2020

Slocan Valley Watershed Gap Analysis

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Prepared for Slocan River Streamkeepers

Updated Feb.2nd, 2020

Contents

Acknowledgements

This project was funded by the RDCK for which we are very grateful. Many people assisted with this document by sharing reports, participating in interviews and answering the questionnaire including: Jeff Burrows, Crystal Lawrence, Jeremy Baxter, Wendy Horan, Gregoire Lamoureux, Richard Johnson, Ryan Durand, Darcie Quamme, Rhia Mackenzie, Alan Thomson, Dahpne Fields, Jennifer Yeow, and Joel Russ. I truly appreciate the support from the community and admire the passion that exists to protect this beautiful place that many of us call home.

Introduction

In response to growing concerns about source water protection, the Regional District of Central Kootenay is taking steps to develop a stronger role in watershed governance and to support collaborative decision-making. A recent document released by the RDCK states that "Source watershed governance proposes an ecosystems based planning approach be taken that includes consideration for the land (tree and soil), water (surface and ground), air (quality), and risk (wildfire and flood hazards)". Ecosystem based conservation planning is a management strategy that as the first priority "maintains or restores natural ecological integrity — including biodiversity across the full range of spatial (from very large to very small areas) and temporal (from short to long periods of time) scales" (Silva Foundation, 2004).

In 2018 Slocan River Streamkeepers Society (SRSS) received a grant from the RDCK to create a document to inform, and provide recommendations, on ecosystem based management strategies to maintain the ecological and hydrological integrity of the watershed. This project has included two key steps; 1) a literature review, and 2) Interviews with the local scientists, members of Streamkeepers and local residents who have been involved with the studies and conservation efforts of the Slocan River.

For the purpose of this analysis, the study area includes the Slocan River from its outlet at Slocan Lake to the confluence with the Kootenay River. The river has been further broken down into six main sections for manageable inquiry, and to facilitate discussion, and can be found in Appendix A. Study area boundaries are illustrated in below in Figure 1.

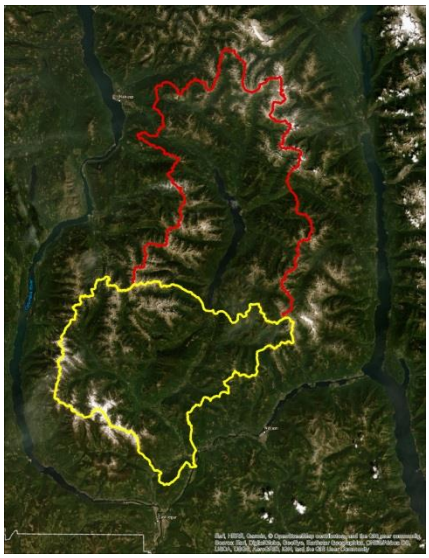


Figure 1. Slocan River Watershed Study Area Boundary, outlined in yellow.

Prior to European settlement, the Slocan River Valley was characterized by a large meandering river with mature Cottonwood and Western Redcedar riparian ecosystems, and was inhabited by the Lakes Nation who lived in harmony with nature and were able to live off the land within the oftentimes harsh climate. River velocity varied due to large woody debris, log jams and rock features, allowing for many different types of habitat. Abundant nutrients in the water from salmon carcasses along with vegetation and woody debris provided food for different species, including a variety of mammals, fish, invertebrates, amphibians, birds, bats and turtles. Piles of large logs provided aquatic habitat and, as they broke down, enriched the water. Large cottonwoods and cedars on the banks not only provided shade and habitat but also absorbed and stored large amounts of water and released it into the air through evapo-transpiration, in turn regulating understory microclimates and surrounding water at a cool, even temperature.

Figure 2. Functioning riparian area on Slocan River, south of Slocan Park, Sept. 2018

In order to set goals for conservation management, it is important to take a deeper look at how elements of the landscape have been altered by the pressures of development. In the Slocan Valley, there are several distinct events that shaped the ecosystems into what they are today:

- **Logging of Flood Plain Riparian Areas** resulted in the loss and fragmentation of habitat and also affected the water cycle of the river system. Clearing cedar and cottonwood, alters the flow regime, increases temperature, and creates bank erosion resulting in increased deposition. Cleared lands were then turned to pasture and used for farming which resulted in more sedimentation. However, additional nutrients are welcome because the river tends to be oligotrophic. In addition, the main river was heavily used to transport logs, resulting in erosion and impacts to aquatic life.

