: Environmental Reserve Zoning. These areas appear to be some stream corridors, primarily beyond private parcels (in areas designated as Open Space), and not along the lake foreshore. There are no further details for this zoning (no DP requirement).
RDCK	Electoral Area J - Lower Arrow Columbia: • Kootenay Columbia Rivers Official Community Plan Bylaw No. 1157 (RDCK 1996). • RDCK Zoning Bylaw No. 1675, 2004 - Electoral Areas F, I, J and K	No Environmental Development Permit.	-

Jurisdict-ion	Electoral Area and Bylaw	Foreshore environmental development permit (DP)?	Bylaw Section reference: summary of DP (or other environmental related) requirements
Village of Nakusp	Official Community Plan (2021)	Floodplain and Steep Slopes Development Permit Areas	Section 4.1.2: Protect and enhance local environmentally sensitive areas, local water bodies and aquatic species, and wildlife corridors through the implementation of the Floodplain and Steep Slopes DPAs). Section 4.1.3: The placement of structures and the alteration of land in proximity to the natural HWM of Upper Arrow Lakes or Kuskanax Creek is regulated by the Floodplain and Steep Slopes DPAs.

1.8.4 Municipalities

The Village of Nakusp has its own independent municipal government and OCP (Village of Nakusp 2021). The OCP has policies to protect some sensitive shoreline areas, through the Floodplain and Steep Slopes Development Permit Areas (Table 2). However, mapping only includes the foreshore at the outlet of Kuskanax Creek to be Floodplain DPA, and some additional foreshore (primarily at the north end of village) is designated as a Steep Slopes DPA. A large section of the Arrow Reservoir foreshore is not included and thus has no form of environmental assessment prior to development. There was also no direct mention of a QEP being required to provide an assessment of the development for environmental purposes. The Village of Nakusp should integrate data from this FIMP into their OCP or relevant bylaws (Section 1.8.3).

1.8.5 Indigenous Peoples

Indigenous Peoples have occupied and used Arrow Lakes (and now Reservoir) since time immemorial. The Arrow Reservoir is part of the traditional territory of the Ktunaxa, Secwepemc / Shuswap, Sinixt, and Syilx / Okanagan Indigenous Peoples. These people used areas on or around the lake for hunting, fishing, foraging and/or traditional ceremonies.

The origin of the lakes' name is from a cultural feature known as "Arrow Rock", located on the east shore of Lower Arrow Reservoir, about 35 km upstream from Castlegar, opposite the community of Renata (Province of BC 2022). Here, a large rock outcrop above the water had a hole filled with arrows, with the arrows said to be shot there by the Lakes people (Sinixt) for good luck, either before or after war (Province of BC 2022). There are written historical accounts of this feature going back to 1826 (Province of BC 2022).

The Crown (federal and provincial governments) are legally obligated to consult and accommodate Indigenous Peoples, where required, on land and resource decisions that could impact their Indigenous Interests (Province of BC 2023). As outlined in Procedures for Meeting Legal Obligations When Consulting First Nations (Province of BC 2010):

> *Consultation activities will vary depending on the level of consultation considered appropriate. Discussions should focus on eliciting pertinent information about the nature, extent and potential impacts of proposed decision on Aboriginal Interests. Steps to accommodate interests may be required where: a proposed activity will adversely impact an Aboriginal Interest; or, there is likely an infringement of a proven aboriginal right or title or treaty right. Opportunities to resolve disputes and to accommodate may emerge from these discussions. Accommodation means addressing concerns and adapting or reconciling interests. It may require avoiding or mitigating impacts on claimed and proven aboriginal rights (including title) and treaty rights. It involves a process of seeking compromise in an attempt to harmonize conflicting interests; however, a commitment to the process does not require a duty to agree – it requires good faith efforts to understand and address each other's concerns. Balance and compromise are important - the Crown must balance concerns regarding potential impact of the decision on the Aboriginal Interest with other societal interests.*

To meet these obligations, government forwards applicable environmental applications made (e.g., *Fisheries Act* Authorizations, BC *Water Sustainability Act* Section 11 Approvals and Water Licenses) to Indigenous Peoples that have interests within the area of the proposed activity. *Also, proponents are generally encouraged to engage with First Nations as early as possible in the planning stages to build relationships and for information sharing purposes that may support consultation processes (Province of BC 2023b)*.

1.9 Stewardship groups

The Arrow Lakes Environment Stewardship Society (ALESS) is the only known stewardship group on Arrow Reservoir. The following summary about ALESS was obtained from their website[4] and from the ALESS President (R. Thompson pers. comm 2022):

> *The ALESS had its beginnings with monitoring water quality in creeks in the Arrow Reservoir watershed in 2011. Three creeks that converged at Burton initially were monitored - Caribou, Snow and Burton (Trout) Creeks* (Dummerauf and Bamber 2012). *McDonald Creek* (Baranowska and McPherson 2017) *and Nakusp Creek, located north of Burton were later added. In 2020, ALESS joined the Water Rangers*

[4] Website: Arrow Lakes Environment Stewardship Society – ArrowLESS (wordpress.com).

Program[5] and added Box Lake to their water quality monitoring program. All of these data are submitted to Environment Canada, under their CABIN protocol, and are available to the public. ALESS have also done work to preserve and enhance several wetlands. They are building a network with other organizations with wetland knowledge (e.g., societies, government and Indigenous Peoples). The intent is to collaborate with these groups and the local community to conduct further wetland work.

In 2021, ALESS initiated a project to map the various subbasins in the Arrow Reservoir watershed. In 2023, mapping will focus on Inonoaklin, Eagle, and McDonald creeks. Inonoaklin Creek is important because of its numerous surface and groundwater users. The other two creeks are important fish spawning and habitat. Digital maps will be provided on the website that can be updated in response to community needs. This program will focus on other subbasins, mapping items that are most useful to the community. Currently maps are available for the area upslope of Burton, showing, among other things, land holdings and creek watersheds.

People are advised to continue to check the website for updates. The organization is open to new members.

1.10 Objectives

The FIMP objective is to provide an overview of lake foreshore fish and wildlife values, condition, sensitivities, and protection requirements. This involved completion of the field and office FIM components, the FHSI analysis and FDG. An important component of this project was to include SAR information.

The intent is that the FIMP outputs will be incorporated into local, regional, provincial, and federal policy and guidelines, where appropriate. The FIMP would be used as a tool to aid in land use planning and ultimately protect high value areas. If repeated, this baseline study's findings could be compared to future results, to identify changes that have occurred over time and to identify any trends that might need consideration. To meet these objectives, the following key tasks were undertaken:

1. Compile existing map base fish and wildlife information for Arrow Reservoir and the associated subbasins. Utilize available expertise, where possible.

[5] Water Rangers Program website: https://waterrangers.ca/. Water Rangers sites on the Arrow Lakes south of Shelter Bay: Syringa Park: https://app.waterrangers.ca/locations/5457, Nakusp: https://app.waterrangers.ca/locations/9528.

2. Inventory foreshore morphology, land use, riparian condition and anthropogenic alterations.
3. Obtain spatially accurate digital video of the shoreline.
4. Quantitatively analyze fish and wildlife values to provide an ecological segment rank.
5. Make recommendations to help protect sensitive foreshore areas.
6. Identify areas for conservation, limited use, as well as suitable areas where development would be more acceptable.
7. Identify level of risks of typical development activities based on the ecological ranking.
8. Foster collaboration between DFO, the Province, regional districts, municipalities, and Indigenous Peoples.

2.0 METHODS

Arrow Reservoir was assessed using the recently revised FIMP methods FIMP (Schleppe et al. 2021). The FIMP involved completing the three components: FIM, FHSI, and FDG.

The Ecoscape/Lotic Environmental project team was carefully selected to include professionals with direct experience conducting FIM, FHSI, and FDG on other similar projects in the province. The team was comprised of:

Ecoscape

- Jason Schleppe as Lead Biologist (MSc, RPBio)
- Project Biologists (field support):
    - Lindsay Lalach (BSc, BIT)
    - Leanne McDonald (BSc, RPBio, PAg)
    - Scott McGill (BSc, RPBio)
    - Brie Fissette (RBTech In Training)
- Dan Austin, M.GIS, GISP as the GIS Specialist (BSc)
- Fabian Cid Yanez, M.Sc., as a Data and GIS Analyst

Lotic Environmental

- Sherri McPherson as Lead Biologist (BSc, RPBio)

Splatsin te Secwépmec

- Shanon Basil, Fisheries Technician, Yucwmenlúcwu (Caretakers of the Land) LLP, provided field support.

2.1 Foreshore inventory and mapping (FIM) methods

Foreshore Inventory and Mapping methods were used to delineate, inventory and map foreshore habitats. The foreshore was defined as the area from the deeper edge of the littoral region of the lake (i.e., where the start of pelagic region begins) to an area up to 50 m beyond the HWM into the upland/riparian zone. Within this area, through completion of the FIM, field technicians counted, catalogued and described the following: land use (e.g., residential development), modifications (e.g., retaining walls, docks, marinas), and biophysical attributes (e.g., shoreline vegetation cover, substrates, large woody debris and aquatic vegetation). The FIM was completed in a four-step process, as identified below.

2.1.1 Step 1 Pre-field assessment

The FIM field Excel database was downloaded. Background information was mapped, including the following data layers:

1. Local government data was obtained, including zoning, cadastral (including government and non-government organization [NGO] conservation areas), and recent aerial imagery. These data were used to help understand the key land use designations, and inform the field surveys (e.g., segment brakes) and conservation recommendations. From this office exercise, there were no significant land use changes evident, inferring that there were no preliminary segment break changes required.
2. Streams with known fish access were mapped, using the results of Arrow Reservoir Tributary Fish Migration Access Monitoring and the provincial database (Hawes et al. 2014 and BC MoE 2022).
3. The Provincial and Federal GIS registries were searched for species and ecological communities at risk and critical habitat data. A review was conducted for other high value habitats potentially present, such as wildlife habitat areas. Mapped occurrences were loaded onto the field maps.
4. All pertinent data above were loaded onto the most recent aerial imagery, and these were loaded onto iPads for field use.

Associated field data mapping protocols were also developed and field forms specific to the Arrow Reservoir FIMP process were developed using a series of fillable forms, and pre-field information necessary (e.g., for FHSI and ZOS).

2.1.2 Step 2 Field assessment

The FIM field assessment was conducted by boat from July 11 - 28, 2022, using a commercially registered 18-foot aluminum hulled vessel. A crew of three to four people were aboard the vessel throughout the three-week assessment period. The crew included

one, if not both lead biologists (Jason Schleppe and Sherri McPherson). When Jason could not be aboard (week 2), his replacement was Scott McGill, who was also experienced with FIMP. Also onboard was an Ecoscape field biologist that rotated weekly (Brie, Lindsay, or Leanne), and a Splatsin technician (Shanon Basil for week 2). On the final day, Emily Mask (Former Applied Reconciliation Coordinator) from LLC also joined to both observe the field methods employed and to assist with field data collection.

The database was used for field collection of FIM data. Field data were collected as follows:

1. The FIM segment breaks were determined in the field using standard methods (morphology, shore type, land use, disturbance etc).

2. Using a laptop computer, data were entered electronically into the MS Excel FIM database field forms.

3. Biophysical and habitat attribute data were collected in accordance with the FIMP methods. All mandatory data were collected, as well as other important but non-mandatory data (e.g., overhanging vegetation, large woody debris, and modifications). For Arrow Reservoir, the littoral widths were considered to be the active littoral area observed at the time of assessment, which represented the habitat condition of the high water /upland interface. The full littoral zone in many cases is considerably wider, when considering the full drawdown of the reservoir. Readers are urged to carefully consider the concept of littoral zone and should not make many inferences from this data as it relates to the complicated nature of littoral width in a reservoir with a large drawdown.

4. In addition to the standard methods of providing counts and/or percentages for iPads were used to spatially mark various data using ArcGIS collector. The marked items were as follows:

   Modifications

   - Lines: retaining walls, erosion control (riprap) and substrate modifications.
   - Points: docks, groynes, boat launches, marinas, boat houses and boat basins.

   Fish, wildlife, and ecological habitat observations

   - Polygons or lines:
     - Aquatic and overhanging vegetation -submergent, floating, emergent, overhanging.
     - Terrestrial habitat areas of significance – significant wetlands.

- Aquatic life - mussels (although none were evident given the high-water level), or other highly valuable fish habitat areas (e.g., areas where fish were visibly rearing and groundwater seeps).

- Points: stick nests, significant wildlife trees, small stream confluences, groundwater seepage areas, and bank nesting areas.

*Note, the a*ccuracy of these spatial attributes has not been confirmed because field time did not allow for field specific measurements. User interpretation of these data are important and must acknowledge these data were collected from a boat. These data may not include identification of all mapped instances or locations or accurately reflect their current size for example.*

5. All iPad GIS mapping were downloaded to the Ecoscape Server and "Cloud" daily to protect from data loss.

6. Geo-referenced still photographs were taken to characterize each shoreline segment and its attributes.

2.1.3 Step 3 Video documentation

Video documentation was conducted to assist in classifying land use and features. A shoreline video was collected by a drone that was launched from an 18 ft commercial vessel. The crew of two (Robert Wagner and Cole Rithaler) collected the video from August 2 - 7, 2022. The weather conditions during the survey were generally dry, clear, and calm, which aided data collection. However, there were intermittent storm and high wind events on August 3-4 that required the crew to halt data collection for short durations.

The video was recorded with a drone with pre-programmed flight path approximately 100 m from the shoreline. The drone was set at 8 - 10 m above the water elevation and centered on the foreshore to allow for a perspective that could capture the most detail possible. The video was recorded in ultra-high definition 4K (3840x2160) at 60 frames per second to gain the most detail and clarity possible.

Video processing involved running the video through software to extract flight telemetry information. The data was visualized as a text overlay in the final video production to identify the segment number, recording date and time, flight speed, coordinates (NAD83-UTM11), compass direction and visual position on the lake with a map reference. The output was provided in MP4 format and uploaded to a private YouTube account for convenience. Viewing rights were restricted to only those with the links provided by the video producer.

The following is a stepwise summary of the video collection methods:

1. Created georeferenced maps showing segments, orthophoto, and landmarks to allow the video field crew to determine location of segment breaks.

2. Created a video for each segment to reduce file size, and to make finding a location of interest easier (instead of scanning one large video).
3. Georeferenced maps were uploaded into iPads to allow the video field crew to see their location on the map.
4. GPS tracks were recorded in sync with the video recording so the start/stop of GPS track was recorded synonymous with the video start/stop.
5. All video and GPS tracks were downloaded post field work, and these were processed on a computer at the office as follows:
    a. Video editing software was used to stabilize the video due to wave action/boat movement.
    b. Metrics were derived from the GPS track data including date, time, speed, direction, and GPS coordinates.
    c. The metrics were synchronized with the videos.
    d. Metrics were graphically displayed on the exported video.

2.1.4 Step 4 Reporting and data analysis

The FIM database was first reviewed and corrected for QA/QC purposes. This involved reviewing all data for all shoreline segments, confirming data attributes, amending observations as required (i.e., scaling of shore type lengths for example using GIS), and ensuring that the database was consistent with the required QA/QC FIMP protocols.

Results of the FIM survey were then analyzed using R Programing Software (R Core Team 2021) and were presented in a series of tables and graphs to describe the overall shoreline condition.

2.2 Foreshore habitat sensitivity index (FHSI)

Foreshore Habitat Sensitivity Index methods were used to rank approximate relative shoreline values based on the data available from the FIM (including biophysical and modification criteria), ZOS determination (using other inventories), and professional judgement. Ultimately, the FHSI identified areas of greatest sensitivity to change from foreshore development or areas where risks to important ZOS or habitat features may occur if development proceeded.

To develop the FHSI, a detailed literature review was conducted to describe foreshore values beyond those identified during the FIM. This information was specifically used to determine the applicable Arrow Reservoir ZOS. The results of this review were used to support criterion and weightings used in the FHSI, as well as support and strengthen the FDG recommendations.

2.2.1 Step 1 FHSI criteria and ZOS development

The FHSI involved first deciding which FIM attributes, ZOS and modifications to consider as criteria and then the weightings to apply in the FHSI. Care was taken to include criteria that both supported a broad range of important habitats, while avoiding duplication of a habitat value. For instance, the overlapping values of juvenile rearing, fish migration and staging were all considered, in conjunction with the biophysical values from the FIM. This step was important to ensure the influence of any given criterion was estimated correctly and did not overly leverage the resultant FHSI rank.

Zones of Sensitivity were determined using the FIM office and field findings, and subsequent literature review/data search. A key step was to contact fish, wildlife and habitat professionals from various organizations (including BC MoF, BC Parks, Indigenous Peoples, BC Hydro, consultants, and the ALESS stewardship group) and request current spatial data for high value / sensitive species and their habitats. Inventory data was specifically sought which was not already on the provincial databases (Conservation Data Centre (CDC) and iMap). For example, regionally sensitive fish species were confirmed by MoF Fisheries staff, bat roosting data was sought from the Wildlife Conservation Society of Canada, freshwater mussel data was sought from Ktunaxa Nation and BC Parks, and bird inventory data was sought from consulting biologists. Orthographic and elevation data (limited) were provided by BC Hydro for use as part of this project. Attempts were made to obtain other mapping data from BC Hydro, but these datasets were not readily available for use. These ZOS are, at minimum, a flagging tool to help call attention to areas of particularly high importance for fish and wildlife. If more detailed data becomes available, the ZOS spatial boundaries can be amended to improve spatial accuracy.

In accordance with the methods, when developing the FHSI, each selected criterion was categorized by habitat. Each criterion was weighted to assess the influence of each category. For consistency with other similar FIMP studies, only two categories were considered: Fish, and Wildlife (which include Ecosystems).

Criteria in the FHSI need to be carefully considered. To be part of the FHSI, data used for each criterion preferably covered the entire spatial area of the lake because incomplete data coverage can skew the spatial outputs of the FHSI. Similarly, an applicable criterion was not to have data that was uniformly or equally distributed across all FIM lakeshore segments because this would not have any effect on the FHSI. An example of this was the White Sturgeon occurrence data, which mapped this species as being present throughout the entire lake. Instead of using this data, only the critical habitat for this species was selected as a criterion. In summary, data used in the FHSI needed to generally be based on reasonable lake sampling and have some type of variation in density spatially around the lake (e.g., high, moderate, low *or* present / absent). In this case, some datasets may not meet all of these requirements simply due to size of the lake.

To determine which data were "considered" in the FHSI for a segment, polygons covering the entire lake were created using the spatial extents of FIM segments to create the polygon. For each segment, a polygon was created. The polygon occurred from a 200 m buffer away from the HWM to the center of the lake, with the bounds of the polygon determined using orthogonal offsets from the segment break at the HWM. The lake wide polygons created were manually adjusted for some segments where the scripted GIS offsets created unnecessary segment polygon overlap or failed to capture represented data. These minor changes were necessary to ensure that data was considered part of the segment and was represented in a spatially accurate way, and not the result of an erroneous scripted orthogonal offset. The polygons created for each segment of the lake were then used to consider data used for criterion in the FHSI as present (Yes), or absent (No) if there was overlapping spatial values (i.e., SARA critical habitat for White Sturgeon overlapped with the orthogonally created segment polygons). During the FHSI, if scripted polygons captured by the spatial mesh were deemed not highly relevant because of low overlap for example (i.e., long segment with less than 10% overlap for stream feature, when segment type was a rocky, steep cliff /bluff shoreline), they were removed from the analysis manually during calibration.

2.2.2 Step 2 FHSI calibration

Calibration of the FHSI involved an iterative process of reviewing the Ecological Rank results that were determined for shoreline segments considering the assigned weightings. The calibration considered the influence of weighting for all habitat categories and individual criterion both within the category and compared to all criteria in the FHSI. The objective was to assign weightings that were representative of the shoreline ecological values present for each FIM segment, considering all fish and wildlife data available and ways they may overlap or influence each other. The purpose of these iterations was to determine the sensitivity of each category and criterion on the FHSI analysis outcome. While these results were visualized on maps to help quickly assess results and influence of the criteria in the FHSI, each iteration was not presented in this report.

The FHSI was calibrated by preparing a suite of R scripts. For each iteration, histograms of shoreline FHSI scores were prepared. If the results clumped into discrete groups, it meant that shoreline segments were similar and that values overlapped. With each iteration of the index, several small database QA/QC corrections were made as required. This involved for example, revisiting and confirming riparian or substrate parameters, and making manual changes to spatial buffers to ensure that the presence/absence data did not overestimate shoreline value in longer lake segments. The final determination of the "breaks" to characterize scores into either Very High, High, Moderate, Low or Very Low Ecological Ranks was determined in large part using the histogram and maps. The goal was to see accurate representation considering the segment location on the lake, length of segment, field observations, professional opinion, reference literature, and the values within the identified ZOS.

The last phase of FHSI calibration involved scrutiny of the categories, criteria, and weightings by other professionals. The FHSI analysis was refined once a consensus was reached (i.e., the Ecological Ranks assigned to different shoreline segments were appropriate).

2.2.3 Step 3 Reporting, data analysis and map production

Results were analyzed and presented in a series of graphs, tables, and figures to describe the overall shoreline condition. The maps summarized the FIM inventory data, and included categories and criteria used in the development of the FHSI. A map set depicting the FHSI Ecological Ranks, including spatial habitat data, was provided to portray the FHSI results. These map sets and associated mapping deliverables are available in GIS and can be integrated into any planning or permit process easily. These outputs provide a framework for considering the variety of different values around the lake.

2.3 Foreshore Development Guide (FDG)

The FDG report was prepared in accordance with the FIMP methods and the FDG template (Schleppe et al. 2021). This involved completing the following stepwise process:

Step 1: The FDG map was prepared using the FHSI outputs. The map depicted the pertinent fish and wildlife information needed to guide development planning. This included: The FHSI Ecological Ranking for each segment (ranging from very high to very low) as colour zones; and, b) the ZOSs.

Step 2: For each colour zone and ZOS, a general summary and recommendations were provided. Information on habitat sensitivity, anthropogenic disturbance risks, acceptable activities, and conservation recommendations were included.

Step 3: The Activity Risk Matrix (ARM) identifies the level of risk of typical activities for each colour zone and ZOS. The ARM and associated recommendations from the FDG template were updated from the template in the methods document, as necessary.

Step 4: The template table outlining the typical regulatory requirements for each activity listed in the ARM was reviewed and updated, as necessary. Additional tools provided in the FDG template were also reviewed and updated as necessary, including the list of federal, provincial and local environmental legislation, and the Best Management Practices (BMP) list.

Step 5: All GIS, habitat, and fisheries data were finalized into appropriate databases and provided as a final deliverable. The ARC GIS files for linking data to the database were also provided. This step ensured that the colour palettes used, and links for integration into GIS platforms, wereconsistent.

2.4 Traditional Ecological Knowledge (TEK)

Indigenous Peoples Traditional Ecological Knowledge (TEK) can contribute to a broader understanding of existing ecological values. The FIMP framework was updated with a proposed process for meaningfully including Indigenous Peoples and TEK into FIMP Projects (Schleppe et al. 2021). The FIMP project team reached out to local First Nations and requested participation in field data collection and/or inclusion of First Nations TEK data. The Ktunaxa Nation, Okanagan Nation Alliance, Splatsin te Secwépmec, and Colville Tribes were contacted in the spring and summer of 2022. Splatsin te Secwépmec expressed interest in participating, so the Arrow Lakes field survey was designed to incorporate First Nations TEK through engagement and involvement of Shanon Basil, Fisheries Technician, Yucwmenlúcwu (Caretakers of the Land) LLP, who provided field support for an entire week on Arrow Lakes.

Shanon was a valuable member of the field team; he assisted with wildlife observations and counts of shoreline modifications observed. He also recounted cultural and archaeological significance of certain areas of the lake and shared these meaningful observations with the field team.

Due to timing constraints, there was no further TEK or engagement with other Nations by the report publication deadline.

3.0 FORESHORE INVENTORY AND MAPPING RESULTS

Water levels in the Arrow Reservoir in 2022, as measured at the Nakusp Hydrometric Station, ranged from a high of 438.6 masl on July 7 to a low of 424.7 masl on December 1 (Environment Canada 2023; Figure 2). The FIM assessment was conducted from July 11 - 28, 2022, when water levels ranged from 438.5 - 438.3 masl and were amongst the highest for the year. The video collection occurred from August 2- 7, when the water level was just starting to recede (ranged from 438.3 – 437.8 masl).

The total length of the Arrow Reservoir study area shoreline was determined to be 507,483 m (507 km). The shore length was determined by using all available data to estimate the full pool elevation of the reservoir. The FIM data attributed to the approximate HWM / full pool elevation that was generated should not be considered equivalent to a field surveyed HWM. The FIM line was generated using data provided by BC Hydro and is considered an approximation. This FIM line may not be spatially accurate, and any formal delineation of the reservoir boundary or its cartographic representation should not be implied by referencing data in this study. Although BC Hydro raw data was used to generate this line, this raw data has not been shown or used in any other way, where only the data that was spatially modelled in this work is shown. The foreshore was divided into 185 contiguous segments, for areas surveyed during this assessment. It is acknowledged that if the reservoir is surveyed upstream of the study area, additional segments will be added to the

dataset. The FIM database with all data collected by segment is best viewed electronically and has not been provided in tabular format because it is hard to interpret. FIM maps showing segment location and key segment information are provided in Appendix A.

A few general items of note, pertaining to interpretation of the FIM results on this reservoir are as follows:

- For the purposes of this report, the Percent Natural of a shore segment was what the natural condition would be, post flood, after the reservoir was filled. The authors acknowledge that when the reservoir was flooded there were impacts to both the aquatic and terrestrial environments. Thus, in this case, a shoreline was deemed Natural if the post flood "riparian conditions" were undisturbed from some form of human alteration. The concept of "natural" in this case is not indicative of a natural, unregulated lake, but that of an undisturbed, flooded reservoir. The intent of collecting FIMP data in this way is to help provide a summary of current reservoir shoreline condition, and track change over time resulting largely from transportation, residential, commercial, or industrial land development. Readers must not consider statements made regarding "Natural" condition to infer that the shoreline has not already been heavily altered from the original shoreline areas of Upper and Lower Arrow Lakes (i.e., a shoreline that showed no impacts in a post flood scenario would be 100% Natural in this study, but could similarly be considered 100% disturbed at the same time due to the influences of reservoir flooding).

- Arrow Reservoir has a large (21.5 m) drawdown (BC Hydro 2007). As a result, this survey considers the full pool condition. Due to the large drawdown, the concept of lakebed substrates and littoral zone are complicated. Visibility of lakebed substrates was also a bit challenging due to turbidity and/or water depths. Estimates were made, but further spatial survey of reservoir bed substrates at low water would be useful. Littoral widths were considered to be those at the time of assessment, versus that of the entire littoral zone that would be present over the duration of a full year (i.e., the approximate water elevation at peak to a depth of 6 - 10 m at the lowest water elevation is an approximate area where the littoral zone would occur during any given year over the course of that year).

3.1 Summary of shoreline disturbance

Overall, 87% (440,241 m) of the shoreline was in a Natural condition, while the remaining 13% (67,241 m) was considered Disturbed (i.e., areas that had any sign of being altered) (Figure 3). The Natural areas were mostly present along forested areas (ranging from young to mature), undeveloped rural lands, or in parks. Disturbed areas were spread around the lake and were focused in lower gradient areas, where there was road access and already established communities and their respective transportation corridors and subdivisions.

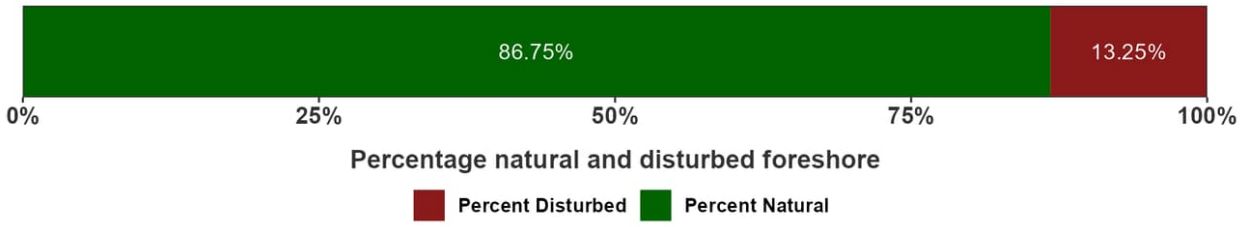


Figure 3. Summary of lake wide shoreline disturbance

Existing natural areas occur in many areas of Crown Land, and within at least parts of the many provincial and regional parks that dot the shoreline. There were also many areas within private land areas that were not yet fully developed and thus disturbed. Privately held lands are the most vulnerable to future anthropogenic impacts. As mentioned, these privately held lands are often developed, subdivided, or built out, where buildout on Arrow Reservoir was found to be at the very early stage during this study. Over time, ongoing land alteration will continue to occur as the lake develops further.