- **Mining** led to a sudden and abundant upsurge of human settlement and loss of habitat partially due to fire to facilitate exploration, and to the creation of tailing ponds where toxic metals were abandoned.

- **Railways and Roads** confined the river, reduced the meander, and altered side channels, resulting in increased erosion on the side of the river opposite the railways, and provided easy access for human use. Flood plains of river tributaries were restricted which created a barrier for the cold-water input from mountain runoff.

- **Construction of the Grand Coulee Dam** led to the extirpation of Chinook salmon from the Slocan and Little Slocan rivers, and the resulting loss of nitrogen and phosphorus from decaying salmon carcasses altered river nutrient dynamics.

- **Alteration of the Lemon Creek Channel** occurred in the late 1940's to preserve CP Rail Bridge. The creek was bermed and channelized to enter the Slocan at a site where the opposite bank was a bedrock wall. This created a constriction in the Slocan River, and altered habitat upstream and downstream of the confluence. The stretch of river upstream was essentially flooded and turned into a lake like ecosystem with an altered temperature regime. Immediately downstream, habitat was improved, however further along downstream where water velocity slows, sediment deposition occurred. This led to channel infilling and flooding.

- **Human Habitation and Agriculture** concentrated in the floodplain as well as upslope led to continued removal of riparian area trees, loss of wetland habitat and bank erosion. Bank stabilization measures, such as rip rap rock, altered erosion patterns. Eventually, sections of the river became channelized. Additionally, presence of livestock impacted water quality and fencing altered wildlife movement. Trapping, fishing and hunting of selected species (e.g., beaver, otter, and trout) also had a major impact.

- **Logging in Tributary Riparian Zones** increased sediment load flowing into the main river, affected water-temperature regimes and patterns of discharge.

- **Invasive Species** introduced into the watershed changed habitat to favor non-native species such as reed canarygrass *(Phalaris arundinacea)*, Didymo (*Didymosphenia geminate*), and bull frogs. Pikeminnow (a.k.a. squawfish) are native, however, populations have exploded because they are resilient to warm water and spawn in reservoirs.

One of the main things that sets the Slocan River watershed apart from most larger river systems in the province is the complete absence of hydroelectric development. This presents great opportunities for restoration and habitat enhancement projects, for scientific research as a control site, and as a conservation sanctuary for flora and fauna otherwise affected by hydroelectric development.

Additionally, a significant amount of research has been conducted in the Slocan Valley as part of compensation programs for development in neighboring valleys. This work can be used as baseline data to identify long-term trends caused by the present-day environmental challenges, such as climate

change. Due to a number of wetland and riparian restoration projects, there is a growing scientific knowledge base about wetland monitoring and species at risk, and there appears to be a growing awareness of the importance of ecological restoration and conservation and support for organizations such as the Streamkeepers, Slocan Lake Stewardship Society, Slocan Solutions, Perry Ridge Water Users Association, and Valhalla Wilderness Society.

A distinguishing characteristic of the river valley is the presence of prehistoric concentrations of pit dwellings in three locations along the Slocan River shown below in Figure 3. There are archaeological sites currently being studied at Slocan Narrows, Koch Creek, and Kootenay River, identified as being originally inhabited by the Lakes People.

Settlement in the Slocan Valley is mostly rural and 76% of residents obtain water directly from surface sources or wells beside the river (Streamkeepers, 2009). Water licenses are issued by the Ministry of Forests, Lands, Natural Resource Operations and Rural Development, and approval to divert and use surface and groundwater are guided by the *Water Sustainability Act* (WSA). Where the WSA covers the quantity of water that can be diverted, drinking water safety falls under the jurisdiction of Interior Health BC. Responsibility for water quality, safety, and flow defaults to residents with minimal enforcement and government controls; residents often have a strong sense of the inviolability of private land ownership and management.

In spite of the challenges, over time, the Slocan River Watershed has proved to be a resilient, unique and ecologically diverse area and remains an ideal candidate for conservation projects.

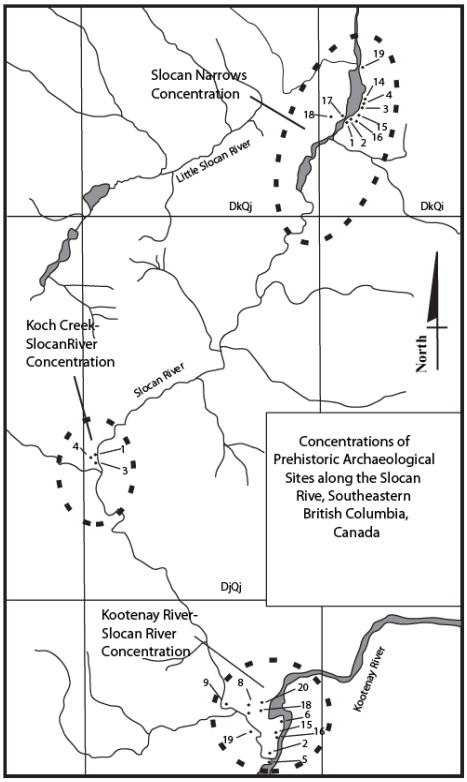


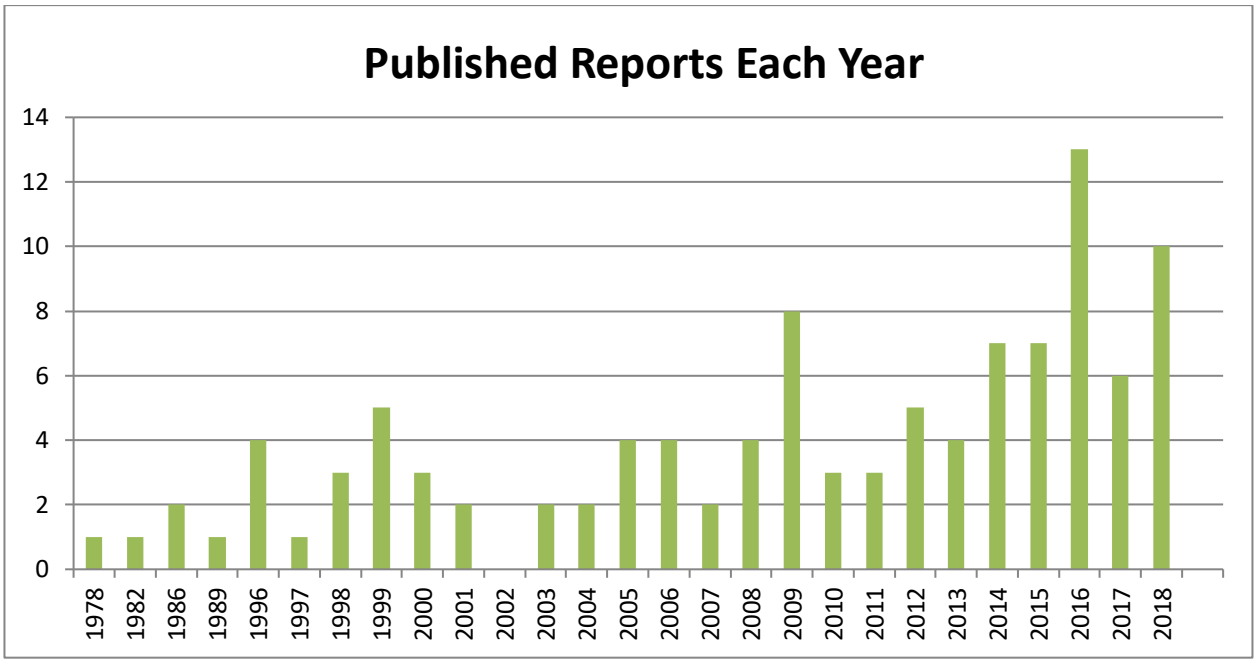
Figure 3. Map of Archaeological Sites. Goodale 2009

Literature Summary & Findings

Assessing and reporting on species of interest and ecological conditions in the Slocan River Valley has been carried out and reported fairly regularly since the early 1980s. There are currently over 100 reports that cover a broad scope of subjects, from floodplain mapping to fish population assessments, to species at risk, and wetlands. This document is intended to summarize existing work, thereby providing guidance for management strategies aimed at preserving and enhancing ecological and hydrological integrity of the river.

Reports were gathered and reviewed from the World Wide Web, personal files, local consultants, and members of Streamkeepers, as well as from industry including Columbia Power Corporation. A total of 105 reports were reviewed dating back to 1978. There are likely many more reports in print from the 1980s and '90s that are not available online. Once the reports were consolidated, they were sorted and saved by subject. All reports have been entered into a database, with a link to where they can be found online, where applicable. This spreadsheet is currently being stored by the Slocan River Streamkeepers and is available upon request.