The Provincial Parks are as follows:

- Arrow Lakes Park - Shelter Bay Site (Class A)
- Arrow Lakes Park - Fauquier Site (Class A)
- Syringa Park (Class A)
- Arrow Lakes Park - Burton Site (Class A)
- Arrow Lakes Park - Eagle Site (Class A)
- McDonald Creek Park (Class A)
- Inonoaklin Park (Class C)

During the field work, many developments appeared to have been in place for some time. There were, however, some observations of the shoreline being impacted from recent and ongoing new development. As these areas continue to be developed and used, further shoreline impacts are expected. As a result of repeating FIMP studies over a 10 - 14 year period, rates of shoreline loss (change from natural to disturbed) for other lakes in the region have been calculated. The rate of loss at Windermere Lake was calculated to be 0.07% per year, while the rate loss at Kootenay Lake was 0.12% per year (Schleppe and McPherson 2021 and 2022, respectively). The changes appeared to be from small incremental losses, usually in the form of removal of patches of riparian vegetation (Schleppe and McPherson 2022). Although there were no big losses in natural areas, the losses were indicative that the Best Management Practices were not being followed. This can be improved in the future through improved engagement with landowners through stewardship and enforcement.

3.2 Summary of land use disturbances

Natural land use areas were the most prevalent, extending along 66% of the foreshore (Figure 4, Figure 5). This was generally represented by forested areas situated on steep terrain with limited or no road access to the shoreline. Rural Residential land use followed, representing 22% of the foreshore. A large proportion (75%) of Rural Residential areas remained undeveloped, benefiting the foreshore ecosystem.

Figure 4. Example of an undisturbed, Natural Area and associated riparian habitat on Arrow Reservoir.

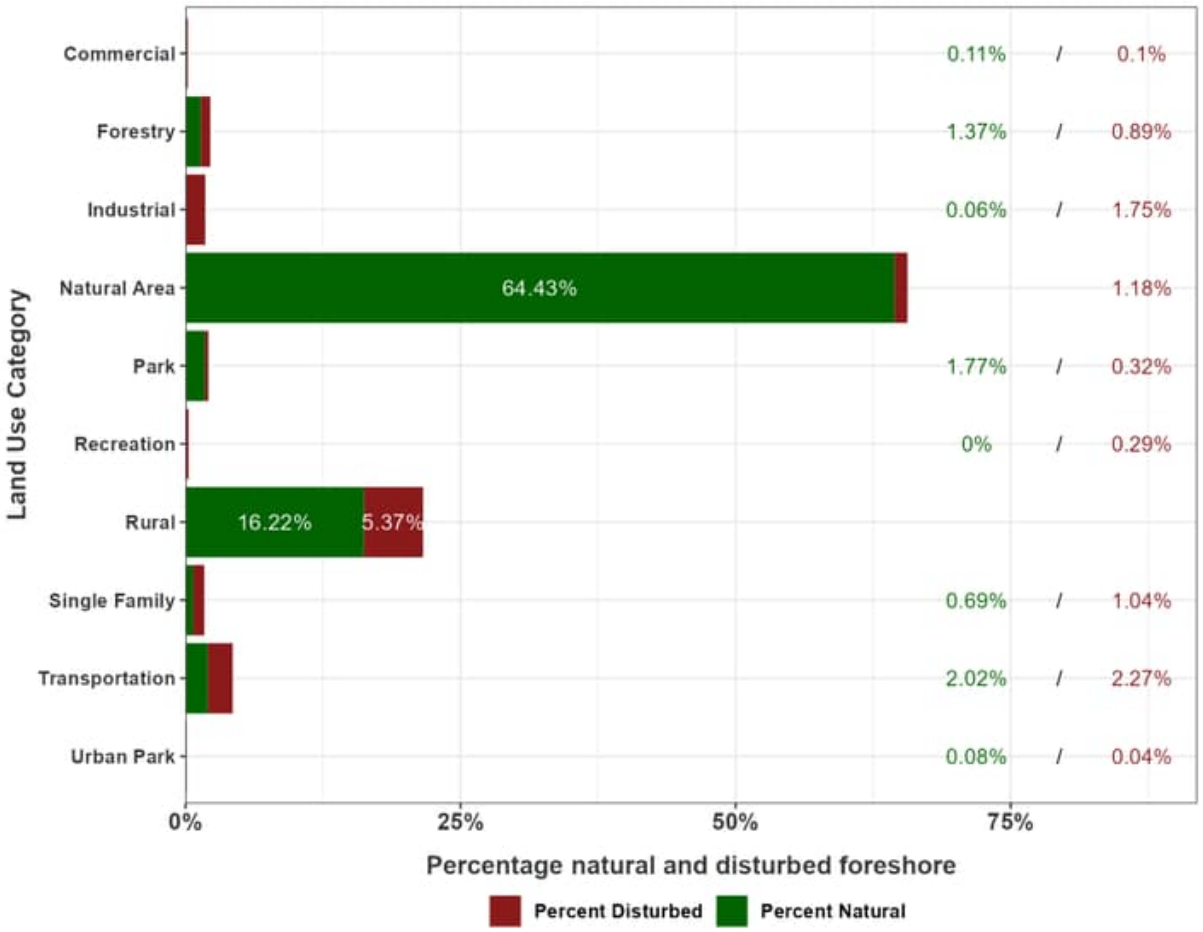


Figure 5. Land uses and their respective extent of disturbance.

The Transportation land use occurred along 4% of the foreshore and was the third most predominant land use type observed. This land use was defined by public roads, railways, and ferry terminals. Nearly half of the transportation corridors were identified to be natural since they were set back with a riparian buffer present to the foreshore. The Single-family and remaining land uses represented a small proportion of the lake (each less than 5%) and a combined total of 8%. Although these land uses covered an overall low proportion of the shoreline, they often had considerable disturbance. For example, forestry disturbance included areas with extensive log booms and landings.

Although shore types that resulted in disturbance appear small in proportion to the whole lake foreshore, they tended to be concentrated in limited low lying valley bottom areas (Figure 6). These areas held value for human uses due to their relative ease in access, level areas for building, agricultural richness, and recreational beach access. However, they also similarly tended to be situated in the high value habitats for fish and wildlife, due to the presence near river mouths, wetlands, more extensive emergent aquatic vegetation, and deciduous and mixed riparian vegetation, etc. It is acknowledged that the determination of

slope was made from a boat, and some of the shoreline segments may have had more than one type.

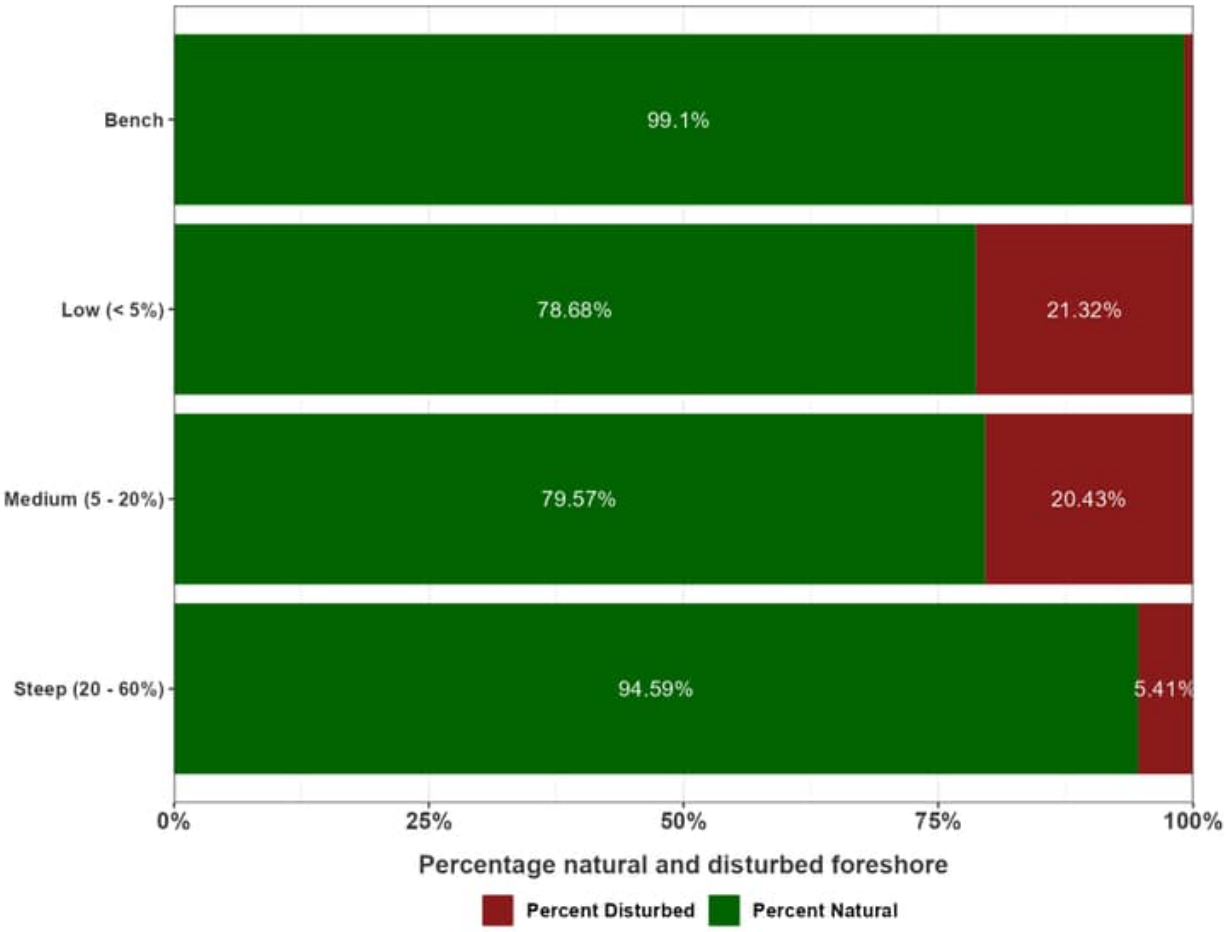


Figure 6. Shoreline disturbance relative to shoreline slope.

The greatest disturbances to shoreline areas usually occur in processes of shoreline densification. This occurs, for example, where land use changes from Rural or Natural area (or similar) to a more urban land use like Single-family development, or when large areas of land are cleared for agriculture as seen on Okanagan Lake (Schleppe and Plewes 2017). The small incremental changes occurring in areas like Single-family land use on Kootenay Lake resulted in a rate of loss of natural shoreline area of 0.29% on a lake wide scale, or approximately 225 m annually. This rate was similar to Okanagan Lake, which experienced a 0.20% loss per year (Schleppe and Plewes 2017) and Windermere Lake, which experienced a loss of 0.18% within this land use (Schleppe and McPherson 2021). These similarities highlight that loss rates are most likely associated with land use, given that each of these lakes occur within a different local government jurisdiction with different policies to protect habitat. In this case, Arrow Reservoir has many rural areas, which are currently

in a relatively natural state. Great consideration should be given to any land use decisions made, given the observations on other more developed lakes in BC. It is expected that if densification of the shoreline occurs, there will be an elevated rate of loss of the shoreline over time.

While few new subdivisions were observed, there were some lakefront homes or accesses for future homes that had been recently constructed, re-built, or substantially renovated (Figure 7). On these more urban lots, there was very little shoreline restoration observed as part of a reconstruction process. The incremental, slow losses of riparian habitat can only be balanced with appropriate commitment to incremental shoreline restoration, otherwise, ongoing losses will occur and only a few remnant patches will remain over time on these urbanized lots.

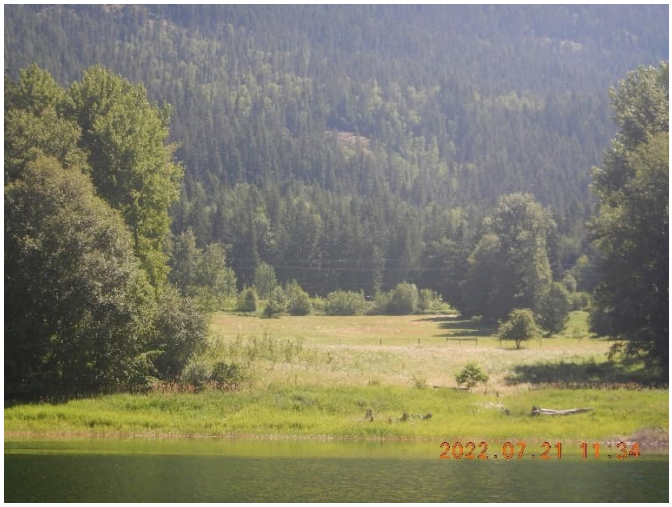


Figure 7. Examples of riparian disturbance on rural (left) and single-family development observed on Arrow Reservoir.

3.3 Summary of disturbance along different shore types

Rocky and Gravel shore types were the most prevalent at Arrow Reservoir, occurring along 42% and 34% of the shoreline, respectively (Figure 8). These shore types are where disturbance occurred most, with 58% of the total shoreline disturbance occurring on Gravel and 23% on Rocky Shore. These shore types were generally associated with lower gradient areas that are easily accessible for land development and are often locations for transportation corridors.

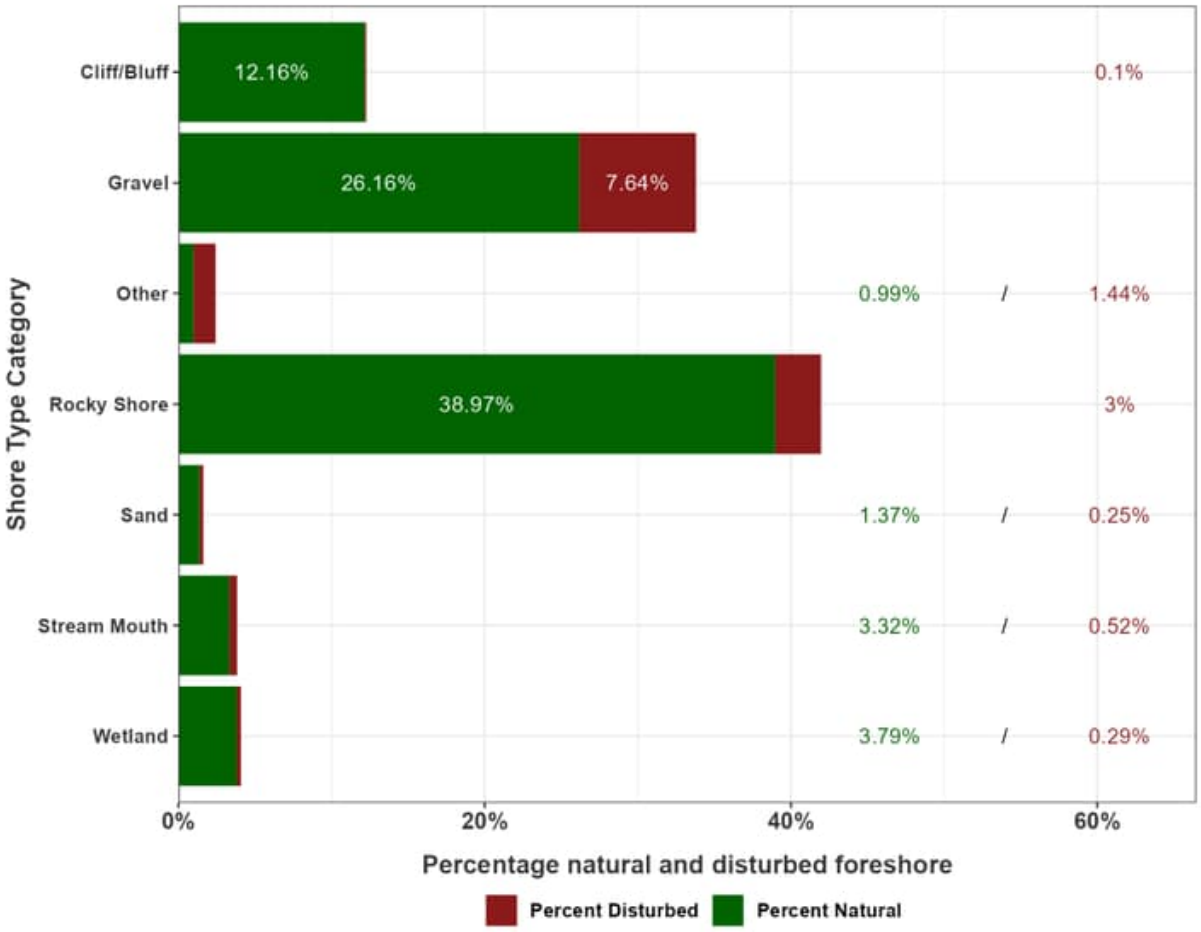


Figure 8. Shore types and their respective extents of natural and disturbed lengths (of the total shoreline), where the *values on the right represent percentages of natural (green font) and disturbed (red font), that do not fit on the bars*.

Cliff/Bluff shore type followed, representing 12% of the total foreshore habitat. This shore type had very little disturbance (0.1%), owing to constraints of accessing and developing on steep ground.

The remaining shore types represented less than 5% of the shoreline each and 12% combined. Of these, Wetland and Stream Mouth were highly valued for fish and wildlife habitat. Because these high value habitats were present along only a small proportion of the lake, even small extents of disturbance accounted for a high percentage of their available habitat. Specifically, 7% of Wetland habitat and 14% of Stream Mouth habitat were disturbed, accounting for 2% and 4% of the total length of shoreline disturbance, respectively. Restoration and preservation should occur in these and other high value areas.

Overall, maintaining and restoring rocky shores and gravel beach areas is considered important, both for fish and wildlife, as this is where impacts were found to be highest. Continuing to maintain wetlands and other areas of high biodiversity and habitat value such as stream confluences is also important. Further, there are often additional benefits related to flood management and protection or property and infrastructure from keeping these habitats intact and functional.

3.4 Summary of anthropogenic modifications

There were several types of foreshore modifications present along the Arrow Reservoir shoreline (Figure 9, Figure 10). A summary of counts and associated observations were as follows:

- Docks were the most abundant modification, with a total of 210 counted.
- Boat launches followed, with a total of 189, where 163 were gravel and 26 were concrete. This number includes both public and private concrete boat launches, and the many rudimentary gravel access points off properties seen into the lakes. A reconciliation with appropriate Crown Land licenses or tenures was not undertaken, but it was assumed that appropriate rights to space were not obtained prior to construction for some of the launches, similar to other modifications. Simple removal of concrete boat launches would easily restore lakebed disturbance in many areas. For instance, if 15 launches were removed, and each was 2 m wide and 3 m long, a total of 90 m^2 of lakebed habitat would be restored.
- There were 103 retaining walls. Retaining wall construction was often hard to differentiate with erosion control. In this study, rock walls were considered a retaining wall if they were more vertical in nature, when compared to erosion control which was less vertical and was associated with a clear intent to reduce shoreline losses.
- There were 97 groynes observed. Groyne construction typically resulted in rocky shore being transitioned to gravel beach, where larger rock substrates were moved and placed into groynes, leaving behind smaller gravel substrates. Groynes varied considerably in their size (length and profile), and thus in their potential to impact the environment.
- There were 69 swim floats.
- There were 29 boat houses, with 28 of these over the water and 1 observed on land. Additionally, there were 12 covered boat lifts present on the water or shore.
- There were 7 marine rails. Most were associated with Single Family or Rural land uses.
- There were 14 boat basins. Most of these appeared to be excavated in wetland habitat south of Nakusp.

- Lastly, there were 4 marinas. These were classified as small or large marinas, with large having more than 20 slips. Although the number is small, marinas have a sizable footprint.

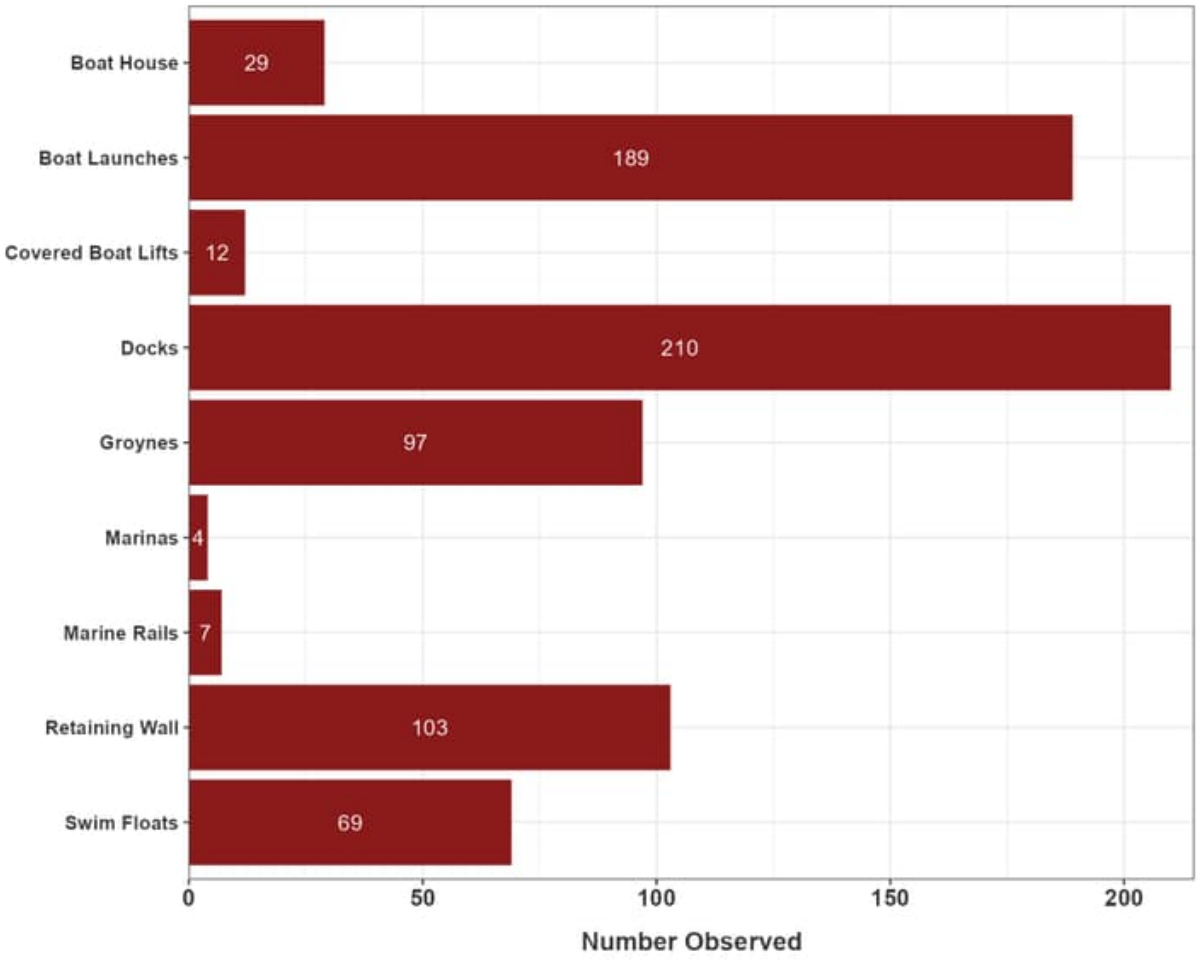


Figure 9. Total number of different shoreline modifications observed.

Figure 10. Examples of modifications, such as marina's (top) and retaining walls (bottom) observed on Arrow Reservoir.

The extent of shoreline disturbance was reviewed for modifications that were assessed as line features (Figure 11), with the following observations:

- Substrate modification was the most apparent lakebed disturbance and was estimated to occur along 7% (36,007 m) of the shoreline. Substrate modifications included significant movement of natural substrates or earthworks, and ballast deposition for road and railroad construction. Substrate modification also included instances where substrate was obviously piled to make groynes, or had been "picked" of larger rock for access, or from alterations such as a boat launch operation on gravel beaches.
- Retaining walls were present along 0.7% (3,493 m) of the shoreline. Retaining walls were installed to harden up the shoreline to protect from erosion (e.g., using rip rap, or vertical structures). Extensive installations were not commonly observed to the

same extent as other lakes. For instance, extensive stacked rock walls were not present like the Okanagan, Kootenay, or Windermere Lake systems. Restoration and removal of hard, vertical retaining walls for softer, bioengineered shorelines that allow natural shoreline processes to occur is recommended. In 2017, Okanagan Lake experienced significant flooding and during these events it was observed that hardened areas tended to experience more significant impacts than those with natural vegetation cover and a more natural floodplain area (Schleppe, J. personal observation from numerous Okanagan related flood restoration initiatives 2020).

- The extent of erosion protection represented 2.8 % (14,259 m) of the shoreline.
- The road occurred along 2.4% (11,984 m), and the railway occurred along 0.9% (4,491 m) of the shoreline. The road ran along the east side of the lakes but was largely set back from the shoreline. The railway ran along the southwest shore of the lake and also was set back.

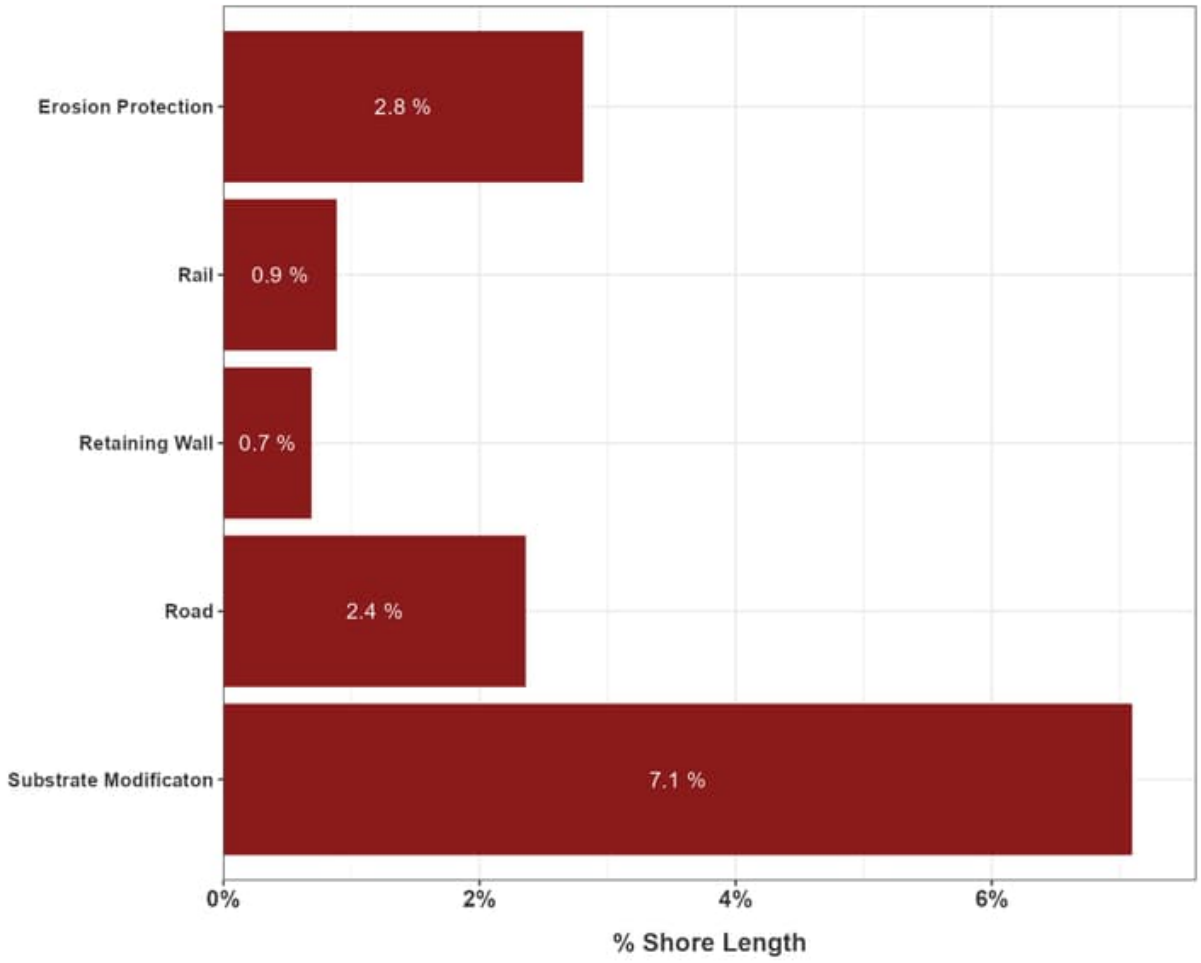


Figure 11. Foreshore length (m) of disturbance.