During the process of gathering reports, the need for a centralized data housing and retrieval system for the Slocan River Watershed became apparent. At the time of publication, we are developing a system in partnership with Selkirk College.



Overview, Climate & Hydrology

The climate in the Slocan River Valley is continental with warm summers and cold winters, and a wide variety of local climates. It is a result of the complex interaction of the rugged topography of the Cordillera and weather systems prevailing from the west. There are three Provincial Parks located within the watershed boundaries: Valhalla to the west, Goat Range to the north and a small part of Kokanee Glacier to the east.

The Slocan River is fed by outflows of Slocan Lake at an elevation 535 meters. It is a free-flowing river that is unregulated by hydroelectric development. However, high flows downstream of Lemon Creek are constrained due to a bar at the confluence of Lemon Creek and the Slocan River (Miller, 2005). Extensive historic flow records exist for the Slocan, dating back to 1916. Water Survey Canada stream flow gauging and/or high and low flow data exist for tributaries including Lemon, Christian, Jerome, Mcfayden, and Elliot Creeks. In addition, community monitoring was done on Airy, Winlaw, and Wolverton Creeks. A geomorphologic assessment was completed in 2005 for the Ministry of Transportation.

Detailed information about Slocan River hydrology and geomorphology can be found in the 2005 *Geomorphic Assessment of Slocan River* by Sitkum Consultants available on request

The Slocan River watershed can be divided into three broad ecosystem types: forest, floodplain (wetlands & riparian), and freshwater aquatic.

Forests

The forest ecosystems in the lower Slocan River watershed are characterized by steep broken terrain and narrow valleys. Ecologically, the area is a transition zone between wet areas to the north and dry areas to the east, west and south, resulting in mixed-tree-species forests. Depending on aspect and elevation, forests are dominated by mixed stands of Engelmann spruce and subalpine fir, western red cedar, western hemlock, whitebark pine, ponderosa pine, and Douglas fir. Prior to settlement large western red cedar and western hemlock stands dominated the main Slocan River riparian ecosystem. Similar stands of riparian ecosystems existed in large tributaries to the Slocan river but have been extirpated due to extensive logging (Silva, 1996).

Floodplains and Wetlands

Currently, remaining riparian areas are a mix of Black cottonwood stands, young conifers and other deciduous shrubs.

Riparian and wetland habitats in the Slocan Valley are among the few low-elevation floodplain systems remaining in the West Kootenay (CBWRAP, 2014). In a 2014 report called *The Columbia Basin Riparian and Wetlands Action Plan* prepared by FWCP stated that "In general, the remaining wetland and floodplain habitats in this focal area [Slocan] are in fair condition, maintained by a natural hydrograph and that wetlands in this system are to some degree less productive due to the lack of nutrients and sediment in the system" (FWCP, 2014). The benefits of wetlands and riparian areas are widely accepted by the scientific community and include water and carbon storage, microclimate moderation, flood control, bank stabilization and erosion control, and provide habitat for wildlife.

An excerpt from a 2004 *Amphibian Survey for the Columbia Forest District* is helpful to highlight the importance of wetlands in the Columbia Basin (Dulisse et al. 2010):

"Machmer (2004) estimates that 175 vertebrate wildlife species in the Columbia Basin are associated with wetlands and 97 of these species depend on wetlands for survival. Small wetlands as seen in the Slocan Valley are particularly important to amphibians because they often lack fish that prey on amphibian larvae. Many of these wetlands are not known to local land managers, biologists and naturalists and they receive little management attention. Although small wetlands are integral to the ecological integrity of our region, there is a general lack of binding legislation protecting this habitat. Sampling small wetlands is key to mid-level amphibian monitoring because they are more common on the landscape and often contain greater amphibian species richness than larger wetlands."

The Slocan Wetland Assessment and Monitoring Program (SWAMP) was created to assess the abundance, distribution, and ecological integrity and function of wetlands and riparian habitat throughout the Slocan watershed" (Durand, 2016). A total of 150 wetlands were inventoried from 2013 to 2015 and includes information about site conditions. In 2018 detailed mapping of wetlands in the Bonanza Creek watershed was performed.