4.0 FORESHORE HABITAT SENSITIVITY INDEX CRITERIA DEVELOPMENT AND RESULTS

Arrow Reservoir has a variety of important fish and wildlife species and habitat values. An overview of these, with a focus on sensitive values, are provided in this section. This section culminates with the FHSI rationale table, which explains and supports the FIM, fish and wildlife ZOS values, as well as the modification criteria, that were determined to be included in the FHSI (Table 7). The subsequent FHSI logic table, where all these values were included in the evaluation towards determining the Ecological Rank of a segment follows (Section 4.3, Table 9).

4.1 Fish

The Arrow Reservoir Watershed is an important watershed within the Columbia River Basin from a fish perspective. BC Habitat Wizard (BC MoE 2022) and other sources identified that 34 species of fish have been sampled in Arrow Reservoir since 1982[6]. Of these, 9 are SAR or sensitive species (Table 3, which also provides population details), 18 are native species that are secure (Table 4), and 7 are non-native (or exotic) species (Table 5).

[6] The only other sampling record prior to 1982 was in 1949, with Chum Salmon reported to also be present (Province of BC 2022).

Table 3. Sensitive fish species in Arrow Reservoir.

Common name (scientific name)	Sensitivity Status			Population details
	BC Listing	COSEWIC	SARA	
White Sturgeon - Upper Columbia pop. (*Acipenser transmontanus* pop. 2)	Endanger-ed	Endanger-ed	1-Endanger-ed (2003)	There have been significant monitoring and enhancement efforts to help recover the population to pre-dam installation levels (Section 4.1.3). Critical habitat for this species has been identified in the Arrow Reservoir (DFO 2014).
Umatilla Dace (*Rhinichthys umatilla*)	Endanger-ed	Endanger-ed	3 –to be re-assessed (2005)	This species is endemic to the Columbia River basin, specifically the upper and middle mainstem sections and associated large tributaries (COSEWIC 2010a). Although this species was listed in Habitat Wizard as being present in Lower Arrow Reservoir, the COSEWIC species report identifies that in the Columbia River its known distribution is restricted to the mainstem below Arrow Reservoir (below Hugh Keenleyside dam) (COSEWIC 2010a). Although this species is currently not considered to be in the study area, sampling is recommended in the Arrow Reservoir to confirm.
Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*)	Special concern	Special concern	1-Special Concern (2010)	As reported by Sebastian et al. (2000): *Several tributaries in the Revelstoke area support indigenous headwater stocks of Westslope Cutthroat Trout (McPhail and Carveth 1992). For example, a very good population exists above the waterfalls in the Akolkolex River and is also present in the headwaters of Kirkup Creek. Cutthroat trout were also introduced in numerous tributary streams in the 1940s, thus complicating the identification of native populations versus hatchery introductions.*

Table 3. Sensitive fish species in Arrow Reservoir.

Common name (scientific name)	Sensitivity Status			Population details
	BC Listing	COSEWIC	SARA	
Shorthead Sculpin (*Cottus confuses*)	Special Concern	Special concern	1-Special concern	Shorthead Sculpin was listed in Habitat Wizard as being present in the Lower Arrow Lake. However, the COSEWIC species summary (2010b) revealed that this species' distribution on the Columbia River extends downstream from just below Keenleyside Dam. Although it appears to be outside the study area, sampling is recommended to confirm.
Columbia Sculpin (*Cottus bairdi hubbsi*)	Special Concern	Special concern	1-Special concern (2003)	The BC Habitat Wizard identified Mottled Sculpin (*Cottus bairdi*), to be present in the Lower Arrow Lake in 1999. However, the incidence may have been the sensitive subspecies, Columbia Sculpin (*Cottus bairdi hubbsi*). This subspecies has records nearby in the Columbia River downstream of Castlegar, and in the Kootenay River below the Slocan River outlet (BC CDC 2022b). Further sampling in the Arrow Reservoir is recommended to confirm.
Bull Trout - Pacific pop. (*Salvelinus confluentus pop. 26*)	Special concern	Not at risk	-	Bull Trout catches have been relatively low since 2014 (Bassett et al. 2022). There have been significant monitoring and enhancement efforts to help recover the population to pre-dam installation levels (Section 4.1.4).
Burbot (*Lota lota*)	Regionally significant	-	-	Although Burbot are widespread and abundant throughout much of BC, they are considered a species of regional concern in the Columbia River system due to marked declines in their numbers (McPhail 2007). Any viable Burbot population is important and maintaining that status in the Kootenays is necessary (Burrows pers comm).

Table 3. Sensitive fish species in Arrow Reservoir.

Common name (scientific name)	Sensitivity Status			Population details
	BC Listing	COSEWIC	SARA	
Kokanee (*Oncorhynchus nerka*)	Regionally significant	-	-	Kokanee is the single keystone fish species in all Kootenay large lake and reservoir ecosystems and are thus extremely significant for lake wide productivity (Burrows pers comm.). There have been significant monitoring and enhancement efforts to help recover the population to pre-dam installation levels (See Section 4.1.4).
Chinook Salmon (*Oncorhynchus tshawytscha*)	Regionally significant	-		There is a major initiative underway to reintroduce salmon into the Upper Columbia River Watershed. In the US, Chinook Salmon have been captured and released upstream of dam obstructions since 2017. In 2022, Chinook Salmon were captured in the Canadian portion of the watershed, including in the Lower Arrow Lakes, below Keenleyside Dam and the Waneta area (Bringing the Salmon Home Initiative 2022). The Chinook salmon in Lower Arrow Lakes would have migrated through the Hugh Keenleyside Dam lock. See Section 4.1.1 for a more detailed history of the initiative.

Table 4. Fish species in Arrow Reservoir that are not at risk (Province of BC 2022).

Common name (Scientific name)	Common name (Scientific name)
Bridgelip Sucker (*Catostomus columbianus)*	Mountain Whitefish (*Prosopium williamsoni*)
Chiselmouth (*Acrocheilus alutaceus*)	Northern Pikeminnow (*Ptychocheilus oregonensis*)
Lake Chub (*Couesius plumbeus*)	Peamouth Chub (*Mylocheilus caurinus*)
Lamprey (*Lampetra* spp.)	Prickly sculpin (*Cottus Asper*)
Largescale Sucker (*Catostomus macrocheilus*)	Pygmy Whitefish (*Prosopium coulterii*)
Leopard Dace (*Rhinichthys falcatus)*	Rainbow Trout - Interior lineage & large lake piscivore ecotype (*Oncorhynchus mykiss*)
Longnose Dace (*Rhinichthys cataractae*)	Redside Shiner (*Richardsonius balteatus*)
Longnose Sucker (*Catostomus catostomus*)	Slimy Sculpin (*Cottus cognatus*)
Mottled Sculpin (*Cottus bairdii*)	Torrent Sculpin (*Cottus rhotheus*)

Table 5. Introduced (exotic) fish species in Arrow Reservoir (Province of BC 2022).

Common name (Scientific name)
Brook Trout (*Salvelinus fontinalis*)
Carp (*Cyprinus carpio*)
Lake Whitefish (*Coregonus clupeaformis*)
Largemouth Bass (*Micropterus salmoides*)
Pumpkinseed (*Lepomis gibbosus*)
Walleye (*Sander vitreus*)
Yellow Perch (*Perca flavescens*)

Fish stocks in the Arrow Reservoir are very important to local communities, as well as Indigenous Peoples who highly value fish for their cultural and societal importance. The Arrow system supports a modest sport fishery (Sebastian et al. 2000), which mainly targets Bull Trout, Rainbow Trout, Kokanee and Burbot (Arndt 2022). The significance of the fishery was summarized in the recent creel survey results (Arndt 2022):

> *"In 2021, the Arrow Lakes fishery supported 10,100 angler-days, providing important recreational opportunities for local, provincial and some non-resident Canadian anglers. A total of 9,200 fish were caught, with 5,090 kept as a food harvest of 4.8 tonnes. Associated expenditures related to the fishery were estimated at up to $1.5 million, including major purchases wholly or partially attributable to the fishery. This level of angling effort was actually one of the lowest on record, and was probably affected by the heat dome and forest fires that caused poor air quality and poor visibility in the area from late June through early August."*

Bassett et al. (2022) related these results to historic findings:

> *"The 2021 creel survey results are a slight increase from 2020 but less than that from 2001 – 2011, and slightly below expected for the phosphorus added over the last four years. Catch rates were low for Burbot and Kokanee, relatively high for Rainbow Trout, and about average for Bull Trout. Catches of Bull Trout and piscivorous Rainbow Trout (≥ 50 cm) have been relatively low since 2014."*

However, Sebastian et al. (2000) describes that the fishery faces a high degree of uncertainty:

> *"This is because of a recent dramatic decline in Kokanee numbers. Also, a unique stock of piscivorous Rainbow Trout locally recognized because of brightly yellow-colored fins and operculum is also threatened with extinction due to migration blockage at Revelstoke and loss of habitat. Hybridization with introduced Gerrard rainbows may also be affecting the remnant "yellow-finned" rainbow. The fishery on native and augmented adfluvial Bull Trout is quite popular but the decline of Kokanee does not bode well for Bull Trout because of their dependence on Kokanee for food. Small Rainbow Trout that spawn in numerous tributaries and frequent littoral habitat areas, typically near stream mouths, provide good summertime fishing. A fishery for planted Gerrard stock Rainbow Trout exists but is also highly dependent upon an abundance of Kokanee.*

Overall, the Arrow Reservoir foreshore provides important habitats for a variety of fish species and life stages. Since the water levels are regulated and considerably change throughout the year, protecting high value functioning habitats is paramount. Notable fish habitats in Arrow Reservoir are stream mouths, as these areas are essential for staging and migrating life stages for fish that spawn upstream in the tributaries and return to the lake to rear. These areas, as well as wetlands and adjacent habitats with cover and good substrates that provide refuge and foraging habitat are important. As a result, these high value habitats have been included in the FHSI. These habitats must be considered during land use planning to help manage the sensitive populations.

Although all native fish species contribute to the biodiversity of the lake, sensitive species require special attention. This is because the species in the Arrow Reservoir are experiencing population declines, which are indicative of underlying habitat related issues. Wherever possible, habitats for vulnerable life stages should be maintained with improvements made.

Where data was available, habitats of importance for sensitive species were mapped as ZOS and valued high in the FHSI (Table 7, Table 9). All these data highlight the importance and need to adequately protect shoreline habitat values.

Non-native fish species typically are concerns, as they may predate on native species, and/or out compete the native species for habitat and food resources. Often non-native species thrive in impacted habitats to the detriment of the native species. Modifications (i.e., retaining wall, docks, groynes, boat launches and marinas) have been included in the FIM (see previous section), and are also included in the FHSI as a negative influence, because of their potential to impact the shoreline and species inhabiting it.

4.1.1 Salmon reintroduction to the Upper Columbia River Watershed

Significant efforts are currently underway to reintroduce salmon into the Upper Columbia River Watershed. In the US, Chinook Salmon have been captured and released upstream of dam obstructions since 2017. The initiative has been largely undertaken by Indigenous Peoples. The US efforts through to 2020 were summarized as follows from the Lake Roosevelt Forum article (2021).

- *In 2017, the Spokane Tribe of Indians (Spokanes) released 753 yearling Chinook in Tshimikain Creek, which is a tributary to the lower Spokane River, that flows into Lake Roosevelt and the Columbia River. Using PIT (Passive Integrated Transponder) tags, the tribe tracked their migration to the Pacific. In 2019 it was announced that one fish made it to the ocean, then travelled back up the Columbia through salmon ladders into the Chief Joseph Hatchery ladder. In 2020, three more Chinook from the 2017 release made their journey to the ocean and back to the Columbia.*
- *In 2019, the Colville Tribe conducted releases at Kettle Falls, Keller and in Lake Rufus Woods between Chief Joseph and Grand Coulee Dams.*
- *Several adult Chinook releases occurred in 2020: the Colville Tribe released 50 into Lake Roosevelt, and 100 into the Sanpoil River, with many reported to have spawned; the Spokanes released 50 in Tshimikain Creek and 50 into the Spokane River below Long Lake Dam; the Coeur d'Alene Tribe released Chinook in Hangman Creek; and 75 from the Leavenworth National Fish Hatchery were released.*
- *2020 was also the second straight year the Coeur d'Alene Tribe released juvenile salmon. In late March more than 1,450 yearling chinook salmon were released into upper Hangman Creek, 331 kilometers upstream of the current anadromous zone and behind five hydroelectric projects without fish passage facilities. By July, the first Coeur d'Alene fish reared on the Reservation in over 100 years was confirmed to have survived the downstream journey to the Pacific.*
- *Overall, the Tribal passion for salmon reintroduction rests on a foundation of striving to restore the physical and spiritual health of members. At the same time, they see reintroducing salmon as critical to the ecosystem and a benefit to local economies.*

In 2022, Chinook Salmon were captured in the Canadian portion of the watershed, including in the Lower Arrow Lakes, below Keenleyside Dam and the Waneta area (Bringing the Salmon Home Initiative 2022). These fish would have gained access to the Arrow Reservoir through the Keenleyside lock and more are expected (B. MacDonald pers comm 2023). The new Columbia River Treaty is expected to include details in the ecosystem function part about salmon reintroduction (B. MacDonald pers comm 2023).

4.1.2 Mussels

Mussels are also considered fish under the Federal *Fisheries Act* and native mussels hold Indigenous Peoples ecological value. Freshwater mussels are experiencing population declines worldwide due to habitat modification and introduction of non-native mussels etc. (Ministry of Forests, Lands, Natural Resource Operations and Rural Development [FLNRORD] 2018, Metcalfe-Smith and Cudmore-Vokey 2004, Lydeard et al. 2004, Perles et al. 2003, Neves 1997, and Bogan 1993).

A mussel inventory has not been completed in Arrow Reservoir, and mussels were not seen during the 2022 field component of this study, since it was done near full pool water levels. However, our team has been informed of mussel observations along the shoreline, specifically at the south end of the study area where sand substrate is present. There are several potential risks to mussels present along the shoreline, especially in a regulated reservoir. For example, when the water level drops rapidly, mussels may not be able to move fast enough, especially over coarse substrate and can become stranded above the wetted perimeter where they ultimately perish. In 2015, rehabilitation work was undertaken on mussel beds on the foreshore of Syringa Creek Provincial Park to address this very concern (Heagy pers. comm. 2023). The work was completed to ensure the mussels would be able to leave an isolated pool as the reservoir receded, behind what was an old road (Heagy pers. comm. 2023). Other development activities (such as foreshore substrate modification) can also affect mussels. It thus is important that landowners and habitat managers: a) are aware that bivalves may be present along the shoreline, b) have assessments completed prior to developments activities, c) and have mitigation measures in place to protect or at minimum salvage them.

Where mussel presence is known, the habitat was included in the FHSI as a ZOS (Table 7 and Table 9Error! Reference source not found.). However, location data was only limited to the one location discussed above. Although this data was included, it was acknowledged that an incomplete survey of the lake may influence the FHSI, but these influences were considered small. Inclusion was considered important due to the unique nature of the observation. A survey of the shoreline is recommended to map where mussels are present, similarly to that completed on other lakes in the region, including Windermere and Columbia lakes (Schleppe and McPherson 2021, and Moore and Machial 2007) and Kootenay Lake (Schleppe and McPherson 2022, Andreashuk pers. comm. 2021). Location information should be used to update the Arrow Reservoir ZOS and FHSI in the future.

4.1.3 White Sturgeon dam related monitoring and recovery efforts

In accordance with the Columbia River WUP (BC Hydro 2007 and Columbia River Water Use Plan Consultative Committee 2005; Section 1.4), BC Hydro has implemented several monitoring programs in the Arrow Reservoir. These programs have contributed to understanding associated impacts of the dams and water regulation on various species and habitats (BC Hydro 2022b). A list of the White Sturgeon related programs and key findings are as follows:

1. Mid Columbia River White Sturgeon Spawning Habitat (CLBMON-20; 1999-2014). To model the effects of Revelstoke Dam discharges and ALR levels on velocity/depth patterns in the White Sturgeon egg deposition/incubation and early rearing area. The following summary was obtained from the final report of this multi-year study (Hildebrand et al. 2014):
    - *Studies initiated in the mid-1990s identified the presence of a remnant population of wild adult White Sturgeon in the Arrow Lakes Reservoir (Golder Associates Ltd [Golder] 2006). The population was estimated at 52 (95% CI = 37 to 92) adults, which spawned in the flowing section approximately 6 km downstream from Revelstoke Dam. Egg incubation and potential early rearing habitats are located within a few kilometres downstream of the spawning grounds (Golder 2012).*
    - *Spawning has occurred intermittently and has been documented in 8 of 13 years studied, with 1 - 3 spawning events per year. Spawning has occurred in late July to late August, which represents the latest spawn timing recorded for this species throughout its range. The delayed onset of spawning has been attributed to naturally cold water temperatures in this section of the Columbia River that have been exacerbated by hypolimnetic flow releases from Revelstoke Dam. Low numbers of fertilized eggs and post-hatch larvae have been captured, which indicates some successful fertilization and survival to hatch, but recruitment to the juvenile stage from these spawning events has not been detected.*

2. Mid Columbia River Juvenile Sturgeon Detection and Habitat Program and Tracking of Existing Sonic Tagged Sturgeon Monitoring (CLBMON-21; 2007 – 2022). To monitor the success (growth and survival) of hatchery-origin White Sturgeon released into the Mid Columbia River and Arrow Reservoir. BC Hydro (2022b) provided the following summary in their annual report, as obtained from the final report of this multi-year study (Okanagan Nation Alliance [ONA] 2022a):
    - *The monitoring program addressed general habitat use through use of telemetry on a subset of individuals. To date, only 57 individuals have been captured, precluding any quantitative evaluation of survival. Low capture rates may be due to predation, slower growth, or a more challenging reservoir environment to sample. The majority of the fish have been captured within 1.5 years following release (n=39) from the hatchery with the remaining individuals captured between two to ten years following release. While captures of fish years after release*

suggests some capacity for survival, the program has yet to produce sufficient data to estimate survival or year class abundance.

3. Mid Columbia River Sturgeon Egg Mat Monitoring and Underwater Videography Feasibility (CLBMON-23; 2007 – 2018). To provide a longer dataset to improve the confidence in the results. BC Hydro (2022b) provided the following summary in their annual report, as obtained from the final report of this multi-year study (ONA 2022b):
    - *A key result has been the collection of both wild-origin eggs and larvae that were transferred to the hatchery program in each of 2018, 2019, 2020, and 2021. Since the inception of the aquaculture program in 2001, wild White Sturgeon from Arrow Reservoir had not been represented in supplemental progeny that were released. Wild-origin juveniles from the Revelstoke spawning site are being reared to a larger size (700 g) threshold for release to hopefully improve survival in the wild. Prior to successes in 2018 and 2019, very few tissue samples have been obtained as a result of low larval capture numbers.*

4. Mid Columbia River Sturgeon Genetics (CLBMON-24; 2007 – 2021). To analyze samples collected from monitoring under CLBMON-23 to estimate numbers of spawning adults contributing to progeny collected at the Revelstoke spawning area. This study is underway, being delivered in partnership with other recovery team members that have genetic samples from the population (US partners) and experts in White Sturgeon genetics. Results are expected in 2023 (BC Hydro 2022b).

5. Mid Columbia River Sturgeon Incubation and Rearing Study (CLBMON-27; 2009 – 2012). To Investigate aspects of the relationship between temperature and early life history survival and recruitment. The following summary was obtained from the second-year report of this three-year study (Parsley et al. 2011):
    - *The general approach of this study was to incubate and rear White Sturgeon early life stages under two thermal regimes; one mimicking the current, cool water regime of the Columbia River downstream from Revelstoke Dam, and one mimicking a warmer regime similar to conditions found on the Columbia River at the international border.*
    - *Results suggest that thermal regimes during incubation influenced the rate of egg development and size at hatch. Eggs incubated under the warm thermal regime hatched sooner than those incubated under the cool thermal regime. Mean length of free embryos at hatch was significantly different between thermal regimes with free embryos from the warm thermal regime being longer at hatch. However, free embryos from the cool thermal regime had a significantly higher mean weight at hatch.*
    - *Growth of fish reared in the cool thermal regime was substantially less than growth in the warm thermal regime. The magnitude of mortality was greatest in the warm thermal regime prior to initiation of exogenous feeding, but chronic low levels of*

mortality in the cool thermal regime were higher. Fish in the warm thermal regime exhausted their yolk reserves faster than fish in the cool thermal regime.

6. Mid Columbia Effects of REV 5 Flow Changes on Incubation and Early Rearing Sturgeon (CLBMON-54; 2010 – 2014). Examine the effects of the additional (5th) generating unit at Revelstoke Dam on the spawning and early life stage habitat at the known spawning area. BC Hydro (2022b) provided the following summary in their annual report, as obtained from the final report of this multi-year study (Hildebrand et al. 2014):

    - *This work demonstrated that the additional flows from Revelstoke unit five were only slightly beneficial to the conditions experienced at the spawning location and more suitable early life stage habitat exists in the area then previously known. Suitable spawning parameters (depths and flows) existed over most operational scenarios tested.*

Several programs have been implemented to counteract dam related impacts on White Sturgeon, which have been listed below. This information highlights the importance of White Sturgeon in the Arrow Reservoir.

1. In 2001, a White Sturgeon hatchery program was initiated as a conservation measure. As of January 1, 2012, approximately 36,693 hatchery juveniles and 1,454,010 larvae were released into the Arrow Lakes (James Crossman, BC Hydro, personal communication).
2. Mid Columbia Experimental Aquaculture (CLBWORKS-24; 2007 – 2012). The purpose of this program was to provide larvae and juveniles for release to evaluate survival, habitat use, and impacts of Arrow operations on juvenile habitat availability and suitability (CLBMON-21) (BC Hydro 2022b).
3. Mid Columbia Sturgeon Conservation Aquaculture (CLBWORKS-25; 2012 – 2022). This program is a continuation of CLBWORKS-24. One primary goal is to release juvenile sturgeon of a larger body size compared to historical values to help address questions of survival under CLBMON-21 (BC Hydro 2022b).
4. Mid Columbia Sturgeon Upgrade Hatchery (CLBWORKS-26; 2008 - 2010). This involved the construction of temporary rearing facilities that could be located on the banks of the Columbia River (e.g., Revelstoke). However, as of 2022, the facilities remained at the Kootenay Trout Hatchery, pending more certainty on how streamside rearing would fit within recovery goals (BC Hydro 2022b).
5. Critical habitat has been identified for White Sturgeon under the Federal Recovery Strategy (DFO 2014).

*Critical habitat was identified as a ZOS in this FIMP and has been further described in the Foreshore Habitat Sensitivity Index (Table 7 and Table 9).

4.1.4 Other fish species monitoring and enhancement efforts

In addition to the efforts on White Sturgeon above, BC Hydro has implemented several monitoring programs aimed at understanding the effects of its operations on other fish species. In summary, these are as follows:

1. Burbot Life History Study (CLBMON-31; 2008 – 2013). To assess the potential effects of winter drawdown of Arrow Lakes Reservoir to spawning Burbot. The following summary was obtained from the final report of this multi-year study (Robichaud et al. 2014):
   - *Data on Burbot movements, timing and location of spawning were collected using a combination of techniques, including fixed-station and mobile tracking of transmitter-tagged fish, bio-sampling, egg mat sampling, plankton net tows and underwater video observations.*
   - *The focal areas with the highest detected tag presence were Upper Arrow Lake (Beaton and Shelter Bay areas) and The Narrows (near MacDonald Creek).*
   - *Burbot have moved out of the parts of the Revelstoke-Arrowhead Reach that are most affected by the reservoir drawdown, and do not appear to be spawning in the areas most affected by drawdown.*

   * Burbot spawning areas were mapped as a ZOS (Table 7).

2. Tributary Fish Migration Study (CLBMON-32; 2008 – 2014). Assess passage conditions for fish (Rainbow Trout, Kokanee, and Bull Trout) at tributaries to Arrow Reservoir under a range of operating levels and streamflow conditions. The following summary was obtained from the final report of this multi-year study (Hawes et al. 2014):
   - *High vertical fluctuation of the reservoir can cause low to very low tributary stream flows being conveyed through wider, aggraded, more poorly defined, and braided channels over the drawdown zone. When these drawdown zones are exposed and stream flows are low to very low, upstream fish migration can be reduced or blocked.*
   - *The greatest potential for impediments to Rainbow Trout migration in the early spring (late March-early April) occur when reservoir levels are below 429 m and stream flows are low to very low. However, stream temperature monitoring suggests that Rainbow Trout migration may not occur until mid-April and later when passage conditions are good. Good passage conditions continue through June and July and decrease into September.*
   - *The soft constraints target objective for the reservoir levels is 434 m as established by the Columbia River Water Use Plan Consultative Committee. This target is to ensure appropriate elevations for tributary access during the Kokanee spawning period (late August - early November). Kokanee migration access has been observed to be reduced in some tributaries in spite of reservoir levels being at or*

above the 434 m constraint. These access impairments are the result of very low stream discharges on individual watercourses.

- *Bull Trout migrations to spawning grounds can occur as early as April and continue to September. This temporal range makes it difficult to focus on a specific period to monitor tributary drawdown zone conditions. The combined higher stream flows and reservoir levels during earlier tributary access would provide good passage conditions for Bull Trout. Eagle Creek has late summer passage concerns and occasionally Drimmie Creek has the potential to develop a braided channel upstream of the reservoir. However, the remaining tributaries supporting Bull Trout are not likely to have passage concern, since they are generally larger (higher order and magnitude streams) or occur in the upper Arrow basin, where higher elevation watersheds (i.e., more prolonged snow melt) and a wetter climate regime sustains higher flows throughout the year.*

* The stream mouths of tributaries with the potential to support fish populations were mapped and contributed to the FHSI through three ZOSs: salmonid bearing stream ZOS, staging/migration corridor ZOS, and the rearing ZOS (Table 7 and Table 9).

The Fish and Wildlife Compensation Program (FWCP) currently funds two large-scale projects in the Arrow Reservoir related to help address the impacts of dams, as summarized below. This information is provided to emphasize the importance of the Arrow Reservoir fishery.

1. Hill Creek spawning channel was built in 1981 as compensation for lost access to spawning habitat upstream of the Revelstoke Dam. The spawning channel runs adjacent to Hill Creek, which is a tributary to Galena Bay, and is located within the study area, approximately 53 km north of Nakusp. The spawning channel provides enhanced substrate for Kokanee and Rainbow Trout spawning, and rearing habitat for juvenile Rainbow Trout (Porto and Arndt 2006).

2. Arrow Lakes Reservoir Nutrient Restoration Program has been ongoing since 1999. Nutrient addition is a known successful technique to restore Kokanee populations in lakes and reservoirs altered by hydroelectric construction (Bassett et al. 2022). Highlights of this program, as reported for the 2021 fertilization season are as follows (Bassett et al. 2022):
   - *As a result of decreased upstream nutrient inputs, Kokanee stocks in Arrow Lakes declined substantially by the mid-1990s. To address this, nutrients were added (nitrogen and phosphorus in the form of liquid fertilizer) to address productivity using a bottom-up approach. The nutrients are intended to increase phytoplankton populations, which produces Daphnia, the main food source for Kokanee. Kokanee in turn is a food source for piscivores (Bull Trout, Rainbow Trout, and Burbot).*

Productive fish stocks benefit angling, which in turn brings social and economic benefits to local communities and the province.

- *Nutrients were added between late April and early September, using the ferry between Shelter Bay and Galena Bay. Dissolved phosphorus and nitrogen levels were similar to previous years, and indicative of an oligotrophic system. Phytoplankton and zooplankton were above average in 2021, and mysids were below average.*
- *Kokanee returns in 2021 were very low, totaling only 14,000 in Upper Arrow and 67,000 in Lower Arrow. The in-lake Kokanee population for the combined basins was 5 million age 0 and 1.2 million age 1-3, which were both below the post nutrient addition average. The Upper Arrow population was closer to the long-term basin average than Lower Arrow, where the age 0 and age 1-3 populations were only 31% and 39% of average respectively. Kokanee cohort survival in 2021 was near average for age 0-1 and was above average for age 1-2+.*
- *Overall, consecutive years of poor egg to fall fry survival, combined with below average in-lake survival from age 0 to age 1 in previous years resulted in low numbers for all in-lake age classes of Kokanee. This, combined with below average Daphnia outcomes in recent years led to below average Kokanee biomass.*

Other historic enhancement projects completed as summarized by Sebastian et al. (2000) are as follows:

- *Arrow Lakes were stocked with numerous species of fish from the 1920s to the early 1950s. Lake Whitefish and Eastern Brook Trout were successfully introduced: were successfully introduced. Other species stocked were Rainbow Trout (eggs, fry and yearlings), Kokanee, and Cutthroat Trout.*
- *Mysis relicta were introduced into Upper Arrow Lake in 1968 and in 1974 (Northcote 1991). These introductions were made with the belief that Rainbow Trout and Kokanee growth would improve and serve as replacement of food lost due to flooding of the littoral areas of Arrow Lakes. However, Mysis relicta are implicated in the downward trend in Kokanee numbers for Kootenay and Okanagan Lake (Ashley et al. 1997; Ashley et al. 1999) and are also probably partially responsible for the decline in Arrow Reservoir Kokanee numbers.*
- *Barriers to upstream migration were identified and removed to aid Kokanee, Bull Trout and Rainbow Trout. Small debris barriers were removed on Deer, McDonald, Nakusp and Heart creeks. Also, plans were developed to allow Kokanee and Rainbow to pass over the falls at the lower end of Inonoaklin River (Andrusak, 1984). However, agricultural interests opposed the project due to water use concerns and the idea was abandoned.*
- *Removal of the Illecillewaet Dam (~ 2 km upstream from the mouth) was an important restoration project. The dam was successfully removed in 1977, and today*

Bull Trout utilize some 38 km of mainstem and tributary streams for spawning and rearing.

- *A Bull Trout hatchery was installed at Hill Creek. This was the first hatchery in North America dedicated to production of Bull Trout. Rainbow Trout production was later added to the hatchery. Rainbow Trout enhancement focused on the two indigenous stocks, and introduced Gerrards. Unsuccessful attempts were also made to capture and culture the uniquely yellow colored Rainbow Trout.* This hatchery was shifted to Sturgeon around 2000, and then was closed altogether around 2005 (Neufeld pers. comm. 2023).

4.2 Wildlife

Wildlife values in this study collectively included aquatic (non-fish) and terrestrial wildlife, plant and ecosystem values.

4.2.1 Critical habitat for species at risk and red and blue listed species

Sensitive wildlife species occurrences in this study were vertebrates, invertebrates, and vascular plants. These species and/or areas designated as sensitive habitats for them within 50 m of the Arrow Reservoir shoreline, as obtained from the provincial databases (BC CDC iMap 2022b and BC Habitat Wizard 2022) are listed in Table 6. These species and their habitats were identified to be ZOS, with most included in the FHSI (See rationale and FHSI tables, Table 7 and Table 9, respectively).

Table 6. Mapped sensitive habitat and species occurrences for wildlife species at risk within 50 m of the Arrow Reservoir foreshore (BC CDC 2022b unless otherwise noted).

Species Group	Common Name (scientific name)	CDC Shape ID	BC Listing	COSEWIC Status	SARA Status -Schedule	Occurrence details
Vertebrate Animal	Bank Swallow (*Riparia riparia*)	-	Yellow	Threatened	Threatened - 1 (2017)	The Bank Swallow has approved critical habitat (for nesting) along the shoreline of Arrow Lakes, focused in the Narrows (Environment and Climate Change Canada 2022). See ZOS table for more information (Table 7).
Vertebrate Animal	Caribou - Southern Mountain Pop. *(Rangifer tarandus pop. 1)*	10265	Red	Endangered	Threatened - 1	Approved critical habitat for this population is present within 50 m of the shoreline north of Nakusp (BC Habitat Wizard 2022). See ZOS table for more information.
Vertebrate Animal	Grizzly Bear (*Ursus arctos*)	-	Blue	Special Concern	Special Concern - 1 (2018)	BC Habitat Wizard (2022) identified one Wildlife Habitat Area (WHA) under the *BC Forest and Range Practices Act* (FRPA) along the shoreline. This WHA was specified as a Conditional Harvest Zone to protect the Grizzly Bear. The WHA was found along the west bank of the Lower Arrow Lake. See ZOS table for more information.
Vertebrate Animal	Canyon Wren (*Catherpes mexicanus*)	3954	Blue	Not at Risk (1992)	-	Syringa Creek area, 1991 and 1983. The 1983 sighting was on Deer Park Road (BC Vertebrate Record File 1991).

Species Group	Common Name (scientific name)	CDC Shape ID	BC Listing	COSEWIC Status	SARA Status -Schedule	Occurrence details
Vertebrate Animal	White-throated Swift (*Aeronautes saxatalis*	8228	Blue	-	-	Syringa Creek area: seen annually from 1986 - 1991 in numbers from 2 to 10 by G. Davidson, during breeding bird surveys (Summers 1993). Also seen east along the highway to Robson.
Invertebrate Animal	Western Bumble Bee (*Bombus occidentalis*)	126302 126551 126555	Blue	Threatened (2014)	-	• In 2019, five bees were collected in Syringa Provincial Park (Heron et al. 2019). • In 2015, one bee was photographed at Edgewood (Klinkenberg ND; accessed 5 January 2020). • In 2019, one bee was photographed at Burton Creek (J. Gatten, pers. comm. 2020).
Vascular Plant	Whitebark Pine (*Acorus americanus*)	N/A	Blue	Endangered	Endangered - 1 (2012)	Proposed critical habitat for Whitebark Pine is present throughout a 62,804 ha area that includes a considerable section of shoreline north of Nakusp (BC Habitat Wizard). However, all plants mapped have been well away from the shoreline at higher elevations. See ZOS for more information.
Vascular Plant	Mountain Moonwort *(Botrychium montanum)*	136973	Blue	-	-	Observed in 2014 at Edgewood in terrestrial grassland/herbaceous habitat (Batten 2021).
Non Vascular Plant	Silver Hair Moss (*Fabronia pusilla*)	134311	Red	Endangered (2014)	Endangered - 1	Last observation was in 1890 in Deer Park: collected from crevices of rocks (New York Botanical Garden herbarium). However, as reported in 2001, the site is now submerged behind a dam (BC Bryophyte Recovery Team 2007), and this species was thus not considered in the ZOS or FHSI analysis.

There were other sensitive wildlife attributes that were considered ZOS along the Arrow Lakes shoreline. These included:

1. Local biologists provided bat roosting habitats that were not identified in the provincial databases.
2. Also, the BC *Forest and Range Practices Act* (FRPA) designated both Grizzly Bear Wildlife Habitat Area (WHA) and Old Growth Management Areas (OGMA; BC Habitat Wizard 2022).
3. Our FIM field work identified the presence of raptor nests, which were most likely stick nests for Bald Eagles (*Haliaeetus leucocephalus*) and Osprey (*Pandion haliaetus*).
4. The BC Hydro studies (see next) identified that aquatic vegetation and wetland areas were high value, as have other past FIMP studies (i.e., Kootenay and Windermere lakes [Schleppe and McPherson 2022 and 2021, respectively]). These habitats were thus also included as a ZOS.

Further details for these ZOS are found in the rationale and FHSI tables. Note, although included on mapping for this project, CDC Blue listed sensitive species/habitats were not included in the GIS database. This data belongs to the Province and it is expected that it will continually be updated, as more observations occur. *Any QEP who is working on the Arrow Lakes system must review the provincial databases for the most current listings at the time of completing an environmental impact assessment for a proposed project.*

4.2.2 Wildlife monitoring and enhancement efforts

BC Hydro has monitoring programs aimed at understanding the effects of its operations on wildlife. Although some of the work was north of the FIMP study area (in the Revelstoke Reach), this information was provided as it highlights habitats of value, the species present, sensitivities and the importance of maintaining existing functioning habitat. Overall, the results of these studies support the high values given to Wetland Shore Type, Percent Natural Shoreline, and Vegetation Band Width FIM criteria, and the Aquatic Vegetation ZOS in the FHSI (Table 7 and Table 9). These programs are summarized below:

1. Nest Mortality of Migratory Birds (CLBMON-36; 2008 – 2017): Assess the impacts that reservoir operations have on the productivity of birds breeding in the reservoir drawdown zone. Only the Revelstoke Reach was assessed, which was limited to the very north part of the FIMP study area. The following summary was obtained from the final report of this multi-year study (Craig and Gill 2020):
    - *Sixty-five species were found nesting in the drawdown zone. Nesting activity occurred earlier in wetlands than other habitats. Nests were concentrated at higher elevations, where vegetation was most established. Highest nest densities occurred in shrub and wetland habitats.*

- *The greatest causes of nest failure were predation and abandonment. However, nest success was also influenced by reservoir operations, with 7.5% of monitored nests flooded. There were some ground or low shrub nesting species for which flooding caused the most nest failures. A SARA species, the Short-eared Owl (Asio flammeus), nested on the ground at relatively low elevation in 2010 and 2016, with all nests flooded.*

2. Amphibian and Reptile Life History and Habitat Use Assessment (CLBMON-37; 2008 - 2018 & 2020). To assess the relative influence and importance of the current reservoir operating regime on the life history and habitat use of amphibians and reptiles occurring in the drawdown zone. The following summary was obtained from the final report of this multi-year study (Hawkes et al. 2020).
   - *Twelve sites within the drawdown zone were monitored including: Revelstoke Reach, Beaton Arm, and mid Arrow Lake (Burton Creek and Edgewood). Habitats were closely tied to the typical 10 m change in elevation (430-440 masl).*
   - *Four amphibian and six reptile species were documented. The most detected species were Western Toad (Anaxyrus boreas), Pacific Chorus Frog (Pseudacris regilla), Western Terrestrial Garter Snake (Thamnophis elegans), and Common Garter Snake (Thamnophis sirtalis), which were typically observed in reed canary grass mesic habitat.*
   - *The most common amphibian species observed in the drawdown zone were Western Toad and Columbia Spotted Frog (Rana luteiventris), followed by Pacific Chorus Frog and Long-toed Salamander (Ambystoma macrodactylum). Coeur d'Alene Salamander (Plethodon idahoensis) used upland habitats adjacent to the drawdown zone.*
   - *Common Garter Snakes were the most abundant reptile followed by Western Terrestrial Garter Snake. Western Painted Turtles (Chrysemys picta belli) were common in Revelstoke Reach. Three other reptile species were also documented using habitats in the upper elevations of the drawdown zone: Western Skink (Plestiodon skiltonianus), Northern Alligator Lizard (Elgaria coerulea), and Rubber Boa (Charina bottae).*
   - *Most species were widely distributed and abundant. Certain species (e.g., Western Skink; Rubber Boa, and Western Painted Turtle) were more limited in their distribution with Western Skink and Rubber Boa constrained to south of Lower Inonoaklin Road and Western Painted Turtle found primarily in Revelstoke Reach.*
   - *Species diversity was highest in Montana Slough (Revelstoke Reach) and Edgewood South. Airport Marsh and Beaton Arm were also high diversity monitoring sites.*
   - *Breeding amphibian populations, a productivity indicator, were documented for most monitoring sites, with Revelstoke Reach (Airport Marsh, Cartier Bay, Montana Slough), Bush Arm KM79, and Valemount Peatland being the most productive.*

- *Most species were found in wetland-associated habitat types such as wool-grass-Pennsylvania buttercup (Columbia Spotted Frog), Kellogg's sedge (Common Garter Snake, Western Terrestrial Garter Snake), and swamp-horsetail (Long-toed Salamander, Western Toad). Other vegetation community types with frequent detections included clover-oxeye daisy (Long-toed Salamander, Western Toad, Western Terrestrial Garter Snake), driftwood (Common Garter Snake) and willow-sedge (Columbia Spotted Frog). Occupied vegetation communities were distributed between ~430 and 451 masl.*
- *For most species, detections were most frequent in the reed canary grass mesic habitat type. Other frequented vegetation communities included reed-rill (Columbia Spotted Frog), industrial/urban/recreational (Pacific Chorus Frog), vegetation poor ponds (Western Toad, Western Painted Turtle), sandy beach (Common Garter Snake), redtop upland (Western Terrestrial Garter Snake), and gravelly beach (Northern Alligator Lizard).*
- *Pond-breeding amphibians including Western Toad, Columbia Spotted Frog, Long-toed Salamander, and Pacific Chorus Frog were mainly associated with wetland habitats, with the majority of those habitats occurring in Revelstoke Reach. Wetland habitats were characterized as having varying degrees of open water, soft substrates, and complex vegetation that included both emergent and submergent vegetation.*
- *Of the amphibian species detected, one (Western Toad) is at risk (COSEWIC and SARA Schedule 1 species of Special Concern). For reptiles, the Intermountain-Rocky Mountain Population of the Western Painted Turtle is blue-listed in BC and is a SARA Schedule 1 species of Special Concern, as is the Western Skink. The Rubber Boa is yellow-listed in BC, but is also a SARA Schedule 1 species of Special Concern.*
- *There was limited evidence of direct effects of reservoir operations (timing, duration, frequency of inundation) on most of the species using these habitats. There was evidence of reduced seasonal habitat availability resulting from the variable yet predictable manner in which the reservoir was managed. As it filled in the spring and summer, the amount of useable habitat available to amphibians and reptiles decreased. Thus, there was a direct relationship between increased reservoir elevations and the reduced seasonal distribution and habitat use of amphibians and reptiles. As the reservoir fills, amphibians and reptiles continue to occupy pond habitats that have not yet been inundated. They also occupy habitats at the leading edge of the reservoir until there is either no drawdown zone left (i.e., if reservoir reaches full pool), the reservoir begins to recede, or amphibians and reptiles return to their wintering habitats, which are primarily above the normal high-water mark. For species that bred in the drawdown zone (i.e., pond-breeding amphibians), breeding occurred in ponds and wetlands prior to inundation from either reservoir. Western Painted Turtle was the only species confirmed to overwinter in the drawdown zone (Revelstoke Reach, Arrow Lakes Reservoir) and*

there was no indication of adverse effects of reservoir operations on wintering individuals.

3. Amphibian and Reptile Life History and Habitat Use Assessment: Western Painted Turtle Population Trends Assessment (CLBMON-37; 2010 – 2017). To determine the abundance, diversity, and productivity (reproduction) of the Western Painted Turtle utilizing the drawdown zone and how these vary within and between years. This study area was the Revelstoke Reach. The following summary was obtained from the final report of this multi-year study (Challenger and Hawkes 2020):
    - *Adult Western Painted Turtle population in Revelstoke Reach may have undergone a statistically significant decline since 2010. Total adult abundance (i.e., age 10+) was estimated at approximately 890 adult turtles in 2010, declining to roughly 630 adults by 2017.*
    - *There are several possible factors that might be influencing the turtle population. These include road-based mortality of females during the nesting period, reduced habitat suitability at nesting sites (which occur outside of the drawdown zone), nest predation, and increased (although unmeasured) rates of predation on juveniles. Previously completed work indicated that the turtle populations in Revelstoke Reach will experience potential, seasonal (and temporary) habitat displacement relative to changing reservoir levels but the overall impact of reservoir operations on turtles appears to be negligible.*

**Additional FIMP notes not stated in the above report:*

- Western Painted Turtles (Intermountain - Rocky Mountain Population) are a species of Special Concern both federally (SARA Schedule 1) and provincially (blue listed). The habitat utilized by this aquatic species is summarized as follows (COSEWIC 2006):

  "*This species is found in the shallow waters of ponds, lakes, sloughs, and slow-moving stream reaches. Suitable wetlands have muddy substrates, an abundance of emergent vegetation, and numerous basking sites. Habitat also includes riparian zones bordering wetlands. Females nest up to 150 m away from water, in loose, warm, well-drained soils".*

- The provincial dataset (BC CDC imap) shows no occurrence data for this species in the Arrow Lakes, including in the Revelstoke Reach, where observations were made in the above studies. It is thus recommended that inventories for this and other sensitive herptile species be expanded throughout the lakes, and for the provincial database to be updated accordingly.

4. Neotropical Migrant Use of the Drawdown Zone (CLBMON-39; 2008 – 2017). The effects of reservoir operations on neotropical migrant songbirds in Revelstoke Reach (Airport Islands, Machete Island and Jordan River) during fall migration. The following summary was obtained from the final report of this multi-year study Pavlik 2020:

- *Broad habitat-use by migrants was highly stratified with abundance and species richness of both fall and spring migrants highest in forest, followed in descending order by shrub, grassland, and unvegetated habitats. At a finer scale, fall migrants had the highest abundance and species richness in well-developed riparian habitat (riparian forest, riparian shrub) and complex wetland habitat (swamp, cattail, wet meadow). Spring migrants had the highest abundance and species richness in forested habitats (upland forest and riparian forest), well-vegetated wetland habitats (swamp, cattail), and shrub savannah.*
- *Reservoir operations impacted quantity of fall migrant stopover habitat available as, for example, 79% of drawdown zone area was flooded when reservoir elevation reached 438 m above sea level, but effects were largely mitigated by the relatively low use of habitats below that elevation (unvegetated, grassland, wetland, low shrub) and the ability of most species to move to higher elevation shrub and forested habitats. Reservoir operations, observed during the study period, had no significant effect on quality of stopover habitat for most fall migrants, except for those few species that are obligate grassland users.*
- *Reservoir operations had limited effects on spring migrant habitat and, therefore, on spring migrants, until late in the spring migration (late May) when reservoir levels began to inundate grasslands. Even then, effects on use of the drawdown zone were minimal as there were relatively few grassland-using spring migrants present in the drawdown zone by late May.*

5. Shorebird and Waterbird Monitoring Program (CLBMON-40; 2008 – 2017, includes Beaton Arm in 2016 - 2017). Reviewed the use of the Revelstoke Reach wetlands during spring and fall migration, the importance of these wetlands for breeding waterbirds, and how ecological functions are impacted by reservoir operations. The following summary was obtained from the final report of this multi-year study (Gill and Craig 2020):
   - *Reservoir operations had a strong effect on migrant waterbird distribution, and ground-nesting waterfowl and raptor breeding success. However, operations had minor to no effect on migrant waterbird abundance, annual waterbird habitat quality, or tree-nesting raptor breeding success.*
   - *Usage of the drawdown zone by waterbirds was well-pronounced during the spring and fall migrations. The spring migration period was relatively short and peaked in mid-April, whereas the fall migration lasted several months and generally peaked in late October. Wetland features within the drawdown zone were disproportionately important habitats for migrant waterfowl. Reservoir operations influenced wetland habitat during the fall migration, but not during the spring migration. The fall shorebird migration was well-pronounced temporally but was never observed to involve many shorebirds. Shorebirds generally moved rapidly through the study area in small groups.*

- *During the breeding season, Short-eared Owl and Northern Harrier used the vast low elevation grassland areas for foraging and nesting. All Short-eared Owl nests were flooded. Whereas Bald Eagle and Osprey foraged in ponds or within the reservoir pool, and nested above the drawdown zone in upland forest habitat.*
- *Waterfowl brood-rearing primarily occurred in drawdown zone wetlands or in the shallow flooded and vegetated margins of the reservoir pool.*
- *The most important impact of reservoir operations to waterbirds is likely the impacts to productivity of ground-nesting waterbirds via nest flooding (e.g., Mallard, American Wigeon, Spotted Sandpiper, Killdeer, Spotted Sandpiper, Northern Harrier and Short-eared Owl).*
- *Waterbirds appeared to be able to find suitable stop-over and staging habitat within the drawdown zone during the migration regardless of the variable reservoir levels that were observed. As such, impacts to migrants were relatively minor.*

BC Hydro has implemented several projects in the drawdown zone to benefit waterfowl, birds, turtles and other wetland wildlife species affected by operations. Projects completed are summarized below (BC Hydro 2022c and BC Hydro 2013). This information augments the understanding of high value wildlife areas and identifies possible options for similar areas identified to require enhancement.

1. Feasibility study of the Revelstoke Reach (CLBWORKS-29A; 2008-2009). This study led to the implementation of the Arrow Lakes Reservoir Wildlife Enhancement Program – Physical Works (CLBWORKS-30A). A summary of the works completed from the most recent report is as follows (Golder 2009):
    - *Airport Marsh (Site 6A) –This involved construction of a riprap mattress to halt the erosion of the east arm of the outflow channel located near Airport Marsh and Machete Island. Work was completed in October 2013 to halt erosion and protect high value wildlife habitat.*
    - *Nest boxes (wildlife enhancement structures) were installed in2013 and 2014 to provide additional nesting habitat for cavity nesting ducks.*
    - *The Cartier Bay wetland (Site 15A) - approximately 26 ha of wetland was created by a collapsed box culvert at the bottom of a gap in the abandoned rail bed that ran 300 m west of the Cartier Bay peninsula and parallel to the old highway. The collapsed culvert held back water and prevented the Cartier Bay wetland from draining as the Arrow Lakes Reservoir water levels dropped. The box culvert was eroding, putting the wetland at risk from draining. In October 2016, rock rip rap was installed on the river side of the old rail line at the box culvert to protect the wetland and reinforce the box culvert. In May 2020 a new outflow channel was observed to be forming on the north side of the wetland, which in October 2020 was stabilized temporarily using sandbags to prevent further erosion. A more permanent structure was planned to be installed upon design and permitting.*

- *Bat enhancement projects were also completed. In 2019, two BrandenBark bat poles were installed at one location (Montana 3). In 2020, one mini-Condo, Rocket Box, back-to-back maternity box and one BrandenBark bat pole were installed at one location (Hayfield)*.

2. Study of High-Value Wildlife Habitat for Potential Enhancement and Protection (CLBWORKS-29B; 2012 and 2016). This was a preliminary feasibility assessment for wildlife physical works opportunities on the middle to lower Arrow Reservoir (outside of Revelstoke Reach). The most recent report was by Hawke and Tuttle (2016).

3. Arrow Lakes Reservoir Wildlife Enhancement Program – Physical Works (CLBWORKS-30B). This included the detailed design, construction, and ongoing maintenance of the Burton Creek project, located south of Nakusp, on the east side of Arrow Lakes. The project was summarized as follows by Miller and Hawkes (2020 and 2022):
    - *Prior to construction, the project area at Burton Flats consisted of a shallowly undulating (nearly flat) expanse of annually inundated drawdown zone. The terrain supported sparse to dense graminoid cover (consisting primarily of non-native reed canarygrass intermixed with native sedges), interspersed with some small stands of black cottonwood on higher ground. The aim of the project was to increase the spatial and temporal availability of wetland habitat for wildlife in the drawdown zone by creating a series of excavated pools between elevations 434 masl and full pool (440 masl), and enhancing riparian and wetland vegetation on the banks of the pond features via a planting program. The wetland design included shallow and deep pool configurations as well as pools with and without surface flow connectivity to allow a comparative assessment of the effectiveness of different types of configurations. Elevated, planted mounds that created nesting and other habitat at higher elevations (>439 masl) were also incorporated into the design for continued learning about habitat enhancement within, and adjacent to, the drawdown zone.*
    - The project was completed in two phases, in 2019 and 2021. Also, the following bat habitat enhancement structures were installed on the mounds in 2021: a rocket box, one back-to-back maternity box and one BrandenBark bat pole.

Table 7. Summary of FIM, ZOS and modification criteria and rationale for inclusion in the FHSI.

Category	Criteria	In FHSI	Rationale
FIM	Shore Type	Yes	Shore type describes the shoreline morphology and is related to many aspects of fish and wildlife productivity. Shore type values were determined using the initial habitat index that considered fish life stage habitat specificity (Schleppe and Arsenault 2006), and subsequent studies completed in the East Kootenay Region, including Kootenay Lake (Schleppe and Cormano 2016 and Schleppe and McPherson 2022). These values further considered the methods review completed on all lakes, where the general ranges in former habitat rankings were summarized for all lakes where an FHSI was completed (Schleppe et al. 2019). Finally, shore type was considered based upon the specific habitats observed around Arrow Lakes. Stream mouth habitat was highly valued because it was limited and provides important spawning, staging and forage habitat for native fish (e.g., Burbot, Bull Trout, Westslope Cutthroat Trout, and Kokanee), and food sources and connectivity from upland areas for wildlife. Wetlands were also valued high for their fish rearing and staging and avian values. The coarse substrates associated with gravel and rocky shorelines often were associated with possible coarse spawning and rearing potential. Cliff/bluffs were associated with deep water offering refuge. Sand beach habitat was of the lowest value to fish and wildlife and was typically associated with more intensive development and associated recreational uses.
	Foreshore Substrate	Yes	Substrates relate directly to aquatic life productivity. Lakebed substrates provide key growth media for periphyton, which in turn support benthic invertebrate communities, and fish and wildlife foraging. Substrates were evaluated considering Okanagan and Shuswap watershed studies (e.g., see summary in Schleppe et al. 2019), and subsequent studies in the East Kootenay Region such as Windermere Lake (Schleppe and McPherson 2021). Spawning substrates (gravel and cobble) were valued highest, followed by foraging substrates (finer substrates). The value of substrates was reduced compared to other studies because of the influence of the large drawdown zone in the reservoir. • Cobble and gravel substrates supported important habitats including spawning (although in this regulated lake, this is likely inhibited, except for coarse fish), rearing, and invertebrate production. These substrates also support avian fauna and wildlife by providing a growth medium for aquatic vegetation. • Boulder, organic, mud, marl, and fines all supported aquatic vegetation, which in turn provided important forage and cover areas for fish, avian fauna and wildlife. • Sands and bedrock had the lowest biodiversity potential.
	Percentage Natural	Yes	The length of shoreline in a natural condition was determined for an approximate depth upland of 50 m, and this was used to determine the % natural for the segment. This criterion relates to the risks of change from a natural state, where the closer to a natural state, the higher the risks to ecosystem function are likely to be. As the percentage of lake wide natural shoreline decreases, the inherent value of any remaining natural areas will increase. However, the % natural criteria recognizes that disturbed habitats can have value, depending upon the level of urbanization present (Schleppe et al. 2019). This criterion considers all categories of FIM data and has some inherent overlap with other FIM criteria.
	Aquatic Vegetation	Yes	Native aquatic vegetation provides important habitats for fish and wildlife, including nesting, forage, biomass production, and cover. The % aquatic vegetation for each segment was determined using the cover of one or all aquatic vegetation types (submerged, floating and/or emergent). Overall, this criterion was weighted relatively low in the FHSI because of overlap with other criteria such as wetland shore types.
	Overhanging Vegetation	Yes	Overhanging vegetation provides important habitat function, such as cover, nutrient additions and forage opportunities.
	Large Woody Debris	Yes	Large woody debris (LWD) provides important cover for fish and also provides a variety of wildlife functions. In Arrow Lakes, LWD was common in many areas, and this is reflected in the low weight assigned to this criterion.
	Vegetation Band 1	Yes	Riparian vegetation provides important ecological values for both aquatic and terrestrial species. These values include food, cover, nesting areas, erosion protection etc. This study provided an estimate of vegetative quality values for the Riparian Bands 1 and 2 that were included in the FIM dataset. Band 1 was the first distinct vegetation zone along the shore, while band 2 occurred immediately upslope of it. The two bands together represented a maximum 50 m width along the segment. Vegetation Band 1 was assigned a higher weight than Vegetation Band 2 because it contributed to shoreline fish and wildlife habitat to a greater extent.
	Vegetation Band 2	Yes	

Table 7. Summary of FIM, ZOS and modification criteria and rationale for inclusion in the FHSI.