Prior to SWAMP's initiation, the Slocan River Streamkeepers Society had commissioned two studies, an *Aquatic Habitat Inventory* (AHI) of the Slocan River and a *Sensitive Ecosystem Inventory* (SEI) of the offsetting riparian areas. SEI and AHI have been merged into one map for SWAMP.

SWAMP also spawned a series of projects that continue. Developing protocols to use benthic invertebrates to measure wetland health is an ongoing research project by Integrated Ecological Research (Darcie Quamme), under the SWAMP collaborative. It incorporates innovative methods specifically designed to assess and establish baseline data for wetlands.

Two acoustic recording units (ARU's) have been acquired and are managed by the Slocan Lake Research Centre. They record bird and frog vocalizations and have been deployed at various wetlands to document the "singers" each spring. This baseline data gathering will continue, especially in the wetland restoration projects.

Riparian area restoration on the Slocan River was a component of the Brilliant Expansion Compensation Program to enhance Rainbow Trout habitat. In collaboration with the Slocan River

Streamkeepers, projects were implemented on private land, the equivalent of six linear kilometers. Success of riparian restoration projects in Slocan has been mixed with roughly 50% survival rate of trees planted (Corbett, 2012) mainly due to environmental variables, foraging wildlife and rigorous maintenance requirements. Specific recommendations regarding sampling protocols were made in *Slocan River Rainbow Trout Habitat Enhancement and Slocan River Riparian Restoration Program Interim Program Evaluation* 2015 (Amec, 2016) and are attached to this document as Appendix B.

Further information about wetland and riparian areas in the Slocan can be found on the Slocan River Streamkeepers website:
https://slocanriverstreamkeepers.wordpress.com/

in *The Columbia Basin Riparian and Wetlands Action Plan* found here:
http://fwcp.ca/app/uploads/2015/07/fwcp-columbia-riparian-wetland-action-plan.pdf

and in the *SWAMP 2018 Work Consolidation and Status Report* found here:
https://slocanriverstreamkeepers.wordpress.com/swamp/
https://slocanswamp.org/

Sensitive Ecosystems

A Sensitive Ecosystems Inventory (SEI) of the Slocan Valley was conducted by Ryan Durand in 2013. The main purpose of SEI is to map the ecological diversity of a given area, and to identify and quantify at risk and uncommon elements within it. This report describes the type and extent of ecosystems in the Slocan Valley and was used to develop regionally specific sensitive ecosystem classes and subclasses. A total of 3,019 polygons were mapped for the project, encompassing 10,963 hectares. The most commonly mapped ecosystem types were:

- not sensitive (24.8%, 2,716.9 ha)
- young conifer forests (15.8%, 1,728.8 ha)
- mature conifer forests (15.3%, 1,678.9 ha)

Not Sensitive classes accounted for 56.9% (6,212.7 ha) of the study area, whereas Sensitive Ecosystems encompassed 22.9% (2,495.8 ha), and other Important Ecosystems was 20.6% (2,254.5 ha).

Detailed information about Slocan River watershed characteristics can be found in *An Ecosystem-Based Landscape Plan for the Slocan River Watershed* by Silva Forest Foundation here:
http://www.silvafor.org/assets/silva/PDF/Plans/SVPlanFull1996toWebSepta2009.pdf

Maps and further information about Sensitive Ecosystem Mapping and can be found in the *Preliminary Slocan River Sensitive Ecosystems Inventory* by Ryan Durand here:
https://slocanriverstreamkeepers.wordpress.com/reports/

Fresh Water Aquatic

The freshwater ecosystems of the Slocan River Watershed are home to a diversity of species. It is characterized by variable temperatures, and low nutrient levels (Miller, 2005).

Water temperature in Slocan River may be considerably warmer than others in the region because it begins at the outflow of Slocan Lake and then flows through a wide shallow area for approximately 5 kilometres (Arndt, 1999). Temperature data has been collected periodically by Environment Canada between 1949 and 1976 and by community groups on several creeks in the watershed since 1994. Temperatures on the main river are on average around 14^0 C and have been recorded as high as 24^0C (Shaw, 2013). Increasing water temperature is of particular concern due to its potential negative impact on juvenile fish (Arndt, 1999; Oliver, 2001; and Corbett, 2006) and water quality (Winlaw Watershed Committee, 2003).