<table>
<tr><th>Category</th><th>Criteria</th><th>In FHSI</th><th>Rationale</th></tr>
<tr><td>Fish ZOS</td><td>Critical Habitat – White Sturgeon</td><td>Yes</td><td>
The Arrow Lake Reservoir White Sturgeon population is an endangered species both federally and provincially (BC CDC 2014; Section 1.5). The Federal Recovery Strategy identifies critical habitat areas, which are the geospatial areas that contain the biophysical functions, features, and attributes necessary for survival or recovery (DFO 2014). The two critical habitat areas outlined in the strategy defined the White Sturgeon ZOS. These areas were the Beaton Reach and Narrow Burton Reach (see Table 8 and Figure 12 for details).

Table 8. Summary of critical habitat for white sturgeon in the FIMP study area (DFO 2014).
<table>
<tr><th>Critical Habitat</th><th>Life stage</th><th>Function</th><th>Feature</th><th>Attributes</th><th>Notes</th></tr>
<tr><td rowspan="2">Beaton Reach</td><td rowspan="2">Late juvenile and adult</td><td>Feeding</td><td>Food availability often associated with depositional area.</td><td>Depths greater than 10 m; lower velocity holding areas; source of fish and invertebrates, preferably salmonids.</td><td rowspan="2">• Upstream feeding movement by some adults may occur in spring and early summer as the reservoir fills.
• Individuals (primarily juveniles) tend to select the reservoir-river interface area.
• Summer temperatures as high as 13ºC in the main area of use for juveniles.
• Telemetry data on early juveniles suggests use of river thalweg habitat with no indication of shallow water habitat use.
• Regulated reservoir elevations may have influenced winter flows and water temps. It is not known whether this has affected the suitability of overwintering habitats.
• Feeding areas are used all year.
• Overwintering areas are used from November to March.</td></tr>
<tr><td>Overwintering</td><td>Depositional area.</td><td>Depths greater than 10m, and Velocity greater than 0.5m/sec.</td></tr>
<tr><td rowspan="3">Narrow Burton Reach</td><td>Early and late juvenile</td><td>Potential rearing and adult feeding</td><td>-</td><td>-</td><td rowspan="3">• Juvenile use is only suspected within this area but may increase as hatchery juveniles continue to be released upstream.
• Rearing areas are used all year.
• Feeding areas are used all year.</td></tr>
<tr><td rowspan="2">Adult</td><td>Feeding</td><td>Food availability often associated with depositional area, and confluence with tributary that provides spawning habitat for salmonids in spring and fall.</td><td>Lower velocity holding areas; and source of fish and invertebrates, preferably salmonids.</td></tr>
</table>
</td></tr>
</table>

Table 7. Summary of FIM, ZOS and modification criteria and rationale for inclusion in the FHSI.

Category	Criteria	In FHSI	Rationale
Fish ZOS	Critical Habitat – White Sturgeon… continued	Yes	 Figure 12. White Sturgeon critical habitat in the study area, shown as: overview, Beaton Reach and Narrow Burton Reach, respectively. Source: DFO 2014. The mapped polygons contributed to the FHSI as either presence or absence in any overlapping shore segments. Two additional critical habitat areas are present in Arrow Lakes, but these are upstream of the study area near Revelstoke. These are the Columbia River adjacent to Revelstoke Golf Course, which is the only confirmed spawning area; and Big Eddy and Salmon Rocks, which is an adult feeding and staging area.

Table 7. Summary of FIM, ZOS and modification criteria and rationale for inclusion in the FHSI.

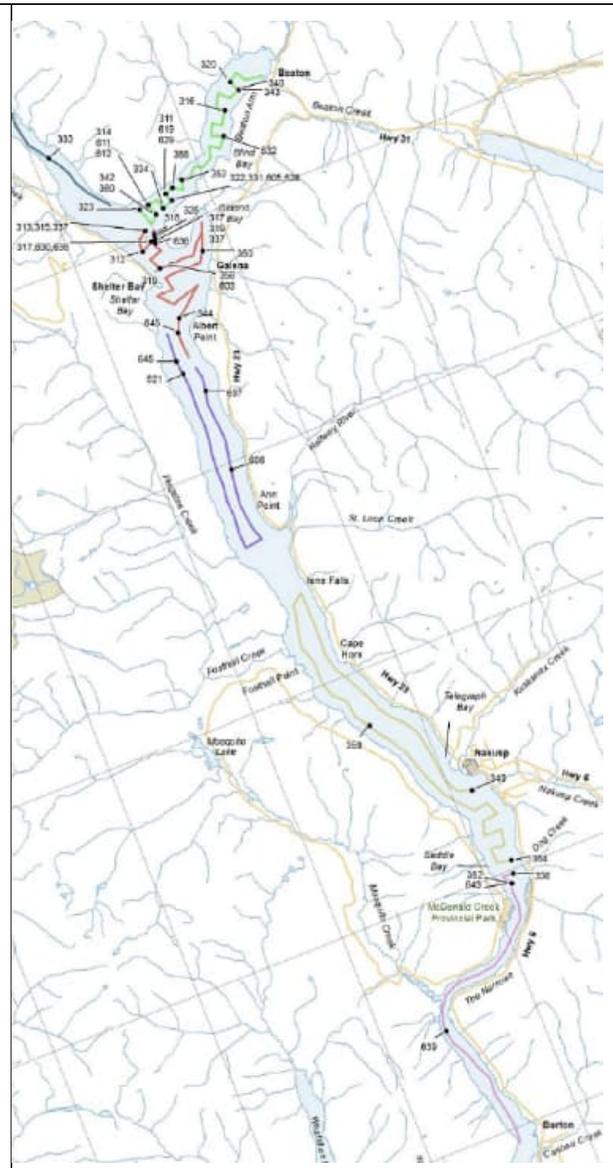
Category	Criteria	In FHSI		Rationale
Fish ZOS	High Value Burbot Area (Spawning)	Yes	 Figure 13. Survey tracks and tags detected for surveys conducted in March 2013 (Robichaud et al. 2014).	Burbot are considered a species of regional concern in the Columbia River System due to declines in numbers (McPhail 2007). Compared to the early 2000's, Burbot harvest estimates have been generally lower in recent years (Arndt 2022). However, this general decrease is likely related to reduced phosphorus inputs (Arndt 2022). Although the population is not believed to be at risk (Arndt pers comm. 2022), any viable Burbot population is significant to maintain in the Kootenays (Burrows pers comm. 2022). BC Hydro commissioned a five-year study of the Burbot life history and habitat use in the Arrow Lakes (2009 – 2014 CLBMON-31). Overall, spawning location findings from this study as summarized in the Year 5 report are as follows (Figure 13; Robichaud et al. 2014): • *Winter tracking (February/March) found consistent locations of elevated Burbot concentrations. The highest concentrations of fish were in the Beaton Arm/Shelter Bay area during the presumed spawning period and, to a lesser extent, in the McDonald Creek area in The Narrows. Spawning timing in Beaton Arm area was from mid-March onward and spawning probably occurred mainly in deep water areas (>20 m) near the bottom.* • *Although spawning was a plausible reason for these fish to be aggregated, it was not conclusively demonstrated that it occurred. Nevertheless, indirect evidence existed to support that spawning occurred, including that a high proportion of fish sampled were in advanced stages of ripeness (or recently spawned), telemetry data did not indicate much movement, and an egg plume was evident in a video.* The presumed Burbot spawning locations were interpreted from the reports and mapped as a ZOS. This ZOS also contributed to the FHSI.

Table 7. Summary of FIM, ZOS and modification criteria and rationale for inclusion in the FHSI.

Category	Criteria	In FHSI	Rationale
Fish ZOS	Salmonid Stream	Yes	The results of Arrow Lakes Tributary Fish Migration Access study completed by Ecoscape for BC Hydro (Hawes et al. 2014) and the Provincial database were the resources used to identify streams used by salmonids. Salmonid Streams were the Halfway, Incomappleux and Whatshan rivers, and the following creeks: Bannock, Beaton, Bowman, Burton (Trout), Cape Horn, Caribou, Cayuse, Cinnamon, Comaplix, Cranberry, Deer, Delta, Dog, Eagle, Fauquier, Fosthall, Gladstone, Meadow, Heart, Henrys, Hill, Hutchison, Hyham, Jenning, Johnston, Kuskanax, Little Cayuse, Lovesay, Mackenzie, McDonald, Michaud, Moberly, Mosquito, Nacillewaet, Nakusp, Octopus, Pin, Pingston, Pup, Reinecker, Renata, St. Leon, Stoney, Sunshine, Syringa, Taite, Thompson, Town, Tulip, Turner, Van Houten, and Worthington. It is important to note, salmonid presence in these streams may be based upon historic records, and this study has not considered access concerns, where some streams may have resident fish but upstream migration from the reservoir is inhibited. Future work could be used to rank the stream mouth ZOS to better reflect values more pertinent to reservoir productivity. The key native salmonids that are currently in the reservoir that rely on these streams for spawning are Rainbow Trout, Bull Trout and Kokanee (Hawes et al. 2014). Other salmonids that potentially use these streams include Westslope Cutthroat Trout and Chinook Salmon (once re-introduced to the Upper Columbia River Basin). In terms of the foreshore, the outlet and associated alluvial fan areas of these streams are important habitats not only for spawning, but also for rearing. However, these habitats in the Arrow Reservoir have been impacted by the dam operations. Hawes et al. (2014) summarizes this as follows: *"Upstream migration of fish populations in tributary streams can be blocked or reduced as a result of low stream flows being conveyed through wider, aggraded, more poorly defined, and braided channels over the drawdown zone. The dynamic channel form exhibited over the drawdown zone of many tributaries is the result of the high vertical fluctuation of the reservoir."* Maintaining natural shoreline habitat in these areas that already experience challenges from reservoir operations is important for various reasons, including for: maintaining channel stability, maintaining spawning substrates, and providing cover elements. Because of these high fisheries values, all salmonid stream mouths were mapped as independent segments, with the segment start and end points defined as the outer edge of the most active areas of the alluvial fan. These areas were mapped as a ZOS. As well, all other (non-salmonid) streams were mapped as a ZOS point.
	Juvenile Rearing	Yes	The foreshore provides important juvenile rearing habitat. The foreshore habitats around stream mouths are particularly important for salmonid rearing, as the fish migrate out from their natal streams into the larger lake or reservoir environment. These lake shallows at and near the mouths of tributaries are very productive areas, providing good forage opportunities. These areas also provide cover elements (terrestrial and aquatic vegetation, large woody debris etc) to allow the small young fish to safely grow. Juvenile rearing shoreline habitat value was determined manually by assigning a value of High or Low rearing potential based on the following review: 1. Segments with salmonid spawning streams - high. 2. Segments adjacent to salmonid spawning stream - physical characteristics were evaluated, with the following features contributing to high rearing value: wetland, gravel or sand beach shore type; wide littoral zone, high overhanging vegetation. Segments evaluated to have high rearing potential were designated as a ZOS. The complex littoral zone made determining important fish rearing areas challenging because they were likely to vary over time dependent upon the elevation of the reservoir.

Table 7. Summary of FIM, ZOS and modification criteria and rationale for inclusion in the FHSI.

Category	Criteria	In FHSI	Rationale
Fish ZOS	Staging Areas	Yes	Adfluvial fish have a life history strategy in which adult fish spawn and juvenile fish rear in streams but migrate to lakes to feed as subadults and adults. This is vital survival strategy in reservoirs like Arrow Lakes, since the drawdown zone with its varying water levels does not offer stable habitat for shore spawning (Arndt pers comm. 2022). In the Arrow Reservoir, this strategy is utilized by the following salmonids: Rainbow, Kokanee, and Bull Trout species utilize this strategy. This Staging ZOS is where adults must hold or stage until environmental conditions are adequate to migrate upstream into and out from the streams before and after spawning. It is also where the juveniles migrate out into the lake. Fish at these times are vulnerable and this is considered a sensitive life-stage. Fish migration areas are generally encapsulated by the Staging ZOS or the Juvenile Rearing ZOS and were thus not differentiated. The fish are vulnerable in this ZOS, given their life history stages, making habitat rich with cover important. However, development intensity around streams is often high, with an elevated importance of this habitat requisite. This ZOS was determined based on adjacency to spawning streams. The primary resource used to determine the ZOS was the Arrow Lakes Tributary Fish Migration Passage Monitoring study completed by Hawes et al. (2014).
	Native Mussel Beds	Yes	Mussels are considered a fish under the Federal *Fisheries Act*, and native mussels hold Indigenous Peoples ecological value. The Freshwater Molluscs – Wildlife in BC at Risk Brochure (BC Ministry of Environment, Lands and Parks 2000) summarizes their sensitivity as follows: *Freshwater mussels are the most endangered animal group in North America and are disappearing at the fastest rate of any known group of organisms. More than half of all North American species of freshwater mussels are considered imperiled. As aquatic habitats are degraded or become altered for other uses, the habitat for freshwater mussels is disappearing. Most mussel species have a complex life cycle involving a fish host, free living form, and the more commonly observed mussel. Even where conditions allow for the continued existence of the mussels themselves, if the habitat can no longer support the required fish host or if access to the fish host is eliminated by dam construction, water diversion, or alien fish species, the mussels cannot reproduce and will eventually disappear.* Mussels were not evident during the 2022 Arrow Lakes FIM due to the field work being conducted during high/full pool water levels. However, mussels are known to be present, with rehabilitation measures undertaken at Syringa Provincial Park in 2015 (Figure 14; Heagy pers. comm. 2023). Mussel presence at this location was identified as a ZOS in the FHSI. Further inventory work is recommended to identify other locations along the shoreline of Arrow lakes where mussels are present, and for the FHSI to be updated accordingly.

Table 7. Summary of FIM, ZOS and modification criteria and rationale for inclusion in the FHSI.

Category	Criteria	In FHSI	Rationale
	Native Mussel Beds, continued…	Yes	 Figure 14. Mussel habitat at the south end of Arrow Lakes, at Syringa Provincial Park (Heagy pers. comm. 2023) Information from other lakes studies suggest that there is a high potential for mussels to be present elsewhere in the Arrow Lakes. During the 2021 Kootenay Lake FIM, mussels were evident from the boat in finer sand and gravel bottomed shoreline areas (Schleppe and McPherson 2022). As reported in the Kootenay lake FIMP, snorkel survey work completed by the Ktunaxa Nation on Kootenay Lake from 2016-2017 found the following (Andreashuk pers. comm. 2021): *Species observed in Kootenay Lake were Western Floater, Oregon Floater, Western Pearlshell (respectively, Anodonta kennerlyi, A. oregonensis, and Margaritifera falcata). Live mussels were rarely found in water <1 m deep. Mussel beds were found at all creek deltas reviewed. The density at the deltas was suspected to be related to the cool well oxygenated water and food source from the nutrients in the creek. Mussels move both horizontally (e.g., due to drawdown), and vertically (may bury themselves seasonally or during environmental stress). They have been observed spread out in small pockets of fines and gravels between cobbles and utilizing cover if available (at the base of large macrophyte root stems, up against submerged/embedded LWD).* The Rocky Mountain Ridged Mussel (*Gonidea angulate*) is at-risk federally under SARA (special concern, Schedule 1), and provincially (red-listed/endangered). If found, this species has specific guidelines for surveys and relocation (FLNRORD 2018). Mussels are not in the BC Freshwater Fishing Regulations and are thus not to be harvested.

Wildlife ZOS	Critical Habitat – Bank Swallows	Yes	The Bank Swallow (*Riparia riparia*) is a threatened species under SARA. Critical habitat for nesting for this species has been identified in the Arrow Lakes in the Narrows section (Environment and Climate Change Canada [ECCC] 2022). Confirmed nesting locations that were active between 2015 and 2021 as provided by J. Arndt (pers. comm. 2022) were also mapped, as were unconfirmed/historic nesting sites evident during the 2022 FIM field survey. These nests were present in steep (near vertical) consolidated sand banks, near the top of the bank, along the edge of the water.
			
			A summary of pertinent Bank Swallow life history and habitat use from the Recovery Strategy (ECCC 2022, unless otherwise noted) is as follows:
			• Nests present in:
			  o Erodible material that includes any proportions of the following substrates: sand, silt, loose clay, fine gravel, organic soils.
			  o Vertical or near-vertical structure.
			  o Minimum height of bank face of 0.5 m.
			• An aerial insectivorous bird that nests in colonies on steep bank faces along waterbodies and human-made habitats.
			• Forages over open country and aquatic habitats that support insect populations.
			• The species predominantly winters in the Southern Cone Grasslands of Chile, Argentina, Paraguay and Uruguay.

Table 7. Summary of FIM, ZOS and modification criteria and rationale for inclusion in the FHSI.

Category	Criteria	In FHSI	Rationale
	Critical Habitat – Bank Swallows, continued…	Yes	• The most likely primary threats to the Bank Swallow are broad-scale ecosystem modifications, including pesticide use resulting in less abundant invertebrate prey. The loss of natural nesting sites from erosion control measures and a reduction in prey availability as a result of climate change may create further pressure on the species. • Broad strategies to address threats aim to reverse the loss of nesting, foraging and roosting habitats. • Generally, arrive at their breeding grounds in North America during early spring and depart late summer to midfall. • Have high site fidelity if nests were successful the previous year (Darvill pers. comm. 2021). Disturbance to nest sites can possibly cause direct harm to the birds if actively nesting, or impact habitats if they are altered due to the site fidelity. As provided by R. Darvill (pers. comm. 2021): "*Breeding and feeding sites have been described as usually within 200 m of where young are fed, but this distance may vary depending on availability of foraging areas and may be up to 1 km away. Given this research a 200 m buffer is recommended for construction during the nesting period*". Critical habitat and known nest locations (respectively, from ECCC 2022 and J. Arndt pers comm. 2022) were included in the FHSI as a ZOS. The other general bank nesting locations seen during the FIM that were not confirmed through the above sources, were only marked as a "Bank Nesting" ZOS and were not included in the FHSI. This is because the use of these sites by the Bank Swallow was not confirmed.
	Critical Habitat – Caribou (Southern Mountain Population)	Yes	Approved Critical Habitat for the Southern Mountain Population of Caribou (Central Kootenay local population unit) is present throughout a 271,400 ha area along the Arrow Reservoir. However, only a small area north of Nakusp comes within 50 m of the shoreline (BC MoE 2022*;* Figure 15). Note, that the critical habitat area presented was identified to be edited in Sept 2022, and thus the difference from that shown in the Recovery Strategy (Environment Canada 2014). This species/population is listed as being endangered both federally and provincially. The following summary of the species habitat requirements was obtained from the Federal Recovery Strategy (Environment Canada 2014): *Southern Mountain Caribou require large ranges of relatively undisturbed, interconnected habitat where they can separate themselves (horizontally and by elevation) from predators; modify their use of habitat in response to various natural and human-caused habitat disturbances and human activities; and can access their preferred food sources. In the Southern Group, where the snowpack is deep, caribou predominantly use high elevation mature and old subalpine forests in mid and late winter where they forage on arboreal lichens. During early winter before snow has consolidated, and during spring, they use lower elevation mature and old forests (with some subpopulations moving down into cedar/hemlock forests in valley bottoms). Due to their specific life history characteristics, southern mountain caribou are limited in their potential to recover from rapid, severe population declines. Habitat alteration (i.e., habitat loss, degradation, and fragmentation) from both human-caused and natural sources, and increased predation as a result of habitat alteration, have led to declining numbers. The Nakusp population had 64 Caribou in 2014, and was said to be decreasing.*

Table 7. Summary of FIM, ZOS and modification criteria and rationale for inclusion in the FHSI.

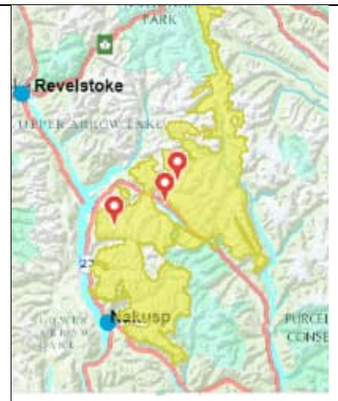
Category	Criteria	In FHSI	Rationale
Wildlife ZOS	Critical Habitat – Caribou (Southern Mountain Population), continued…	Yes	 Figure 15. Mountain Caribou Central Kootenay critical habitat (BC Habitat Wizard 2022). The Recovery Plan identifies that landscape level plans should prepared and used to address the cumulative effects of habitat alteration and for managing habitat and sensory disturbance. When development (particularly large scale) is proposed in mature forest habitats, MoF or other wildlife specialist input is to be sought, to ensure the development minimizes impacts on this species.
	Critical Habitat (Proposed) – Whitebark Pine	Yes	 Figure 16. Whitebark Pine critical habitat in the study area (BC Habitat Wizard 2022). Proposed critical habitat for Whitebark Pine is present throughout a 62,804 ha area that includes a considerable section of shoreline north of Nakusp (Figure 16; BC MoE 2022). This species is listed as endangered federally (SARA, Schedule 1) and is blue listed provincially. The area was mapped as a ZOS but was not included in the FHSI. This is because the critical habitat area was not final. Also, the Recovery Strategy (ECCC 2017) showed no plants along the shoreline (all were mapped well away from the shoreline at higher elevations). The finalized critical habitat area is to be reviewed in the future FIMP updates, as well as when a development is proposed, and factored in accordingly. The following is a general description of this species (ECCC 2017): *"Whitebark Pine is a high elevation conifer characterized by needles that occur in bundles of five, and closed cones that generally remain on the tree unless removed by animals. The tree may be single-stemmed, but it often is multi-stemmed. Upper branches are typically in an upright growth form, with cones held high on the outer branches. Whitebark Pine is a keystone species, essential to ecosystem function on many alpine and subalpine sites.* It performs a number of ecosystem services (particularly *where it is the dominant tree species), including: moderating snowmelt and run-off, initiating tree islands and facilitating recruitment of more shade tolerant species, pioneering harsh sites, and providing food for wildlife (Tomback and Kendall 2001). The seeds are an important food source for Clark's Nutcrackers (Nucifraga columbiana), Red Squirrels (Tamiasciurus hudsonicus), Grizzly Bears (Ursus arctos) and other high elevation, mountain-dwelling wildlife (Felicetti et al. 2003). Of note, the tree has a mutualistic relationship with the Clark's Nutcracker; whereby, the distribution of Whitebark Pine across the landscape is almost exclusively due to the seed caching behaviour of this bird (Hutchins and Lanner 1982)."*

Table 7. Summary of FIM, ZOS and modification criteria and rationale for inclusion in the FHSI.

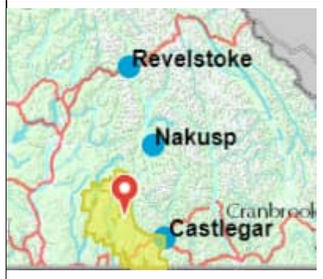
Category	Criteria	In FHSI	Rationale
Wildlife ZOS	CDC Red listed species	Yes	Red listed species refers to any species or ecosystem that is at risk of being lost (extirpated, endangered or threatened) in BC. These species and ecological communities are likely to become endangered if limiting factors are not reversed. White Sturgeon and Mountain Caribou are currently the only red-listed species identified to be present within 50 m of the foreshore. The historic range of these species spans the full study area and was thus not used in the FHSI (all segments across the study area would contribute to the index equally). Instead, the approved critical habitats for these species were mapped as a ZOS and did contribute to the FHSI (see rows in this table above). Also, the red-listed plant species - Silver Hair Moss (*Fabronia pusilla*) was not mapped or included in the FHSI analysis. This was because although it was last observed in 1890 in Deer Park, in 2001 the site was reported to be submerged behind a dam (BC Bryophyte Recovery Team 2007). Even with no specific red listed accounts currently, sensitive species present and rankings are updated as more information becomes available. During a proposed review, the QEP will need to review the CDC BC Species and Ecosystems Explorer for current accounts specific to their project area.
	CDC Blue listed species	Yes	The BC CDC (2022b) had polygons mapped for five blue listed species within 50 m of the Arrow Lakes foreshore. Blue listed refers to any native species or ecological community considered to be of Special Concern in BC. These species or ecological communities have characteristics that make them particularly sensitive or vulnerable to human activities or natural events. As presented in Table 6, the current blue listed species present are: Grizzly Bear, Canyon Wren, White-throated Swift, Western Bumble Bee, and Mountain Moonwort. Blue-listed accounts were mapped as ZOS and included in the FHSI. Grizzly Bear had its own ZOS due to specially designated habitat (see next). Sensitive species present and rankings are updated and change with time as more information becomes available. During a proposed review, the QEP will need to look up the species accounts for further details using the BC iMap platform (BC CDC 2022b) or equivalent provincial database for current accounts specific to their project area. For these reasons, these data were not included in the GIS database; however, they were included in the FHSI.
	Wildlife Habitat Area (WHA) for a Species at Risk – Grizzly Bear	Yes	 Figure 17. Grizzly Bear WHA (yellow polygon; BC Habitat Wizard 2022). The Grizzly Bear is blue listed in BC and Special Concern under SARA. There is a Grizzly Bear Wildlife Habitat Area (WHA) present along a great extent of the west bank of the Lower Arrow Lake (Figure 17; BC MoE 2022). In BC, WHAs are designated under the BC Forest and Range Practices Act (FRPA). This WHA was specified as a Conditional Harvest Zone to protect the Grizzly Bear. This area was mapped as a ZOS and included in the FHSI.

Table 7. Summary of FIM, ZOS and modification criteria and rationale for inclusion in the FHSI.

Category	Criteria	In FHSI	Rationale
Wildlife ZOS	Old Growth Management Area (OGMA)	Yes	There were several shoreline sections where FRPA designated non-legal Old Growth Management Areas (OGMA) were present (Figure 18). These high value areas were identified as ZOS and included in the FHSI.  Figure 18. Old Growth Management Areas (dark green polygons) along Arrow Lakes, from upper (left) to lower (right; BC Habitat Wizard 2022).
	Raptor Nest	Yes	Section 34 of the BC *Wildlife Act* prohibits possessing, taking, or destroying (i) a bird or its egg, (ii) the nest of an Eagle, Peregrine Falcon, Gyrfalcon, Osprey, Heron or Burrowing Owl, or (iii) the nest of a bird not mentioned in (ii), when the nest is occupied by a bird or its egg unless authorized under permit. This ZOS was established to identify the raptor nests requiring year-round protection in accordance with the BC *Wildlife Act*. Osprey and Bald Eagle nests observed along the Arrow Lakes shoreline during the FIM were mapped as ZOS. These raptor nests were evaluated in the FHSI.
	Bat Site	Yes	Bat ZOS information was reviewed and/or obtained from the Kootenay Community Bat Project (KCBP) biologists - Dr. Cori Lausen and Jason Rae of the Wildlife Conservation Society Canada (WSC), and Elodie Kuhnert (all pers comm. 2022). In the Kootenay Region, there are five sensitive bat species, seven species that are not at risk and one species that is unranked (Community Bat Programs of BC 2022): • SARA listed endangered species: Little Brown Myotis (*Myotis lucifugus*), and Northern Myotis (*Myotis septentrionalis*). • BC Blue listed species: Townsend's Big-eared Bat (*Corynorhinus townsendii*), Western Small-footed Myotis (*Myotis ciliolabrum*; suspected in Kootenay Region), and Fringed Myotis (*Myotis thysanodes*). • Species not at risk: Hoary Bat (*Lasiurus cinereus*), Silver-haired Bat (*Lasionycteris noctivagans*), Big Brown Bat (*Eptesicus fuscus*), Yuma Myotis (*Myotis yumanensis*), Californian Myotis (*Myotis californicus*), Long-legged Myotis (*Myotis Volans*), and Long-eared Myotis (*Myotis evotis*). • Unranked: Eastern Red Bat (*Lasiurus borealis*).

Table 7. Summary of FIM, ZOS and modification criteria and rationale for inclusion in the FHSI.

Category	Criteria	In FHSI	Rationale
Wildlife ZOS	Bat Site, continued…	Yes	All bat roosts in the project area were mapped as ZOS for all species. The following rationale for including species that are currently secure was provided by C. Lausen (pers comm. 2022): *Although not yet documented in BC, white-nose syndrome (WNS) is expected to arrive. WNS is a fungus that attacks bats during hibernation and is easily spread, which has killed millions of Little Brown Bats in eastern Canada and US (Community Bat Programs of BC 2022). Many more bat species are likely to be devastated, and BC scientists have been operating under the assumption that all bat species are likely to receive a listing of some form within the next decade. This is most true of the eight Myotis species in BC, all of which are expected to be vulnerable to WNS die-back. There are also other threats on bat populations including logging and wind energy. The latter is a federally important threat and the three species of 'migratory tree bats' are now under Committee on the Status of Endangered Wildlife in Canada (COSEWIC) review (Silver-haired, Hoary and Eastern Red bats). Two of these species (Hoary and Silver-haired bats) occur in the West Kootenays, and the third, Eastern Red bat, is expected to be present, as it has been detected in the East Kootenays. If these species are recommended by COSEWIC for listing, it will likely occur within a few years. Additionally, Ministry of Environment is currently assessing all bat species in BC with NatureServe criteria and are looking to change provincial listings even now before WNS is detected in the province (Purnima Govindarajulu, announcement made Dec. 1, 2021 to BC Bat Action Team).* Mechanisms to protect bats and their habitats are as follows (C. Lausen pers. comm.): *Under the BC Wildlife Act, as a vertebrate - bats cannot be killed, harmed or harassed. In the Kootenay Region, Ministerial Order M213 provides a list of Wildlife Habitat Features that are to be protected, and this includes bat hibernacula and bat nursery roosts. This is restricted to natural features only (i.e., a bat in rock crevice just outside a mine is protected, but if that crevice occurs inside the opening of the mine, it is not protected). There is a "Mines Best Management Practices" by BC MOE that provides guidance for bat hibernacula in mines in BC, but no legal protection is provided by this. Federally listed species have no special protection, unless on federal lands and so that does not apply around Arrow Lakes.* Bat roost data was included in this Foreshore Habitat Sensitivity Index (FHSI). Bat roost data is considered sensitive and the locations have thus been masked and buffered 200 m (as recommended by E. Kuhnert pers comm. 2021). If a development is proposed within a Bat ZOS, then the GIS database is to be reviewed to determine the source organization to be contacted. This will either be SPI (SPI_Mail@gov.bc.ca) or the Kootenay Bat Project (kootenaybats@gmail.com). Provide: rationale for the request, precise location information and activities expected to occur on site or other reasons for requiring the information name of person submitting request, company name, and contact information (business address, email, and phone number). Release of details of masked occurrences is subject to the signing of a Confidentiality and Non-reproduction Agreement and a demonstrated "need-to-know".
	Aquatic Vegetation	No	Aquatic vegetation provides valuable fish and wildlife habitats and important ecosystem functions. Studies on Arrow Reservoir have found this vegetation to provide habitat to a host of species including amphibians, reptiles, bats and birds (see Section 4.2). The Arrow Reservoir FIM field assessment found emergent aquatic vegetation to be most prevalent, followed by overhanging, and wetland low and mid bench vegetation. Floating and submergent aquatic vegetation were nearly absent. "Area of emergent vegetation" was determined and was used to quantify this ZOS for each segment. Area was decided to a better measurement to use for the analyses than length, as area allowed the dense beds observed in the low-lying areas to be evaluated greater than the thin line of emergent vegetation evident at the edge of many segments. Although aquatic vegetation was a ZOS, to avoid over evaluation, it was accounted for in the FHSI in the Biophysical data.

Table 7. Summary of FIM, ZOS and modification criteria and rationale for inclusion in the FHSI.

Category	Criteria	In FHSI	Rationale
Modifications	Retaining Wall	Yes	Retaining walls influence fish in a variety of ways and are indicative of further shoreline urbanization. See FIMP methods document for rationale (Schleppe et al. 2021).
	Docks	Yes	Dock influence fish in a variety of ways and are indicative of further shoreline urbanization. See FIMP methods document for rationale (Schleppe et al. 2021).
	Groynes	Yes	Groynes influence fish in a variety of ways and are indicative of further shoreline urbanization. See FIMP methods document for rationale (Schleppe et al. 2021).
	Boat Launch	Yes	Boat launches influence fish in a variety of ways and are indicative of further shoreline urbanization. See FIMP methods document for rationale (Schleppe et al. 2021).
	Marina	Yes	Marinas influence fish in a variety of ways and are indicative of further shoreline urbanization. See FIMP methods document for rationale (Schleppe et al. 2021).

4.3 Summary of FHSI Calibration

Several iterations (i.e., ~20) of the FHSI analysis were run. These included both iterations with the criterion weightings adjusted to assess the resulting FHSI Ecological Ranks, and smaller iterations that used the same weightings on new data or amendments to data collected. The results from each iteration outcome and the results of each output were kept in a log for reference. For each iteration, the following items were considered to aid in determination of the final weighting for a criterion:

1. The Ecological Ranks assigned to each habitat segment (and how well they mirrored the professional opinions of the project team).
2. The appropriateness and defensibility of the associated weightings (by category and criterion).
3. The range of the resulting final FHSI scores and how individual criterion or habitat categories could affect the FHSI and act to differentiate habitat values along the shoreline.
4. The identified FHSI score for each segment were categorized between Very High, High, Moderate, Low and Very Low by identifying the largest gap in a histogram of FHSI scores to identify the FHSI Ecological Ranks.
5. Total percentage of shoreline for each FHSI Ecological Rank for each land use type, to understand the influence of FIM attributes and influence of modifications in the FHSI Ecological Ranks.
6. Total percentage of shoreline for each FHSI Ecological Rank for each shore type to understand the influence of shore type using multiple different lines of evidence from habitat categories.

It must be acknowledged that the FHSI is a tool that uses available spatial data, and inherent overlapping values in habitat to help understand where important lake habitat values may exist. This tool cannot explicitly identify all important habitats, shore segments, or other important microsites present. The intended use for this document is a flagging tool for the public, proponents, and agencies to better understand where key values are and help make more informed land use decisions. Due to the variety of influences on the reservoir, calibration was challenging. All segments have important values, even those ranked as Moderate and Low.

Table 9 presents all the FHSI criteria considered, and the associated mathematical methods or logic used to include them in the FHSI. Mapping provided in Appendix B shows base data that were considered.

Table 9. The parameters and logic for the Foreshore Habitat Sensitivity Index of Arrow Reservoir

Class (Category)	Criteria (Sub-Class)	Percent of the Category	% of Total FHSI	Logic	Uses Weighted FIM Data	Variable Values Contributions	Percentage of Class in FHSI
Biophysical	Shore Type	35	10.7	(S % of Segment Shore Type * Shore Type Variable Value) * Score	Yes	15 = Stream Mouth = Wetland > Gravel Beach = Rocky Shore (12) > Sand Beach (7.5) = Cliff /Bluff , Other (4.5)	31
	Substrate	9	2.9	(S % Seg Substrate * Substrate Value) * Score	Yes	4 = Cobble > Gravel (3.2) > Boulder = Organic = Mud = Marl (2.8) > Fines = Sands (1.2) > Bedrock (0.8)	
	Percentage Natural	12	3.6	% Natural * Natural Score	Yes	% Natural	
	Aquatic Vegetation	23	7.1	Index * Aquatic Vegetation Score	No	Index = Segment_Veg_Area/Max_Seg_Veg_Area, Area = (SV + EV + FV)	
	Overhanging Vegetation	12	3.6	Index * Overhanding Vegetation Score	No	Index = Segment_OVeg_Area/Max_Seg_OVeg_Area	
	Large Woody Debris	9	2.9	# of Large Woody Debris/km * Relative Value * LWD Score	Yes	> 15 LWD/KM (4), 15 > LWD/KM > 10 (3.2), 10 > LWD/KM > 5 (2), 5 > LWD/KM > 0 (0.8)	
Wildlife	Bank Swallow	11	2.9	Presence * Score	No	4 = Present , Absent (0)	27
	CDC Red	21	5.7	Presence * Score	No	8 = Present , Absent (0)	
	CDC Blue	11	2.9	Presence * Score	No	4 = Present , Absent (0)	
	Raptor Nest	5	1.4	Presence * Score	No	2 = Present , Absent (0)	
	Bat Sites	11	2.9	Presence * Score	No	4 = Present , Absent (0)	
	Grizzly Bear	11	2.9	Presence * Score	No	4 = Present , Absent (0)	
	Caribou	11	2.9	Presence * Score	No	4 = Present , Absent (0)	
	Whitebark Pine	11	2.9	Presence * Score	No	4 = Present , Absent (0)	
	Old Growth	11	2.9	Presence * Score	No	4 = Present , Absent (0)	

Table 9. The parameters and logic for the Foreshore Habitat Sensitivity Index of Arrow Reservoir

Class (Category)	Criteria (Sub-Class)	Percent of the Category	% of Total FHSI	Logic	Uses Weighted FIM Data	Variable Values Contributions	Percentage of Class in FHSI
Fish	Salmonid Stream	17	5.7	Presence * Score	No	8 = Present, 0 = Absent	34
	High Value White Sturgeon Area	26	8.6	Value* Score	No	% Segment	
	High Value Burbot Area	21	7.1	Value * Score	No	Value	
	Juvenile Rearing Area	17	5.7	Presence * Score	No	8 = Present , Absent (0)	
	Staging Area	9	2.9	Presence * Score	No	4 = Present , Absent (0)	
	Native Mussel Bed	11	3.6	Presence * Score		5 = Present , Absent (0)	
FIM Shoreline Vegetation[2]	Band 1	67	5.7	Segment Veg. Bandwidth Value * Vegetation Quality Value * Band Vegetation Score	Yes	Bandwidth > 20 m (4) , 20 > Bandwidth > 15 m (3.2) , 15 > Bandwidth > 10 m (2.4) , 10 > Bandwidth > 5 m (1.6) , 5 > Bandwidth > 0 m (0.8)	9
						Vegetation Class = Natural Wetland = Disturbed Wetland = Broadleaf = Shrubs (4), Coniferous Forest = Mixed Forest (3.2), Herbs/Grasses = Unvegetated (2.4), Lawn = Landscaped = Row Crops (1.2), Exposed Soil (0.2)	
	Band 2	33	2.9	Segment Veg. Bandwidth Value * Vegetation Quality Value * Band Vegetation Score	Yes	Bandwidth > 20 m (2) , 20 > Bandwidth > 15 m (1.6) , 15 > Bandwidth > 10 m (1.2) , 10 > Bandwidth > 5 m (0.8) , 5 > Bandwidth > 0 m (0.4)	
						Vegetation Class = Natural Wetland = Disturbed Wetland = Broadleaf = Shrubs (2), Coniferous Forest = Mixed Forest (1.6), Herbs/Grasses = Unvegetated (1.2), Lawn = Landscaped = Row Crops (0.6), Exposed Soil (0.1)	

Table 9. The parameters and logic for the Foreshore Habitat Sensitivity Index of Arrow Reservoir

Class (Category)	Criteria (Sub-Class)	Percent of the Category	% of Total FHSI	Logic	Uses Weighted FIM Data	Variable Values Contributions	Percentage of Class in FHSI
Modifications	Retaining Wall	81	-2.1	% Retaining Wall * Score	No	% Retaining Wall	-2.7
	Docks	3	-0.1	# Docks per Kilometer * Score	No	# Docks per Kilometer	
	Groynes	3	-0.10	# Groynes per Kilometer * Score	No	# Groynes per Kilometer	
	Boat Launch	7	-0.20	# Boat Launches per Kilometer * Score	No	# Launches per Kilometer	
	Marina	7	-0.20	# Marina per Kilometer * Score	No	# Marinas per Kilometer	

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

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

In running these different FHSI iterations, the following broad trends were observed:

- There was a high degree of spatial overlap between ZOS used to weight some of the FHSI Categories (e.g., Fish and Wildlife) and FIM attributes such as shore type and substrate. Since most ZOS were treated as binary variables (e.g., present or absent from a shore segment), they were weighted similarly across Categories. It was apparent that "duplication" in values may have occurred due to the binary nature of how data were incorporated into the FHSI (e.g., where a Yes or No's presence/absence impacts a large segments for instance). These criteria were considered both individually, and as a group in review. The final weightings given to ZOS attributes were reduced to account for overlapping values. However, these ZOS were kept in the FHSI to document known presence of high value habitat areas. In this way, further data resolution (i.e., addition of new segments when important habitat attributes are found embedded within a larger segment) and delineation of important new habitat data as collected (e.g., littoral habitat valuation), can continue to contribute to the broader understanding of where key habitat values exist around the reservoir (i.e., future or further refined ZOS).

- The overall influence of substrates was lessened compared to other FIMP studies (e.g., Kootenay Lake) due to the nature of the reservoir. This is because the contribution of the different sediments to habitat value were often less pronounced in the Arrow Reservoir. For instance, low gradient sites with more fine substrates (sands, silts, muds, and organics) may be more important than rockier shorelines, due to their ability to support aquatic vegetation growth, a unique and limited value in the reservoir. However, the relative weighting of each substrate type was kept consistent with other FIMP studies, allowing the values of these finer substrate areas to be captured by aquatic vegetation. It is likely that the values of lakebed substrates vary throughout the different reservoir elevations over the year, further suggesting that reducing the influence of substrate in the FHSI was appropriate.

4.4 Summary of FHSI Ecological Rankings

The output of the FHSI was a relative Ecological Rank assigned to each FIM habitat segment. This result is best viewed on the full-scale map (Appendix B). Figure 19 summarizes the FHSI data, showing the range of scores and values where habitat rankings between each FHSI Rank were split. A summary of the percentage of shoreline for each FHSI rank and for each shore type broad land use category is also presented in Figure 20 and Figure 21. Figure 22 presents a summary of the FHSI results in map format at a large scale to portray ecological ranks along the entire shoreline.

Spatial patterns in areas of higher value emerged with the iterative results during calibration. With each iteration of the index, it was possible to visually assess the patterns

in the FHSI rankings that resulted from the different criteria, their presence, and their weightings by reviewing these summary figures. The location of the break between High and Very High was challenging to determine because of longer shoreline segments in more natural areas. The FHSI ultimately identified numerous important and high value areas around Arrow Reservoir.

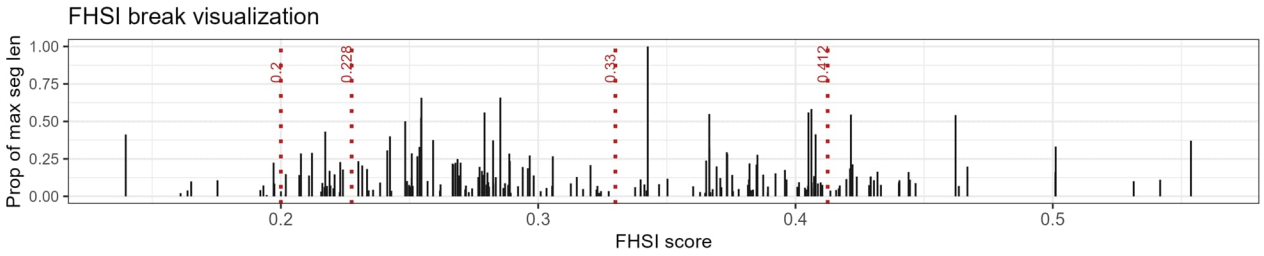


Figure 19. Proportion of shoreline/segment length for the range of calculated FHSI scores, and within each of the Ecological Rankings (breaks shown as vertical dashed lines).

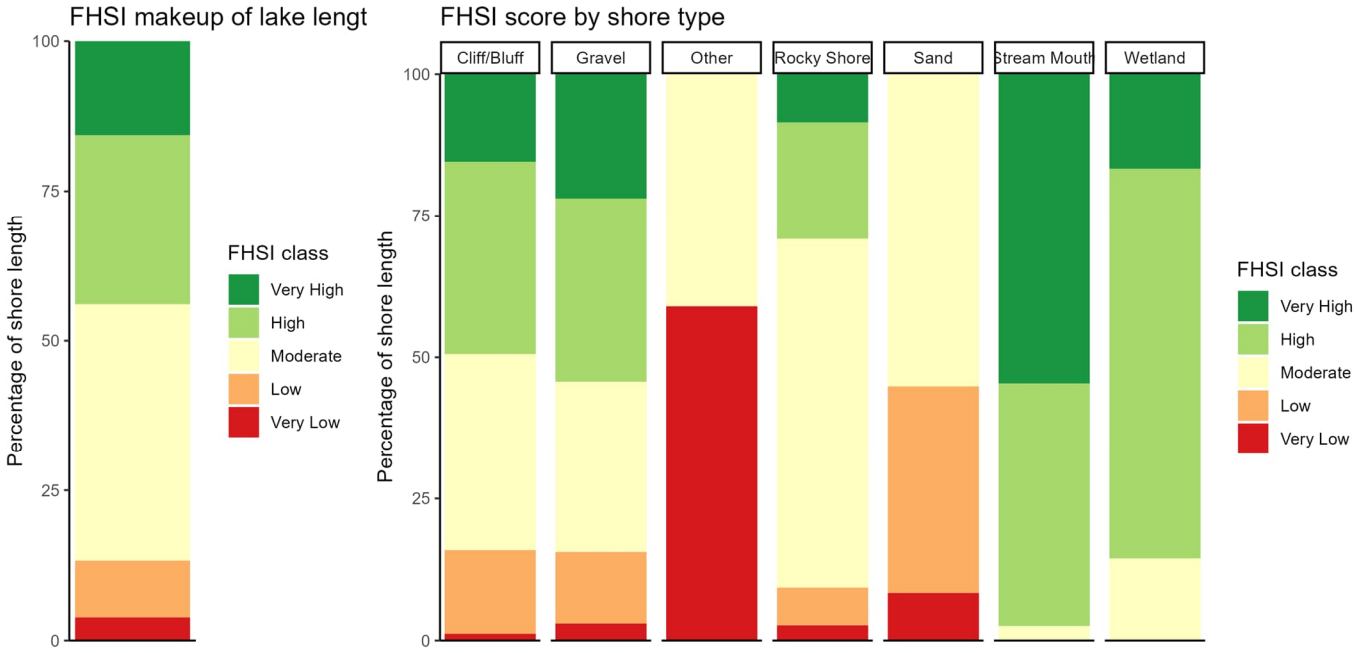


Figure 20. FHSI Ecological Rankings, summarized as percent of shore length for the entire lake (left), and for the various shore types (right).

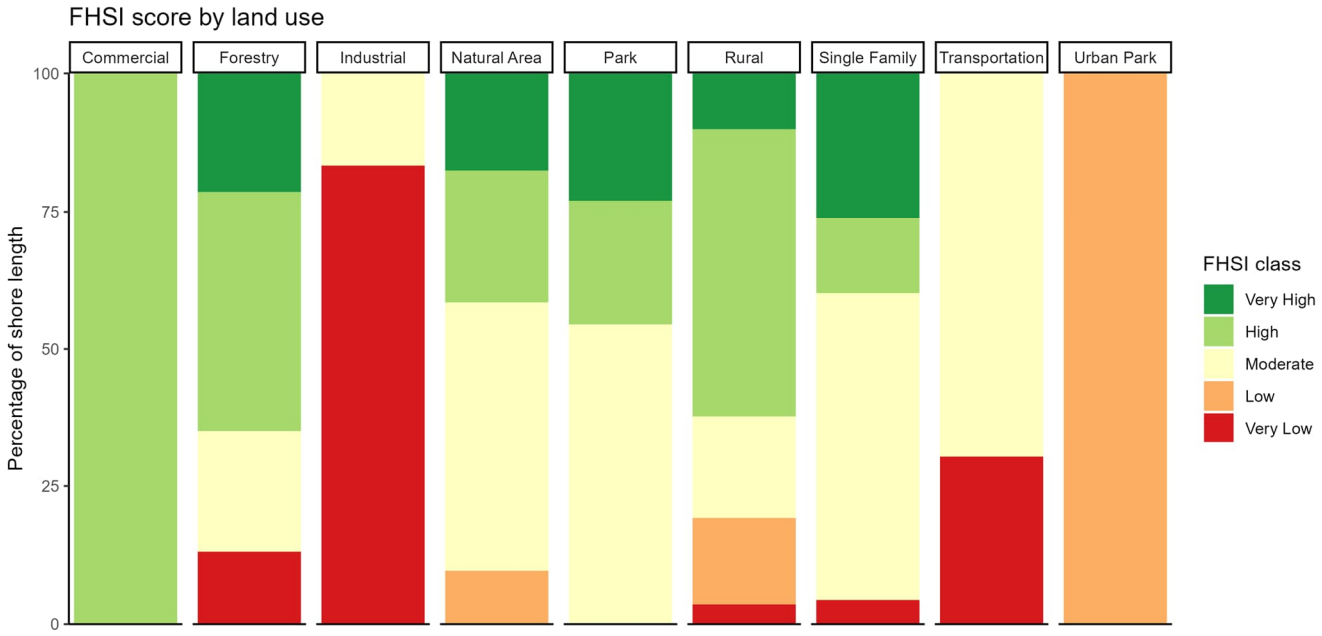


Figure 21. FHSI Ecological Rankings, summarized as percent of shore length for the various land uses.

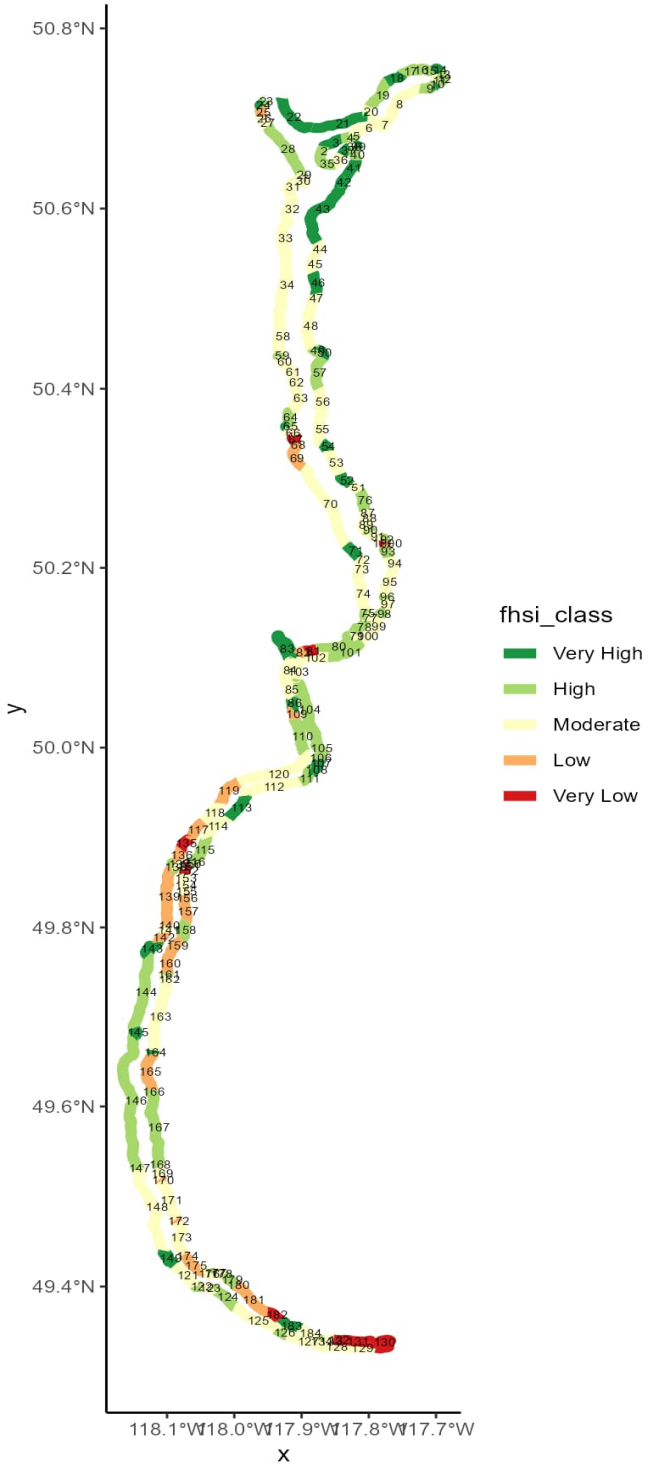


Figure 22. Overview of FHSI Ecological Rankings for Arrow Lakes.

The FHSI identified that 15.7% of shoreline had a Very High Ecological Rank, and 28.3% of the shoreline had a High Rank, which translates to approximately 79,758 and 143,886 m of shoreline, respectively. Some related observations were:

- Almost all Wetland and Stream Mouth shore types were ranked as Very High or High.
- Approximately 50% of the Cliff/bluff and Gravel shore types were also ranked as Very High or High.
- These areas had numerous overlapping fish and wildlife ZOS, contributing directly to their high value.
- Land uses with a high proportion (>50 %) of these highly ranked ecological areas were Commercial, Forestry, and Rural areas. It is noted that Commercial and Forestry represented only small proportions of the shoreline at 0.12 and 2.26%, respectively (Figure 5).

The areas of Moderate ranked shoreline accounted for 42.8% of the shoreline or 217,923 m. General observations for Moderately ranked shoreline were:

- These areas occurred in locations that had fewer overlapping ZOS or were in areas with important ZOS that were impacted by development.
- These areas were common to some extent in all shore types except for the "Other" shore type (see below).
- Land uses with a high proportion (≥50%) of Moderately ranked areas were Natural Areas, Park, Single Family, and Transportation.

Areas of Low and Very Low Ecological Rank occurred along 13.3% or along 67,649 m of shoreline. Observations associated with the Low and Very Low ranked shoreline were:

- These areas occurred in areas of increased development intensity, which were predominantly typed as "Other" shore type (where the shoreline was unrecognizable, and in this case was mainly the Hugh Keenleyside Dam). This ties into the result that Industrial land use was predominantly (>75%) ranked Very Low.
- Low ecological ranked segments were also scattered across other land uses, at least to a small degree including Forestry, Natural Areas, Rural, Single-Family, and Transportation.
- Areas with more intense development often lost many of the habitat values that were originally present, highlighting the importance of protection of natural areas in any development process.
- Often similar lake assessments have found that single-family land uses had a high percentage of these low ecological ranked segments, such as was seen at Windermere and Kootenay lakes, where these low ranking represented closer to approximately 50% (Schleppe and McPherson 2021, 2022). However, at Arrow Lakes, this was not as apparent. Typically, dwellings at Arrow Lakes were modest, set back, and maintained more natural features and/or fewer modifications than seen elsewhere. It would be beneficial if this trend continued.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Arrow Lakes/Reservoir is generally in a natural state, noting how natural has been defined for the purposes of this report and its intended use. Rural areas are starting to develop to a greater extent, but the shoreline is still relatively unimpacted. However, these rural areas would likely be at risk if land use changes occur resulting in densification of the shoreline (i.e., it is rezoned from Rural to Single Family). General recommendations to help protect, conserve, and better manage urban impacts on the foreshore of Arrow Reservoir are provided below. These recommendations highlight that effort should focus on finding ways to integrate lakeshore planning across and between all levels of government and Indigenous Peoples. Also, restoration should be highly promoted. The best habitat improvements include re-naturalizing or softening the shoreline on a lot-by-lot basis using riparian restoration, floodplain restoration at important stream confluence and wetlands, and bioengineering. Other restoration opportunities also exist such as the works by BC Hydro and the Fish and Wildlife Compensation Program. Focus should be placed on maintaining or enhancing the upland/full pool interface (particularly on disturbed private parcels or Crown Land areas that are failing to naturalize post flood), and on vegetated areas at lower elevations of the large littoral zone that withstand flooding. Recommendations are categorized and are generally directed to different levels of government.

Development pressure and associated challenges are expected in the future, similarly to that experienced at other now more highly developed lakes. Shoreline planning must carefully consider that much information is still unavailable. Data gaps can result in high value areas not being identified. Further, impacts of climate change need to be considered to ensure that important refugia habitats that contribute to the resiliency of species and overall lake health are identified and maintained. Examples of these important habitats include floodplains, old growth forests, wetlands, and vegetated shoreline areas. Integrating these habitats into appropriate land use policies and decisions should be a priority to minimize continued incremental losses.

5.1 Overview and road map

The recommendations below are broken down into a variety of different categories, with some specific to each different level of government. Ultimately, collaboration between the different levels of government is needed because each agency will rely upon another governmental level for actions such as enforcement (i.e., *Water Sustainability Act* or *Federal Fisheries Act*), land use policy (i.e., land use decisions mostly occur at the local and regional government level), and implementation (i.e., all levels).