Up until the construction of the Coulee Dam in 1936, spawning salmon contributed to nutrient balance in this area. Oliver (1998) estimates that the "spawning run of Chinook salmon into the Slocan and Little Slocan Rivers was between 9,000 and 18,000 fish per year, the loss of nitrogen and phosphorus from decaying salmon carcasses to whole-river nutrient dynamics was likely considerable". Since the bedrock formations of Slocan River watershed lie in the granitic Nelson Batholith, silica is the predominant mineral. Silica has low solubility in water therefore many of the Slocan River tributary streams have low conductivity/mineral hardness.

Though there have been some exceedances in phosphorous levels, a report submitted by Lotic (2012) states that "over all there are few parameters of concern identified". It is uncertain if the water and sediment quality exceedances found in the Slocan River watershed were indicative of naturally high levels in the watershed or anthropogenic sources (Shaw, 2013).

Further information about Slocan River water quality can be found in the
Slocan River and Area Water Quality Monitoring Report 2005-2013
by the Streamkeepers and can be found here:

https://slocanriverstreamkeepers.wordpress.com/reports/

Important Tributaries

Tributaries in the watershed serve many functions including sediment and nutrient transportation, cold-water inputs, fish and wildlife habitat, and community drinking water. The contributing drainage area of the Slocan River at Slocan City is 1,660 km^2 and 3,320 km^2 at Crescent Valley near the downstream limit of the study area (Miller, 2005). Lesser streams that are small and well shaded can supply up to three quarters of the nutrients in a river system (Kipp, 2002), and help to keep the main

stem cool. Although all tributaries are important to the integrity of the watershed, there are a few of concern.

1. Lemon Creek is important for multiple reasons. It is an important source of cold-water into the Slocan River and serves as cold-water refuge for fish in the warm seasons. It is prime habitat for Bull and Rainbow trout. By constricting the mouth of the river for the CP Rail Bridge, discharge patterns above and below the confluence were altered permanently. Fish assessments conducted by Peter Corbett throughout the early 2000s show that the section of habitat downstream of Lemon Creek is the most productive reach for fish in the Slocan River. It is also culturally significant because of the Bull trout population and because of concentration of pit houses historically inhabited by indigenous peoples. Despite a JET-A fuel spill in 2012, fish and invertebrate populations are still intact, and water quality has recovered.

2. Winlaw Creek id an important source of water for residents, farms and businesses. There are also documented fish populations within the lower reaches, and spawning occurs at the confluence with the Slocan River. Studies conducted by the Winlaw Watershed Committee in 2003 show that water temperatures remain low making the creek a significant cold-water refuge for fish and input into the mainstem. Water quality data was collected from 1996 to 2003 and can be used today to monitor for any changes that have occurred, or to identify long-term trends.

3. Little Slocan River flows into the Slocan River one kilometer north of Passmore. The headwaters of this system are a complex of lakes and wetlands that provides important habitat for several species at risk. There is high quality salmon spawning habitat throughout, however there was no evidence of Bull Trout spawning in 2018. Rainbow Trout spawning was not evaluated in 2018 (pers. comms, Lawrence, 2109). The Little Slocan River watershed is operated under Tree Farm License # 3 and has been subject to heavy deforestation since the 1950's. Since 1997, numerous landslides have occurred in the floodplain that have altered the landscape, water quality, aquatic habitat and pose a threat to landowners living next to the river.

Fish

The Slocan River and its tributaries provide habitat for both resident and migratory fish populations from the Kootenay River, and serves as a major migratory corridor connecting the Kootenay River to north of Slocan Lake (Miller, 2005). The fish population has been well documented from 1996 to 2016. It is diverse and includes both blue- and red-listed species. Fish are known to utilize the mainstem as well as tributaries that provide excellent rearing habitat (Corbett, 2006). Inventories were conducted in 1996 and in 2006 and provide baseline information of about fish presence in selected tributaries within the watershed.

The Slocan River watershed supports a diversity of fish species. However, the majority of studies focus on Rainbow trout. They are an important indicator of ecosystem health because they require cold, clear water to thrive. For example, maximum summer water temperatures in Slocan River exceed optimum conditions of 16-18^{o}C for rearing (Oliver and Fidler, 2001). They are also important because so many other species in the food chain depend on them, and because of their high value for fisheries. For those reasons, the Slocan River Streamkeepers, in partnership with Peter Corbett, identified spawning productivity of Rainbow trout as "a reasonable measurement of ecosystem health and therefore a valuable biological variable to monitor over time"(Corbett, 2005) and began a long term monitoring program of a variety of environmental and biological processes in the river to serve as a baseline from which to monitor ecological change.

Figure 4 Slocan River Rainbow Trout photo credit: Tyson Ehlers)

Early reports on Rainbow trout populations indicate that Slocan River rainbow trout stocks were not near their "productive potential" (Miller, 2005). The discussion section of the 2016 Amec report suggests that Rainbow Trout populations may be limited by a lack of habitat complexity and cover in some reaches, thermal stress on life history stages other than sub-adult/adult, limited spawning habitat, limited temperature refugia, poaching and other angling practices. Floodplains in the valley have been modified by humans to build roads and railways and for agriculture resulting in the loss of off-channel habitats that are critical to the life cycle of salmonids, including Rainbow trout. According to Peter Corbett in his 2010 *Assessment of Side Channels* the "side channels in particular provide a variety of functions for Rainbow trout", and that "re-establishing water flows into closed off channels not only creates preferred trout habitat but also increases the biological productivity of the river by increasing invertebrate biomass, the primary food source for trout".

Beginning in 2005, Columbia Power Corporation committed to the Slocan River Rainbow trout Habitat Program, designed to "provide suitable compensation for fish entrainment that may have occurred as part of the regular hydroelectric operations of the Brilliant Expansion facility" (Amec, 2016), and included both an instream and riparian restoration component. At that time, baseline and long-term monitoring programs were implemented that focused on fish abundance at installed instream habitat structures. These structures were placed in larger reaches of the river. The Habitat Program also focused on the success of riparian planting along the shoreline. Results of these studies show that "riparian restoration projects that involve an instream habitat component appear to be most effective and side channel enhancement projects may provide beneficial habitat to various age classes of Rainbow trout" (Amec, 2016).

Studies on Rainbow trout populations have shown that densities vary from year to year. A notable decline in abundance was observed at the reach level in 2014 and 2015 compared to 2013 (Amec, 2016). However, compared to the 1990's, population numbers have improved dramatically. Overall there has been a gradual increase in Rainbow trout density through time in all reaches, with the highest density of Rainbow trout through time consistently at Lemon Creek (Amec, 2016). The most recent fish analysis was submitted in 2015 and another is anticipated to go along with new instream habitat installations as part of Columbia Power Corporation's on-going compensation efforts to meet fish enhancement targets. In addition, Rainbow trout spawning surveys were conducted between 2003 and 2009 and are useful tool for monitoring trout populations; however, Crystal Lawrence points out that documentation of adult spawning is limited to below the outlet of Slocan Lake (Corbett, 2006), in three side channels (Corbett, 2011) and in the mainstem near Winlaw and Slocan Park (Oliver, 2001). She goes on to suggests that "replicating these surveys could provide additional insight and may add clarity to the uncertainty in estimates of the adult spawning population" (Amec, 2016). Specific recommendations regarding sampling protocol were made in the *Slocan River Rainbow Trout Habitat Enhancement and Slocan River Riparian Restoration Program Interim Program Evaluation 2015* and are attached to this document as Appendix B.

More recently, data about other significant blue- and red-listed species of fish present in the Slocan River and its tributaries have been collected. Bull trout are a culturally significant species and are provincially blue-listed. Bull trout spawning assessments of Lemon Creek in 2018 identified the key spawning areas in the upper reaches (pers. comms, Baxter, 2019). In the most recent study done in 2018, no Bull trout were found in the Little Slocan River despite the presence of high-quality spawning habitat (pers. comms, Lawrence, 2019), and further studies are required to determine why. Umatilla dace and blue-listed Short-head sculpin are important feeder fish that have also been identified in the Slocan River. For both species, further evaluation is required.

Invertebrates

Terrestrial and benthic invertebrates are an important part of functioning ecosystems. They are food for fish, birds, amphibians and reptiles and are good indicators of ecosystem health because they are sensitive to changes in sediment load, pollutants and pH. Monitoring of benthic invertebrates has been going on in the Slocan River region since 2005 (Lotic, 2012). Several sites in the Slocan River showed that invertebrate populations were stressed, severely stressed or potentially stressed, however assessments were performed on 1-2 years of sampling and therefore only provide a "snapshot of the benthic community" (Lotic, 2012), highlighting the need for continued monitoring.