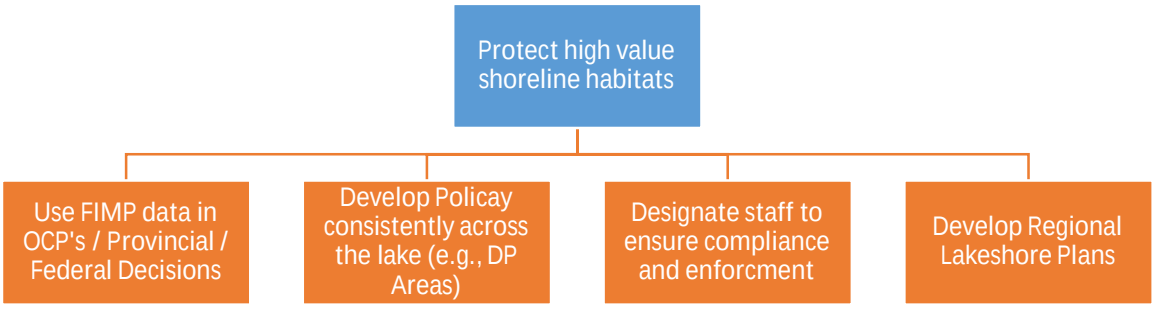
Initial land use decisions for any new proposed development typically occur at a local/regional government level. During this initial process, environmental considerations important to provincial and federal agencies are important to incorporate (such as SARA

critical habitats and spawning habitats, etc). This is because these government agencies may be required to consider future applications that fall under their jurisdiction. For example, parcels rezoned and subdivided to create single family lots where a ZOS occurs but has not been considered, could subsequently result in denial of future applications for docks, retaining walls, etc. under the *Water Sustainability Act* or *Federal Fisheries Act*. This concern is greatest in cases where amended zoning may create multi family or strata type developments that will strongly desire to have marinas constructed to accommodate boat moorage, for example.

The data in this and other FIMP studies on more highly developed lakes (such as Windermere, Kootenay and Okanagan) highlight that lake wide change of shoreline habitat is a slow process that can have large habitat related impacts over time, even if managed with appropriate permits and processes. These small, incremental changes are often hard to regulate, because they can be as simple as the removal of one wildlife tree that has become a danger tree, post construction. For these reasons, lake management must consider alteration at a lake wide scale over a longer period of time (i.e., 20 – 80-year horizon). Finally, these changes are often exacerbated by governmental changes occurring every four years at local, provincial, or federal levels, where new governments may have different priorities or stances on habitat protection.

These changes are likely occurring on nearly every lake in BC that has private holdings along the shoreline. Further, it was apparent that some developments on Arrow Reservoir were not compliant with standard BMP's, and it was not understood if these developments were receiving the appropriate level of environmental review at either the local, provincial, or federal levels. These problems occur for a variety of reasons, including OCP's not requiring development permits, OCP's not having a linkage to the FIMP, an enforcement failure of the provincial or federal agencies, and/or the number of landowners or contractors who are simply ignoring or are unaware of the environmental requirements. While individual losses of habitat may appear small on a lot-by-lot scale, cumulatively impacts do add up.

The following is a road map of the key steps to better incorporate and effectively implement these FIMP results and recommendations to protect high value shoreline habitats:



1. Incorporate new data, such as identified ZOSs, into appropriate planning documents (i.e., Regional District and municipality OCPs). The FDG provides an excellent base to be adapted into these planning documents.

2. Establish Development Permit areas for the *entire lake* within each electoral area and / or municipality. The local governments generally do not have environmental development processes in place for Arrow Reservoir. Impacts are occurring around the entire lake, and thus the Development Permit process should be implemented, requiring high value habitats to be reviewed by a qualified professional and to be appropriately planned to limit impacts. These should be made consistent across the Arrow Reservoir and should specifically identify how best to consider ZOS as areas intended for conservation.

   As found at other lakes with FIMP studies (e.g., Okanagan, Windermere, Kootenay [respectively, Schleppe and Plewes 2017, and Schleppe and McPherson 2021 and 2022]), these losses are typically observed during redevelopment of existing lots or as build out on new lots occurs. For instance, on Kootenay Lake, subdivisions approved prior to the first inventory were areas where ongoing buildout and impacts were occurring almost 10 years after the first survey. Further, these studies showed how slow buildout can also occur and how even slow rates of change add up cumulatively. Failure to implement a Development Permit process could continue to be a contributing factor to environmental losses, and particularly if ZOS are not designated as areas for conservation. Areas without any established guidelines will likely experience greater rates of loss than those with some type of policy for protection of habitat.

   Once new structures are observed and proponents realize that there are no consequences, many other adjacent property owners follow suit and build similar structures. This example is best seen with retaining walls, for example. On Shuswap Lake, a particular rock stacked retaining wall was observed in many locations and upon brief investigation, one contractor had been referred to many different landowners because the “aesthetics” of the wall were desired and subsequently repeated on property after property. Conversely, once neighbouring landowners see that there have been consequences of poor development practices (e.g., fines or requirements for removal), then the others will more likely follow suit with proper planning. The hope is that the good environmental development practices will be noticed and appreciated for their aesthetic values and consequently copied by neighbours.

   Examples from other regions may be sought to help with this step. For example, in the Windermere Lake OCP, the Regional District of East Kootenay (RDEK) currently requires development permits for works within 15 m of shoreline areas designated in the original FIMP as being red (very high and high ecological value) and anywhere within the boundary of an orange zone (ZOS) (RDEK 2019). The RDEK is currently

working on aligning the OCP development permit requirements based on the updated FIMP (K. MacLeod pers comm., Schleppe and McPherson 2021).

3. Agencies should develop enforcement and monitoring plans and commit sufficient resources to the plans so they are successful at taking enforcement action in a consistent and ongoing manner that is collaborative between agencies. During our survey, many observed impacts were directly adjacent to the lake at, near, or below Present Natural Boundary. These observed impacts were likely in violation of either Provincial (*Water Sustainability Act*) or Federal (*Fisheries Act*) policies. Enforcement effort is required to curb these activities. Enforcement will not be effective if it is implemented in a half hazard manner. Enforcement is necessary at all levels of government, which should work collaboratively on lake front development challenges. However, land use has a direct impact on shoreline, which is generally governed by local and regional government.

4. After initial guidelines and enforcement are established, effort should be focused on development of regional lakeshore plans such as a greenspace legacy plan or using tools for watershed planning under the *Water Sustainability Act*. These regional initiatives are extremely important. Densification (i.e., rezoning and subdivision) is the most important determinant affecting rates of loss of nearshore habitat. These impacts are expected to continue to occur because over time, small incremental change is inevitable even with effective enforcement and compliance. For example, once a home is constructed, trees may become hazardous and require removal or small patches of native shrubs will be lost slowly over time. Often these changes occur because no permit is necessary or the change is so small, people think a permit is not required. Thus, larger scale regional plans are important to ensure that sufficient green space and habitat remain as part of rural reserves or areas that are understood to be less developable. For success of this step, all levels of government must work collaboratively.

5.2 Land use policy and lakeshore planning

5.2.1 All levels of government

1. All agencies are to collaborate to prepare an integrated watershed management plan. Federal and provincial agencies should work with local government and Indigenous Peoples to help implement important tools available within existing legislation, such as the *Water Sustainability Act*, *Land Act*, *Fisheries Act,* and regional and municipal policies and bylaws. These pieces of legislation and tools can act together as part of a larger, more regional approach to watershed planning. An integrated watershed management plan with all these linkages is important because no one level of government has all the tools necessary to appropriately plan and manage lake shoreline areas.

2. Identify and protect high value areas as conservation lands. Identify and protect high value areas that are essential for the long-term maintenance of fish and/or wildlife values as conservation areas. All legal tools are to be used to provide this protection, including establishment of parks, SARA designated critical areas, private land covenants and nature conservancy lands, as examples. It is recommended that shorelines with Very High and High Ecological Values, and in particular areas that overlap with ZOS, be protected through the establishment of conservation areas. These areas include creek mouths, contiguous wetlands, and areas with SAR. It is recommended that no development occurs in these areas. Low impact water access recreation, Indigenous Peoples uses and habitat restoration may be permissible. However, permanent structures or alteration of existing habitat should not be acceptable.

3. Incorporate all ZOS into revised planning documents such as OCPs, bylaws, or other policy documents, as appropriate. These ZOS are intended to identify areas of conservation priority, and are, at minimum, to act as flags so that government can understand quickly where important habitats may exist. For instance, the *Federal Fisheries Act* protects all fish. Mussels are also included as fish in this definition (see Section 2 of Federal *Fisheries Act* for definition of a fish, which includes all shellfish). Further, ZOS identify critical habitats for SARA species such as White Sturgeon and should act as important triggers that initiate formal processes such as permit submissions for SARA species. Thus, it is important for all agencies to understand where this habitat is to work in coordination when reviewing proposed activities. This recommendation pertains to local, Provincial and Federal governments. *It was noted that some of the data available was not easily accessible (e.g., bat data) and it may be useful to find ways to improve data sharing and access.*

4. Increase effort and funding towards enforcement and compliance. There appeared to be very little government effort/funding into enforcement and compliance, including of Crown land encroachments, best management practices, OCP adherence in DPAs, the *Water Sustainability Act* or the *Federal Fisheries Act* in the region. Increased effort and funding should go towards this, similarly to what is being done in the Okanagan, Shuswap, and coastal regions. Encroachments such as substrate modification often directly impact floodplain vegetation communities, and subsequently creates a secondary need for erosion control. These encroachments also likely did not consider the potential presence of freshwater mussels, or value of riparian, substrate, and emergent vegetation. Natural emergent vegetation is very often removed slowly over time.

   On Arrow Reservoir, there was at least one active construction project that would have most likely required a *Federal Fisheries Act* Authorization or at minimum, letter of advice, among numerous other likely permits (e.g., Section 11 under the WSA). In this case, the active construction was reported to the BC Report all Poachers and Polluters (RAPP) Line to allow agencies to confirm that appropriate

permits and authorizations were in place for the construction of lake access to at or near the approximate HWM mark.

5. Indigenous Peoples and communities are encouraged to seek funding to further integrate archeological and cultural information into the shoreline planning process. The FIMP Project Team will support this process however appropriate, and will strive to incorporate cultural and archaeological values into FIMP documents. While these data are separate from FIM datasets, there is often a high level of overlap regarding concern areas. Thus, continued collection of these data are important as part of an adaptive management planning process. These datasets can also be easily incorporated into the FDG in an inclusive manner at any time as required.

6. Presence/absence sampling is recommended for the sensitive fish species with uncertain accounts. Some of the sensitive/SARA accounts indicate that although the fish species was listed in Habitat Wizard as being present in Lower Arrow Lake, its Columbia River distribution may be restricted to the mainstem downstream of Hugh Keenleyside dam, outside the study area. This may be the case for Umatilla Dace (*Rhinichthys umatilla*), Mottled Sculpin (*Cottus bairdi;* which may represent the subspecies Columbia Sculpin [*Cottus bairdi hubbsi*]), and Shorthead Sculpin (*Cottus confuses*). Sampling is recommended within the Arrow Reservoir to confirm the distribution of these species.

7. Conduct a mussel survey during lower water levels and map the locations and species present. Use this information to update the ZOS and FHSI for the Arrow Reservoir, so that segments with mussels are valued accordingly, and so mussels have greater protections during development. Follow a similar approach to that used on other lakes in the region that had FIMPs completed (i.e., Windermere Lake, Kootenay Lake [Schleppe and McPherson 2021 and 2022).

8. Continue to conduct wildlife inventories, in particular for sensitive species to improve understanding of high value habitats that require protections. Also, identify and implement enhancement opportunities, such as those completed by BC Hydro (wetlands, bat habitat, etc.) (Section 4.2.2). Submit sensitive species results to the province, so they may be placed on the provincial data base for others to utilize.

9. Complete littoral mapping of the low pool littoral zone. This would be helpful to understand reservoir productivity at varying reservoir elevations. This work would be beneficially combined with bathymetric mapping. By collecting both datasets, a model could be built that considers a variety of different factors, such as substrates, aquatic vegetation, ground water seepage areas, littoral zone widths, amongst other factors. This information would be used to derive littoral zone values at different reservoir elevations.

5.2.2 Local government

1. Use the environmental information in this report to update the Official Community Plans and associated Development Permit Area designations for Arrow Reservoir. This will help identify, plan, and design around these important biological features. Where possible, ZOS should be identified as areas for conservation. Also, consider this information for Regional Growth strategies, and other planning and policy tools. Where possible, link these planning documents with other regulatory tools (see Recommendation 1).

2. Prepare development permit areas for all watercourses, including Arrow Reservoir and its tributaries or adjacent wetlands. Development permit area buffers should be consistent for the entire lake, consider ZOS, and other important features, regardless of the Regional District/Electoral Area or municipality location. Even with Development Permit areas in place, loss will still likely occur, but the rate of loss should be reduced if policies are in place. Without consistency around the lake, development may become focused on areas with lesser requirements.

3. Limit shoreline urbanization. Carefully consider any permit applications that could further urbanize the shoreline. The biggest risks typically occur when rural lands are re-zoned to a denser land use such as single family, multi family, industrial, or commercial. Many remaining rural areas were deemed of Very High or High Ecological value and were typically overlain with ZOS. Regardless of protection measures, it has been observed that slow, incremental losses inevitably continue to occur when a shoreline urbanizes. The simple increased intensity of use could result in increased disturbances along the shoreline. Shoreline densification and urbanization that is likely the single most important factor affecting environmental value loss.

4. Establish riparian setbacks. Appropriate setbacks for development should be determined using the top of bank and/or using a stream boundary definition that includes consideration of the biological floodplain processes. In some cases, the benchmark used for HWM may vary from a surveyed Present Natural Boundary or property line, depending on vegetative cover, floodplains and their processes. Setbacks should generally occur from the edge of these floodplain areas to ensure adequate riparian protection buffers and these should be surveyed and field reviewed by a qualified professional with suitable experience. Notwithstanding, it is recognized that the processes and concepts of floodplain are more challenging on a reservoir such as Arrow that is both regulated and contains “pinch points” or more riverine lake areas that have a direct influence on water elevations.

5. Local governments to establish waterfront zoning. This has been an often-controversial topic, and many local governments have struggled with establishment

of them or defining what should and should not apply. However, there are benefits of some zone establishment, which include the ability to: a) use bylaw enforcement; b) establish a list of acceptable activities on the water or number of structures (i.e., only one dock of a certain size), with deviations requiring a variance; and, c) have more control over activities that may have a direct impact on the foreshore. It is noted that any process such as this has associated costs and can be complicated in areas with overlapping jurisdictions.

5.2.3 Provincial government

1. Halt and reverse unpermitted Crown Land encroachments. Unpermitted Crown Land encroachments were likely present in many locations, from either retaining walls, boat houses, or other types of overwater/near water modifications. It is acknowledged that the concept of Present Natural Boundary on Arrow Reservoir is complicated. Some encroachments appeared to be recently renovated or constructed. Substrate modification was a disturbance often observed below the HWM or in floodplain areas. Loss of vegetation cover was also evidenced. The modifications contribute to habitat loss as impacting other ecosystem functions. For example, loss of vegetation cover can lead to erosion and destabilization of the lakebed, as the natural armour is removed. The following are recommendations to help address these encroachment issues:
    a. Conduct an inventory of encroachments and develop a plan to determine the next appropriate steps to bring structures into compliance.
    b. Initiate a process to remove illegally constructed structures, as is commonly occurring in the Okanagan and Shuswap regions.
    c. Conduct public consultation to educate owners about Crown Lands and their legal requirements when placing structures at or below the HWM on Crown Land.
    d. Use the permit application review period to bring structures into compliance, as this is when a review of the structures and their locations is conducted.
    e. Setup appropriate referrals between relevant agencies to ensure that one permit issuance does not supersede another (e.g., Crown Lands releases tenure for a Marine Rail system, that would also require a Development Permit from a local government for a Boat House).

    It is strongly recommended that the provincial Crown Land Branch works with other agencies on enforcement and establishment of appropriate tools for landowners to begin the process of addressing any permitting requirements. Without more effort, ongoing alterations to the shoreline will likely occur, with potentially significant impacts over time.

2. Address poor retaining wall practices. Retaining wall structures were often present in front of residences, with many built below the HWM. These structures were of variable types, with some constructed of local rock or lakebed rock. These structures can impact the shoreline by eliminating complex habitat features important to fish and wildlife, which may also be lacking on Arrow Reservoir due to the large drawdown. Often the installation of a retaining wall along a property means that the erosive forces are transferred to the neighbouring property, which then triggers additional installations. The following are recommendations to address this issue.

    a. Conduct an inventory and determine what is needed to help facilitate removal and transition of these walls to bioengineered erosion control structures under the *Water Sustainability Act*.

    b. Develop an erosion control structures toolkit that addresses permitting and submission requirements (i.e., including what is most appropriate and where). The intent of this toolkit is to aid in application submissions and facilitate removal of these structures. For some locations, it may be nearly impossible to remove some vertical walls due to other legally approved infrastructure. Whereas, in others it may be easier. The toolkit could likely be developed in conjunction with other Provincial regions.

    These recommendations would also be applicable to local government, who may need to authorize access through a riparian area as part of a development permit process.

3. Ensure that all permitting and associated data collected by Provincial Agencies are accessible. This could be achieved using a model similar to the *Fisheries Act* Registry[7]. This goal is to have a repository of retaining wall / groyne / erosion control projects for the lake. Habitat-related improvements made should also be documented. Together, this information can facilitate adaptive management and best practices. For instance, these data would be useful to help determine the best ways to engineer and construct habitat improvements and continue to monitor them over time. These data could also help adaptively manage to prepare for climate change. This FIM inventory can become the start of the structure inventory. This can be updated during FIM inventories, if GIS data are provided. This inventory of modifications is important to aid agency staff in understanding what works have been done, where, and what values may be present or impacted.

[7] Fisheries Act Registry. Available: https://open.canada.ca/data/en/dataset/2c09d2fd-9a8e-4d8c-b5af-95747e36eaac

5.2.4 Federal government

1. Ensure that all permitting and associated data collected by Federal Agencies is accessible (as outlined above for the Provincial government).

2. There appears to be very little government effort/funding that goes into enforcement and compliance of the Federal Fisheries Act. To address this, see Section 5.2.1 Recommendation 3).

5.3 Addressing cumulative impacts

5.3.1 All potential levels of government

1. To minimize environmental impacts, restrict motorized access in high value habitats, including drawdown areas with emergent aquatic vegetation. It may be important to identify and develop legal restrictions to make important habitat (e.g., wetland and upland habitats) areas off-limits to motorized watercraft or vehicular access to sensitive reservoir lakebed substrates. The restriction reflects that motorized access may cause abandonment of nests, harassment of wildlife, increased predation, flooding of nests from boat wakes, destruction of emergent vegetation, bank erosion and siltation, and increased invasive plant abundance and spread (Province of BC 2021). Arrow Reservoir is very large, with ample deep-water areas, meaning there is much of the lake where impacts are minimal. However, this also means that where key areas occur, protection is warranted.

2. Prepare a greenspace legacy plan. This plan is to designate a total quantity of greenspace that is desired to be maintained into the future to support a healthy and vibrant shoreline. To support this plan, scenarios can be presented that highlight what the shoreline would look like in different development intensities (e.g., status quo of generally no policy versus directed development). The goal would be to sustain both residents and tourism, as well as habitats and species that rely upon the lake. This plan should also include maintenance of appropriate connectivity to upland ecosystems and wildlife habitats over the long term.

   The plan should involve public consultation. This will allow residents to be informed about what change may occur, so they will understand how they can contribute to protection of the shoreline. By bringing stakeholders together, and committing to a greenspace legacy, there will be a reduction in the potential for ongoing and incremental losses that impact the shoreline habitats remaining. Further, this will aid future development planning because it will be well understood where buildout is preferred and facilitated.

   This planning exercise should identify, map, and ensure planning and policies are consistent between all agencies and stakeholders to maintain important habitats

along the shoreline. Lands would then be protected in local, Provincial, or Federal policy aimed at prohibiting densification of areas intended to remain as greenspace. For instance, Local Government (regional or municipal) could incorporate this information into Regional Growth Strategies, Bylaws, and Official Community Plans. Provincial government could help facilitate use of tools within the *Water Sustainability Act* (e.g., Water Sustainability Plans can link land and water decision policy in a long-term watershed or ecosystem-based framework, see Curran & Brandes 2019). This type of planning is critical because most current policy focusses on addressing site specific impacts, which will help ensure a low rate of change around Arrow Reservoir but may not provide adequate long-term protection for shoreline areas.

3. Establish climate refugia. Linked to the previous Green Space recommendation, establish 'Climate Refugia' as outlined in the Kootenay Lake Local Conservation Fund Guidance Document (Amec and Pandion 2018). The concept of climate refugia is described as follows (Amec and Pandion 2018):

   "Species may' become extirpated through parts of their geographic ranges and protecting 'climate refugia' may reduce such losses (Conservation Biology Institute 2018). Climate refugia are diverse and stable conservation areas that promote persistence of biodiversity as environmental conditions change. They are locations that biodiversity can retreat to, persist in, and potentially expand from under changing climate. Approaches and tools for identifying refugia (at the population, species, ecosystem and landscape scale) are currently being developed and pilot tested in the US (Conservation Biology Institute 2018). Most approaches emphasize topographic and geologic complexity. No work has been done in the West Kootenay and addressing climate refugia locally would require development of criteria, an accepted methodology, and then a series of mapping/modeling evaluations to be undertaken."

4. Prevent ongoing losses of aquatic vegetation. It is highly suspected that the ongoing development pressure, groyne construction, intensive recreational use and moorage along the shoreline will continue to impact important emergent and submergent vegetation areas, through slow and incremental losses. Education and compliance and enforcement are required to reduce the potential for ongoing impacts. Local government may also wish to develop policies that apply to areas within 30 m of the shoreline for things such as mooring buoy placement, or moorage. While this requires budget to manage, local governments often have a better ability to achieve a desired outcome than deferring to agencies such as Ministry of Forests or Transport Canada. It is recommended that signage, educational programs, and other forms of communication with lakeside residents and tourists alike are used to help avoid the small, incremental impacts to these important areas.

5. Detect invasive species early so that a rapid management response can be implemented. Invasive aquatic species such as Eurasian Watermilfoil (*Myriophyllum spicatum*), Zebra Mussel (*Dreissena polymorph*) and Quagga Mussel (*Dreissena bugensis*) when present, result in severe impacts to the economy and environment. There should be continued recognition and financial support for invasive aquatic plant and mussel species.

5.3.2 Provincial government

1. Remove illegally constructed structures on Crown Land to help reduce cumulative impacts. A reconciliation of FIM data collected with existing Crown Land licenses or tenures was not undertaken in this assessment. Many of the structures on Crown Land are a significant component of the cumulative impacts observed. Simple removal of concrete boat launches that do not have appropriate licenses of tenures in place would easily restore lakebed disturbance in many areas. For instance, if 15 launches were removed, and each was 2 m wide and 3 m long, a total of 90 m^2 of lakebed habitat would be restored.

5.3.3 Federal government

1. Work with municipal and Provincial agencies and Indigenous Peoples on the recommendations outlined above (see Section 5.2.1).

5.4 Restoration

5.4.1 All levels of government

1. Include riparian restoration in all new or redevelopment shoreline planning scenarios. The incremental, slow losses of riparian habitat can only be balanced with appropriate commitment to incremental shoreline restoration. Otherwise, ongoing losses will occur and only a few remnant patches will remain over time. The outcome of shoreline restoration planning will also be slow and incremental, because it would likely occur with each home rebuild. It is recommended that a minimum requirement of 25% of the riparian areas be restored with each development proposal. While more restoration is encouraged, committing to a minimum such as this will help slow and possibly stop the slow rates of loss over time, or even possibly reverse them.

   A specific analysis could be completed to determine a percentage, with appropriate contingencies, that would be needed to reverse the rates of loss (or at least try and set them to zero). Until FIMP is completed a second time, rates of loss can likely be assumed to be like other large lakes such as Kootenay or Okanagan. This analysis would utilize data within this assessment, such total length of urban development shoreline, and rate of application for new or redevelopment. If undertaken, analyses

such as these are imperative to incorporate into policies such as Regional Growth Strategies, where appropriate benchmarks can be set, and monitored over time to determine their effectiveness. Feedback loops such as this help aid policy and help adaptively manage shoreline related risks over time. Short term policy measures, without appropriate adaptive management may end up failing to achieve their intended results.

5.4.2 Local government

1. Consider landscaping plans for all lakefront developments that are endorsed by a suitably qualified professional. Professional endorsements of the plans ensure that restoration planning is incorporated in some manner, natural riparian vegetation disturbance is reduced, and native species are incorporated. Clear guidelines regarding what is and what is not appropriate are important to aid proponents in planning. In particular, large patios, outdoor living spaces, lakeside cabins or cabanas, are all considered structures that should occur outside of riparian areas.

5.4.3 Provincial

1. Consider bioengineered solutions for erosion control. The BC *Water Sustainability Act* requires a professional engineer to endorse all shoreline erosion control applications. However, the most appropriate design guideline is not clear. For instance, if a 1:200-year design guideline is required, many shoreline areas transition from gravel beaches to armoured rip rap. While this solution is more robust from an engineering perspective, it can still impact shoreline areas by reducing the ability for natural vegetation to establish. In many cases, the best option is to focus on grading shorelines to stable angles, and possibly allowing some importation of appropriate material to maintain shoreline grades to aid in appropriate vegetation establishment. Every scenario is different; and feasibility, constructability, existing and legally constructed infrastructure, and associated risks must all be considered. The focus of this recommendation is to try and facilitate a broader consideration of design guidelines that also incorporate consideration of natural shoreline processes. At a minimum, guidelines should ensure that vertical and hard structures are only permitted in cases where no other viable option is possible. Even in these cases, a minimum grade of 2:1, with benches incorporated and planted should be incorporated.

5.5 Education

All agencies need to participate in education. Education can take many forms and is often supported by data collection. Foreshore Inventory and Mapping, FHSI, and ZOS can all be used in educational materials. The idea is to promote awareness and voluntary compliance with policies and regulation, but also to advise owner of necessary and legal permitting requirements such as Development Permits, *Fisheries Act* Authorizations (or advice), and Provincial *Water Sustainability Act* applications as an example.

1. Use the data in this report in educational outreach to shoreline residents. For example, the Okanagan Collaborative Conservation Program used data from FIM mapping of Okanagan Lake to generate outreach public materials (see: http://lakeshore-living.okcp.ca/). These materials should also include information regarding Crown Lands, and the need to avoid disturbance unless appropriate permission is obtained.

6.0 REFERENCES AND PERSONAL COMMUNICATIONS

References

Amec Foster Wheeler and Pandion Ecological Research (Amec and Pandion). 2018. Kootenay Lake Local Conservation Fund Guidance Document. Report Prepared for Regional District of Central Kootenay, Nelson, BC. 15 March 2018, 63 pp + 43App. AFW Report No: VE52678-2017.

Andrusak, H. 1984. Arrow Basin Fisheries Compensation Proposal – June 1984. Unpubl. MS. Cited in Sebastian et al. 2000. Ministry of Environment, Fish and Wildlife Branch, Victoria BC. 24p. Cited in Sebastian et al. 2000.

Andrusak, H. 1969. Arrow Lake stream survey. Unpubl. MS. BC Fish and Wildlife Branch 1969. Cited in Sebastian et al. 2000.

Arndt, S. 2022. Arrow Lakes Reservoir Angler Creel Survey 2021. Prepared by Ministry of Forests, Lands, Natural Resource Operations and Rural Development Fish and Wildlife Compensation Program Section, Nelson, BC.

Ashley, K., L. Thompson, P. Warburton, Y. Yang, F. Pick, P. Hamilton, D. Lasenby, K. Smokorowski, L. McEachern, D. Sebastian and G. Scholten. 1997a. Kootenay Lake fertilization experiment - Year 4 (1995-96) report. Fisheries Project Report No. RD 58, Ministry of Environment, Lands and Parks, Province of British Columbia. 207p. Cited in Sebastian et al. 2000.

Ashley K. A., I. McGregor, B. Shepherd, D. Sebastian, S. Matthews, L. Vidmanic, P. Ward, H. Yassien, L. McEachern, H. Andrusak, D. Lasenby, J. Quirt, J. Whall, E.Taylor, Kuiper, A. Troffe, C. Wong, and G. Scholten. 1999. Okanagan Lake Action Plan Year 3 (1998) Report. Fisheries Project Report No. 78. Province of BC, Ministry of Fisheries, Fisheries Management Branch. 338p. Cited in Sebastian et al. 2000.

Bassett M., S. Arndt and T. Weir. 2022. Arrow Lakes Reservoir Nutrient Restoration Program (COL-F22-F-3496-DCA) 2021-22 (F22) Activity Report 1 April 2021 to 31 March 2022. Prepared for: Fish & Wildlife Compensation Program (FWCP). Prepared by: Ministry of Forests (MoF), Resource Management (FWCP – Section).

Batten, R. 2021. EXCEL spreadsheet of Herbarium Data Mining. Cited in BC CDC 2022b.

BC Bryophyte Recovery Team. 2007. Recovery strategy for the silver hair moss (Fabronia pusilla Raddi) in British Columbia. Prepared for the B.C. Minist. of Environ., Victoria, BC. 14pp. Cited in BC CDC 2022b.

BC Conservation Data Centre (BC CDC). 2022a. BC Species and Ecosystems Explorer. B.C. Available: https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre .

BC Conservation Data Center. 2022b. Online iMap platform. Available: https://www2.gov.bc.ca/gov/content/environment/plants-animals-

ecosystems/conservation-data-centre/explore-cdc-data/species-and-ecosystems-explorer .

B.C. Conservation Data Centre. 2014. Occurrence Report Summary, Shape ID: 36614, White Sturgeon (Upper Columbia River Population). B.C. Ministry of Environment. Available: http://maps.gov.bc.ca/ess/hm/cdc (accessed Nov 17, 2022).

BC Hydro. 2023. Revelstoke Unit 6 Project website. Available: https://www.bchydro.com/energy-in-bc/projects/revelstoke-unit-6.html

BC Hydro. 2022a. Arrow Lakes Reservoir. Available: Arrow Lakes Reservoir (bchydro.com).

BC Hydro 2022b. Columbia River Project Water Use Plan. Columbia River White Sturgeon Management Plan Monitoring Program and Physical Works Annual Report: 2022. Available: CLB MP5 Columbia River White Sturgeon Management Plan Monitoring Program and Physical Works|Annual Report| July 022 (bchydro.com)

BC Hydro 2022c. Columbia River Water Use Plan Arrow Lakes Reservoir Wildlife Management Plan Physical Works Annual Report: 2022. Available: Arrow Reservoir Wildlife Management Plan (bchydro.com).

BC Hydro. 2021. Columbia River Project Water Use Plan Arrow Lakes Reservoir Operations Management Plan Monitoring Programs Annual Report: 2021. Available: Arrow lakes Reservoir Operations Management Plan Monitoring Program Annual Report | June 2021 (bchydro.com).

BC Hydro. 2020. Revelstoke Generating Station Unit 6 Project Factsheet-November 2020. Available: Revelstoke Unit 6 Project (bchydro.com).

BC Hydro. 2016. News Release. BC Hydro completes upgrades to one of B.C.'s largest power generation facilities, March 28, 2016. Available: Mica Units 5 & 6 Projects (bchydro.com).

BC Hydro. 2013. BC Hydro's Revelstoke Wildlife Enhancement Projects Factsheet – January 2013. Available: Arrow Reservoir Wildlife Management Plan (bchydro.com).

BC Hydro. 2007. Columbia River Project Water Use Plan 11 January 2007, B Revised for Acceptance by the Comptroller of Water Rights. Available: BC Hydro > Columbia Water Use Plan Revised for Acceptance by the Comptroller of Water Rights, January 2007

BC Ministry of Environment (BC MoE). 2022. Habitat Wizard, online database. Available: https://maps.gov.bc.ca/ess/hm/habwiz/

BC Ministry of Environment Lands and Parks. 2000. The Freshwater Molluscs - Wildlife in BC at Risk (brochure). Available: https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/species-ecosystems-at-risk/brochures/freshwater_mollusc.pdf

BC Vertebrate Record File. 2001. Royal B.C. Mus., Victoria, BC. Cited in BC CDC 2022b.

Bogan, A.E. 1993. Freshwater bivalve extinctions (Mollusca:Unionidae); a search for causes. Am Zool 33:599-609. Cited in Perles et al. 2003.

Bringing the Salmon Home Initiative. 2022. Columbia River Salmon Reintroduction Initiative. Available: https://columbiariversalmon.ca/call-to-anglers-to-identify-chinook-salmon-they-encounter/

Canadian Columbia River Forum. 2008. The Columbia River Treaty: A synopsis of structure, content, and operations. Prepared for the Canadian Columbia River Forum by Glen Hearns.

Carver, M. 2022. Transition Hydrology: En Route to a New Runoff Regime. Columbia Mountains Institute CREDtalk presentation. Available: Dr. Martin Carver: Transition Hydrology - En Route to a New Runoff Regime - YouTube

Challenger, W. and V.C. Hawkes. 2020. CLBMON-37. Kinbasket and Arrow Lakes Reservoirs: Amphibian and Reptile Life History and Habitat Use Assessment. Western Painted Turtle Population Trends Assessment. Unpublished report by LGL Limited environmental research associates, Sidney, BC and Okanagan Nation Alliance, Westbank, BC for BC Hydro Generations, Water License Requirements, Burnaby, B.C. 35 pp.

Columbia Basin Institute. No date. High Arrow Dam. Available: Construction of High Arrow Dam: Columbia Basin Institute of Regional History

Columbia Power Corp. 2022. Columbia Power Corp. 2022. Arrow Lakes Generating Station. Available: Arrow Lakes Generating Station | Columbia Power.

Columbia River Water Use Plan Consultative Committee. 2005. Consultative Committee Report Columbia River Water Use Plan. A Project of BC Hydro. Available: Microsoft Word - Columbia CC Main Jul 19, 2005.doc (bchydro.com).

Columbia Shuswap Regional District (CSRD). 2022. Electoral Area B Zoning Bylaw No. 851. Available: CSRD Area B Jun16 Adopted BL851-26, BL851-29 20220911125016404.pdf

Community Bat Programs of BC. 2022. Website. https://bcbats.ca/bat-basics/bat-species-in-bc/ .

Conservation Biology Institute. 2018. Identify and protect climate refugia. Yale Framework for Integrating climate adaptation and landscape conservation planning. Available: https://yale.databasin.org/pages/objectives_5/ . Cited in Amec and Pandion 2018.

COSEWIC. 2010a. COSEWIC assessment and status report on the Umatilla Dace Rhinichthys umatilla in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii + 37 pp.

COSEWIC. 2010b. COSEWIC assessment and status report on the Shorthead Sculpin Cottus confusus in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii + 28 pp.

COSEWIC 2006. COSEWIC assessment and status report on the Western Painted Turtle Chrysemys picta bellii (Pacific Coast population, Intermountain-Rocky Mountain population and Prairie/Western Boreal - Canadian Shield population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 40 pp. Available: Western Painted Turtle (Chrysemys picta bellii) (registrelep-sararegistry.gc.ca) .

Craig, C. and R. Gill. 2020. CLBMON-36: Nest Mortality of Migratory Birds Due to Reservoir Operations – 10 Year Final Report, 2008-2017. Unpublished report by Hemmera Envirochem Inc., Burnaby, BC for BC Hydro Generation, Water License Requirements, Burnaby, BC. 32 pp. +Apps.

Curran, D., & Brandes, O.M. 2019. Water Sustainability Plans: Potential, Options, and Essential Content. Victoria, Canada: POLIS Project on Ecological Governance & Environmental Law Centre, University of Victoria.

East Kootenay Integrated Lake Management Partnership (EKILMP), McPherson S. and Hlushak D. 2009. Windermere Lake Shoreline Management Guidelines for Fish and Wildlife Habitats. Combined agency and consultant (Interior Reforestation Co. Ltd) report.

Environment Canada. 2022. Arrow Reservoir at Nakusp water levels (Station 08NE104). Available: Real-Time Hydrometric Data Graph for ARROW RESERVOIR AT NAKUSP (08NE104) [BC] - Water Level and Flow - Environment Canada (ec.gc.ca).

Environment and Climate Change Canada (ECCC). 2022. Recovery Strategy for the Bank Swallow (Riparia riparia) in Canada. Species at Risk Act Recovery Strategy Series. Environment and Climate Change Canada, Ottawa. ix + 125 pp. Available: Bank Swallow (*Riparia riparia*): recovery strategy 2022 - Canada.ca.

Environment and Climate Change Canada. 2017. Recovery Strategy for the Whitebark Pine (Pinus albicaulis) in Canada [Proposed]. Species at Risk Act Recovery Strategy Series. Environment and Climate Change Canada, Ottawa. viii + 54 pp. Available: https://www.registrelep-sararegistry.gc.ca/virtual_sara/files/plans/rs_whitebark_pine_e_proposed.pdf

Environment Canada. 2014. Recovery Strategy for the Woodland Caribou, Southern Mountain population (Rangifer tarandus caribou) in Canada. Species at Risk Act Recovery Strategy Series. Environment Canada, Ottawa. viii + 103 pp. Available: Recovery Strategy for the Woodland Caribou, Southern Mountain population (Rangifer tarandus caribou) in Canada - 2014 [Final] - Canada.ca

Felicetti, L.A., C.C. Schwartz, R.O. Rye, M.A. Haroldson, K.A. Gunther, D.L. Phillips, and C.T. Robbins. 2003. Use of sulfur and nitrogen stable isotopes to determine the importance of Whitebark Pine nuts to Yellowstone Grizzly Bears. Canadian Journal of Zoology 81: 763-770. Cited in Environment and Climate Change Canada 2017.

Fish and Wildlife Compensation Program (FWCP). 2019. Columbia Region: Reservoirs and Large Lakes Action Plan. Available: https://fwcp.ca/app/uploads/2019/08/Action-Plan-Columbia-Region-Reservoirs-Large-Lakes-Aug-21-2019.pdf

Fisheries and Oceans Canada (DFO). 2014. Recovery strategy for White Sturgeon (Acipenser transmontanus) in Canada [Final]. In Species at Risk Act Recovery Strategy Series. Ottawa: Fisheries and Oceans Canada. 252 pp. Available: https://www.registrelep-sararegistry.gc.ca/virtual_sara/files/plans/rs_esturgeon_blc_wh_sturgeon_0314a_e.pdf .

Fisheries and Oceans Canada (DFO). 1992. Land Development Guidelines for the Protection of Aquatic Habitat. Available: http://www.sxd.sala.ubc.ca/9_resources/fed_%20files/fed%20land%20development%20guidelines.pdf

Forests, Lands, Natural Resource Operations and Rural Development. 2018. Guidance for Freshwater Mussels in the Okanagan. Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Resource Management, Ecosystems Section, Penticton, B.C.

Gill, R., C. Craig. 2020. CLBMON-40: Arrow Lakes Reservoir Waterbird and Shorebird Monitoring Program — 10 Year Final Report, 2008-2017. Unpublished report by Hemmera Envirochem Ltd., BC, for BC Hydro Generation, Water Licence Requirements, Burnaby, BC. 50 pp. + Apps.

Golder Associates Ltd. (Golder). 2006. A synthesis of White Sturgeon investigations in Arrow Lakes Reservoir, BC 1995 - 2003. Report prepared for BC Hydro, Castlegar, BC Golder Report No. 041480016F: 61 p. + plates + 11 app. Cited in Hildebrand et al. 2014.

Golder. 2009. CLBWORKS-29A: Phase II Arrow Lakes Reservoir Wildlife Physical Works Feasibility Study. Unpublished report for BC Hydro Generation, Water Licence Requirements, Castlegar, BC.

Golder. 2012. Middle Columbia River White Sturgeon spawn monitoring: 2011 investigations. Report prepared for BC Hydro, Castlegar, B.C. Golder Report No. 11-1492-0071F: 21 p. + 1 app. Cited in Hildebrand et al. 2014.

Hawes K., D. Drieschner, and R. Wagner. 2014. Arrow Lakes Tributary Fish Migration Access. Year 6 (2013) Fish Migration Passage Monitoring and Final Report. Program No. CLBMON-32 / Q8-8004. Ecoscape Environmental Consultants Ltd. Kelowna, BC. 40pp + maps and appendices.

Hawkes, V.C., K.N. Tuttle, J.M. McAllister, and K.J. Meyers. 2020. CLBMON-37. Kinbasket and Arrow Lakes Reservoir: Amphibian and Reptile Life History and Habitat Use Assessment. Final Report 2008-2018. LGL Report EA3533F. Unpublished report by Okanagan Nation Alliance, Westbank, B.C., and LGL Limited environmental research associates, Sidney, B.C., for BC Hydro Generation, Water Licence Requirements, Burnaby, B.C. 93 pp. + Appendices.

Hawkes, V.C. and K. Tuttle. 2016. CLBMON-29B. Arrow Feasibility Study of High Value Habitat for Wildlife Physical Works. 2016 Update. LGL Report EA3714. Unpublished report by LGL Limited environmental research associates, Sidney, B.C., for B.C. Hydro Generation, Water Licence Requirements, Burnaby, BC. 86 pp. + Appendices.

Heron, J. C. Sheffield and D. Marks. 2019. Bumble Bee (Bombus spp.) surveys in southern interior BC Parks (2019). B.C. Ministry of Environment and Climate Change Strategy, Surrey, B.C. 21 pp. + 8 Appendices. Cited in BC BDC 2022b.

Hildebrand, L. R., A. Lin, M. C. Hildebrand, and D. Fissel. 2014. Effects of Flow Changes on White Sturgeon Spawning, Incubation, and Early Rearing Habitats in the Middle Columbia River (CLBMON-20 and CLBMON-54). Prepared for BC Hydro, Castlegar, BC by Golder Associates Ltd, Castlegar, BC and ASL Environmental Sciences Inc., Victoria, BC. 64 pp. + 3 app and 1 Attachment.

Hutchins, H.E. and R.M. Lanner. 1982. The central role of Clark's nutcracker in the dispersal and establishment of Whitebark Pine. Oecologica 55: 192-201. Cited in Environment Canada 2014. Cited in Environment and Climate Change Canada 2017.

Klinkenberg, Brian (Editor). ND. E-Fauna BC: Electronic Atlas of the Fauna of British Columbia [www.efauna.bc.ca]. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia, Vancouver. Cited in BC CDC 2022b.

Lake Roosevelt Forum. 2021. Upper Columbia Salmon Reintroduction Continues to Gain Momentum. Monday, 11 January 2021. Available: Upper Columbia Salmon Reintroduction Continues to Gain Momentum (lrf.org).

Lindsay, R. A. 1977a, MS. Revelstoke Dam Fish Compensation on the Upper Arrow Lake, 1977. Report to BC Hydro and Ministry of Environment, Fisheries Branch, Nelson, BC. Cited in Sebastian et al. 2000.

Lydeard, C., R.H. Cowie, W.F. Winston, A.E. Bogan, P. Bouchet, S.A. Clark, K.S. Cummings, T.J Frest, O. Gargominy, D.G. Herbert, R. Hershler, K.E. Perez, B. Roth, M. Seddon, E.E. Strong, and F.G. Thompson. 2004. The global decline of nonmarine mollusks. Bioscience. 54: 321-330. Cited in FLNRORD 2018.

Martin, A.D. 1976. Investigations on fish populations that will be affected by the Revelstoke Dam. BC Fish and Wildlife Branch, Nelson, BC. Cited in Sebastian et al. 2000.

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

McPhail, J. D. and R. Carveth. 1992 A foundation for conservation: the nature and origin of the freshwater fish fauna of British Columbia. Vancouver, B.C. University of BC, Dept. of Zoology, Fish Museum. 1992. Cited Sebastian et al. 2000.

McPhail, J.D. and V.L. Paragamian. 2000. Burbot Biology and Life History. Pages 11-24. An offprint prepared for Burbot: Biology, Ecology and Management edited by Vaughn

L. Paragamian and Dave W Willis. Publication Number 1: Fisheries Management Section of the American Fisheries Society.

Metcalfe-Smith, J.L. and B. Cudmore-Vokey. 2004. National general status assessment of freshwater mussels (Unionacea). National Water Research Institute Report No. 04-027. Cited in FLNRORD 2018.

Miller, M.T. and V.C. Hawkes. 2022. CLBWORKS-30B Arrow Lakes Reservoir Wildlife Enhancement Program. Burton Flats Planting Project (Phase 2). Final Report – 2021. LGL Report EA4177. Unpublished report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generation Water Licence Requirements, Burnaby, BC. 30 pp.

Miller, M.T. and V.C. Hawkes. 2020. CLBWORKS-30B Arrow Lakes Reservoir Wildlife Enhancement Program. Burton Flats Planting Project (Phase 1). Final Report – 2019. LGL Report EA3957. Unpublished report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generation Water Licence Requirements, Burnaby, BC. 38 pp.

Neeves, R.J. 1997. A national strategy for the conservation of native freshwater mussels. Cited in Perles et al. 2003.

New York Botanical Garden, Accessed through Consortium of North American Bryophyte Herbaria (CNABH) Data Portal. Available: http//:bryophyteportal.org/portal/index.php (Accessed 18 March 2017). Cited in BC CDC 2022b .

Northcote T. G.1991. Success, problems, and Control of Introduced Mysid Populations in Lakes and Reservoirs. American Fisheries Society Symposium 9:5-16 1991. Cited in Sebastian 2000.

Okanagan Nation Alliance (ONA) 2022. CLBMON21: Middle Columbia River Juvenile White Sturgeon Detection and Habitat Use Study – 2007 to 2021 Synthesis Report. Okanagan Nation Alliance Report prepared for BC Hydro, Castlegar, BC. 69 p. + 6 app.

Okanagan Nation Alliance (ONA). 2022. Middle Columbia River White Sturgeon Spawn Monitoring (CLBMON-23A): 2021 Data Report (Year 15). Report prepared for BC Hydro, Castlegar, BC. 19 pp + 1 app.

Paish, H. and Associates 1974. Environmental assessment of the proposed Revelstoke (1880) and Downie-Revelstoke (1685) development on the Columbia River. BC Hydro, Vancouver. 130p. Cited in Sebastian et al. 2000.

Parsley, M.J., E. Kofoot, and T.J. Blubaugh. 2011. Mid Columbia River Sturgeon Incubation and Rearing Study 2010 Investigations Data Report (CLBMON-27). Prepared by: U. S. Geological Survey, Western Fisheries Research Center, Columbia River Research Laboratory. Prepared for BC Hydro Castlegar.

Pavlik, M. 2020. CLBMON-39: Arrow Lakes Reservoir Neotropical Migrant Use of the Drawdown Zone & CLBMON-11B2: Arrow Lakes Reservoir Revelstoke Reach Spring Songbird Effectiveness Monitoring, Year 10 Final Report, 2008-2017. Unpublished report by Hemmera Envirochem Inc., Burnaby, BC, for BC Hydro Generation, Water Licence Requirements, Burnaby, BC 39 pp. + apps.

Perles, S.J., A.D. Christian, and D.J. Berg. 2003. Vertical migration, orientation, aggregation, and fecundity of the freshwater Mussel Lampsilis siliquodea. Ohio J. Sci 103(4):73-78.

Porto, L. and S. Arndt. 2006. Hill Creek Spawning Channel Rainbow Trout Studies - 2005. 2006. Report prepared for Columbia Basin Fish & Wildlife Compensation Program, Nelson, BC. 41 p. Cited in Arndt 2022.

Province of BC. 2023a. Contacts for First Nation Consultation Areas. Available: Contacts for First Nation Consultation Areas - Province of British Columbia (gov.bc.ca).

Province of BC 2023b. Consulting with First Nations website. Available: Consulting with First Nations - Province of British Columbia (gov.bc.ca).

Province of BC. 2022a. BC Geographic Names - Arrow Lake. Available: BC Geographical Names (gov.bc.ca).

Province of BC. 2022b. Foreshore and Aquatic Crown Land Ownership in British Columbia, general information. Available: https://www2.gov.bc.ca/gov/content/industry/crown-land-water/crown-land/crown-land-uses/residential-uses/private-moorage

Province of BC 2010. Updated Procedures For Meeting Legal Obligations When Consulting First Nations - Interim. Available: Interim Policy for Consulting with First Nations (gov.bc.ca)

Province of BC 1996. *Land Act* [RSBC 1996] Chapter 245. 1996. Available: Land Act (gov.bc.ca).

Regional District of Central Kootenay (RDCK). 2009. Electoral Area K - The Arrow Lakes Official Community Plan Bylaw No. 2022. Available: the arrow lakes (rdck.ca) and schedule - AMD_1675-K-Zoning_Schedules.pdf (rdck.ca).

RDCK. 2004. RDCK Zoning Bylaw No. 1675, 2004 - Electoral Areas F, I, J and K. Available: ELECTORAL AREAS F, I, J AND K (rdck.ca)

RDCK. 1996. 1996. Kootenay Columbia Rivers Official Community Plan Bylaw No. 1157 (electoral areas I and J). Available: Kootenay Columbia rivers (rdck.ca)

Regional District of Central Kootenay (RDCK). 2016. North Kootenay Lake Electoral Area 'D' Comprehensive Land Use Bylaw No. 2435. Available: https://www.rdck.ca/assets/Government/Bylaws/Land~Use-Planning/2435-D_CLUB_Consolidated_2689.pdf#search=%22kootenay%20lake%22

Regional District of Central Kootenay. 2013a. East Shore of Kootenay Lake Electoral Area 'A' Comprehensive Land Use Bylaw No. 2315. Available: https://www.rdck.ca/assets/Government/Bylaws/Land~Use-Planning/2315-A_CLUB_Consolidated_2686.pdf#search=%22kootenay%20lake%22

Regional District of Central Kootenay. 2013b. Electoral Area 'E' Rural Official Community Plan Bylaw No. 2260. Available: http://www.rdck.ca/assets/Government/Bylaws/Land~Use-Planning/2260-E_OCP_Consolidated_2751.pdf

Regional District of Columbia Shuswap (RDCS). 2022. Public interactive web map. Available: Official Community Plans | CSRD, BC

Regional District of East Kootenay (RDEK). 2019. Lake Windermere Official Community Plan (OCP), Bylaw No. 2929. Available: https://www.rdek.bc.ca/bylaws/ocp_zoning_landuse/ocp/lakewindermereocp/

Robichaud, D., G. Glova, and S. Kingshott. 2014 Arrow Lakes Reservoir Burbot life history and habitat use (Year 5). Prepared by LGL Limited, Sydney BC. Prepared for BC Hydro, Vancouver, BC.

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

Schleppe, J. and A. Cormano, 2016. Kootenay Lake Foreshore Inventory and Mapping and Aquatic Habitat Index. Ecoscape Environmental Consultants Ltd. Prepared for: Kootenay Lake Partnership & Fisheries and Oceans Canada.

Schleppe, J., L. Crevier, and R. Plewes. 2019. Foreshore Inventory and Mapping for Species at Risk. Prepared for Living Lakes Canada. Prepared by Ecoscape Environmental Consultants.

Schleppe, J.[1], and S. McPherson[2]. 2022. Kootenay Lake Foreshore Integrated Management Planning. Prepared for Living Lakes Canada. Prepared by: Ecoscape Environmental Consultants Ltd.[1], and Lotic Environmental Ltd.[2]

Schleppe, J.[1], and S. McPherson[2]. 2021. Windermere Lake Foreshore Integrated Management Planning. Prepared for Living Lakes Canada. Prepared by: Ecoscape Environmental Consultants Ltd.[1], and Lotic Environmental Ltd.[2]

Schleppe, J.[1], S. McPherson[2], L. Porto[3], and B. Mason[4]. 2021. Foreshore Integrated Management Plan Methods. Prepared for Living Lakes Canada. Prepared by: Ecoscape Environmental Consultants Ltd.[1], Lotic Environmental Ltd.[2], Wood Environment and Infrastructure Solutions[3], and BC Community Mapping Network[4]. Available: fimp-methods-report-2021.pdf (livinglakescanada.ca).

Schleppe, J. and R. Plewes. 2017. Okanagan Lake Foreshore Inventory and Mapping Update 2016. Ecoscape Environmental Consultants Ltd.

Ministry of Forests and Lands. 1987. Circular Letter to All BC Land Surveyors, Re: Natural Boundary Definition (Circular Letter No 334; July 24, 1987). Surveyor General Branch, Victoria BC. Available: https://ltsa.ca/wp-content/uploads/2020/10/CL334_INACT.pdf

Sebastian D.[1], H. Andrusak[2], G. Scholten[1], and L. Brescia[3]. 2000. Arrow Reservoir Fish Summary - Stock Management Report. Province of British Columbia Ministry of Fisheries. Prepared for Columbia Basin Fish and Wildlife Compensation Program; BC Hydro; and BC Ministry of Environment, Lands and Parks. Prepared by Conservation Section, Fisheries Management Branch, Victoria, BC[1], Redfish Consulting[2], and Consultant[3]. Available: cover.cdr (gov.bc.ca).

Statistics Canada. 2022. Census Program, Census of Population. Available: Census of Population (statcan.gc.ca)

Summers, K. 1993. Status Report of the White-throated Swift, Aeronautes saxatalis in British Columbia. B.C. Minist. Environ., Lands and Parks, Victoria. 18pp. Cited in BC CDC 2022b.

Thorley, J. L. 2008. Aquatic habitat losses and gains due to BC Hydro dams in the Columbia Basin. Prepared for: Fish & Wildlife Compensation Program – Columbia Basin, Nelson, BC.

Tomback, D.F. and K.C. Kendall. 2001. Biodiversity Losses: The Downward Spiral. Pages 243-262. In: Whitebark Pine Communities. Ecology and Restoration. Tomback, D.F., Arno, S.F., and Keane, R.E. (Editors). Island Press. Washington, D.C. Cited in Environment and Climate Change Canada 2017.

Village of Nakusp. 2021. Official Community Plan. Available: Nakusp Bylaw 697, 2021 - OCP Schedule A.pdf

Wikipedia 2022a. Revelstoke Dam. Available: Revelstoke Dam - Wikipedia.

Wikipedia. 2022b. Arrow Lakes. Available: Arrow Lakes - Wikipedia.

Personal Communications

Andreashuk, K. Senior Fisheries Guardian. Ktunaxa Nation Council, Lands and Resources Sector. Email communications in December 2021.

Arndt, J. Wildlife Biologist. Bank Swallow nest sites at Arrow Lakes. Email communications, November 2022.

Arndt, S. Fisheries Biologist, BC Ministry of Forests, Kootenay-Boundary Region, Nelson, BC. Email communications 2022.

Burrows, J. Senior Fish Biologist. BC Ministry of Forests, Kootenay-Boundary Region, Nelson, BC. Email communications, 2022.

Crossman, J. Vice President, B.C. Hydro, personal communication. Cited in DFO 2014.

Darvill, R. Goldeneye Ecological Services, Golden BC. Phone and email communications in January/February 2021.

Gatten, J. Personal communication. Cited in BC CDC 2022b.

Heagy, D. Area Supervisor, Arrow Area, BC Parks. Phone and email communications, January 2023.

Kuhnert, E. Biologist, Kootenay Community Bat Project. Email communications, November 2022.

Lausen, C. Director of Bat Conservation, Western Bat Conservation Program. Wildlife Conservation Society Canada. Email communications, November 2022.

MacDonald, Bruce. March 2023. Foreshore Integrated Management Planning Program Director, Living Lakes Canada; Terra Limnic Consulting.

MacLeod, K. Planning Coordinator, Regional District of East Kootenay. Discussion February 2022.

Neufeld, M. Section Head, Fish and Aquatic Habitat, BC MoF, Nelson. Email communication April 2023.

Rae, J. Biologist, Wildlife Conservation Society Canada (WSC), Email communications, November 2022.

Thompson, R. Arrow Lakes Environment Stewardship Society (ALESS) President. Phone and email communications 2022.

Wight, N. Planning Manager, Regional District of Central Kootenay. E-mail communications. December 2022.

Appendix A. Foreshore Inventory and Mapping GIS Map

Appendix B. FHSI and ZOS Maps

Appendix C. Foreshore Development Guide