Fluctuations in invertebrate population abundance can also point to changes or problems in populations of other species. For example, an increase in mosquito population can be an indication of a decrease in bird, bat and amphibian populations. Also, in a 2008 report by the Streamkeepers, population trends for Rainbow trout were found to follow trends for key invertebrate species including Mayflies, Stoneflies and Caddisflies and water temperature. However, further studies are required to

make definitive conclusions. There are at least four species of listed invertebrates in the Slocan River valley, with the potential for additional at-risk species to occur.

Birds, bats, amphibians and reptiles

Birds, bats, amphibians and reptiles also play important roles in the ecosystem by transporting and dispersing seeds, eating insects (thereby moderating insect populations), and because they are food for animals higher in the food chain. Many depend on riparian and wetland habitat, and the lower Slocan River floodplain is likely very important as nesting habitat and stop-over sites for migrating songbirds and other migrants. There are observations of seventeen listed species at risk including twelve birds, one bat, three reptiles and one amphibian, documented in the 2013 species at risk report. Though there have been some studies about birds, bats, amphibians and reptiles in the Slocan valley there is still very little information regarding their abundance.

Mammals

Many mammalian species, including species at risk such as Woodland caribou, Grizzly bear, Mountain goat, and Wolverine, are known to occur in the valley but there is limited information on abundance, specific habitat use, and movement corridors. Anecdotal evidence supports existence of deer and elk populations, mountain lions and bobcats.

Species at Risk

In total, over forty species at risk were confirmed in the Slocan Watershed (Durand et al. 2017). Of those, there are twenty-four vertebrate animals, three reptiles, one amphibian, five invertebrates, ten vascular plants, and four non-vascular plants. Only one species is known to have been extirpated: the Columbia River variant of Chinook salmon (Oliver 1998). *The Columbia Basin Species at Risk Action Plan* from 2012 identified three recovery species (Lewis' woodpecker, Western Screech owl, and Mountain caribou). Durand recommends "that a series of specific surveys be carried out in the watershed to complement previous studies (such as those completed for the Western skink, Lewis woodpecker, and the extensive fish inventory work). These studies would be completed by experts in the field and focus on under-inventoried areas, namely vascular and non-vascular plants, amphibians and invertebrates.

Further information about Species-at-Risk including status ratings and confirmed species can be found in the *Species at Risk in the Slocan River Watershed* report by Ryan Durand here:
https://slocanriverstreamkeepers.wordpress.com/reports/

and in the *Columbia Basin Species of interest Action Plan* found here:
https://www.bchydro.com/content/dam/hydro/medialib/internet/documents/about/our_commitment/fwcp/columbia_SpeciesofInterest_ActionPlan_2012_jun.pdf

Risks & Threats

There are many risks and threats facing the ecological integrity of the Slocan River watershed that should be considered when developing mitigative strategies or conservation projects. *It is interesting to note that many of the threats have not changed since the arrival the European settlers but, rather, have been intensified by the impacts of climate change.*

For this region, impacts of climate change are predicted to be (Columbia Basin Trust, n.d.):

- Warmer winter, nighttime and summer temperatures
- Increasing glacial melt (loss of cold-water reservoirs)
- Less winter snowpack at low elevations
- Changing stream flow patterns, earlier spring peak flows, lower summer flows
- Wetter conditions with high variability

Outcomes of these changes are expected to be increased water temperature, higher risk of flooding during freshet with extreme precipitation events in between, increased fire hazard, landslides, water shortages, and ultimately the loss of sensitive habitats and biodiversity (Taylor et al. n.d.). These factors, coupled with cumulative effects of loss, fragmentation, and degradation of habitat caused by human impacts have serious implications.

Rising Water Temperatures

Rising water temperatures in the Slocan River watershed threaten both fish populations and water quality. Based on literature, interviews with scientists and results from the questionnaire, this is possibly the most imminent threat associated with climate change. Daily mean temperatures have been found to be higher than 20°C for extended periods of time as illustrated in Figure 5, reaching temperatures as high as 24°C, a temperature well above optimum rearing values for juvenile trout (Arndt, 2000). Stream temperature is likely the major reason for the lack of Bull trout in the Little Slocan River (Irvine and Baxter, 2019). A study of water temperature in relation to juvenile Rainbow Trout is needed to evaluate the effects of above

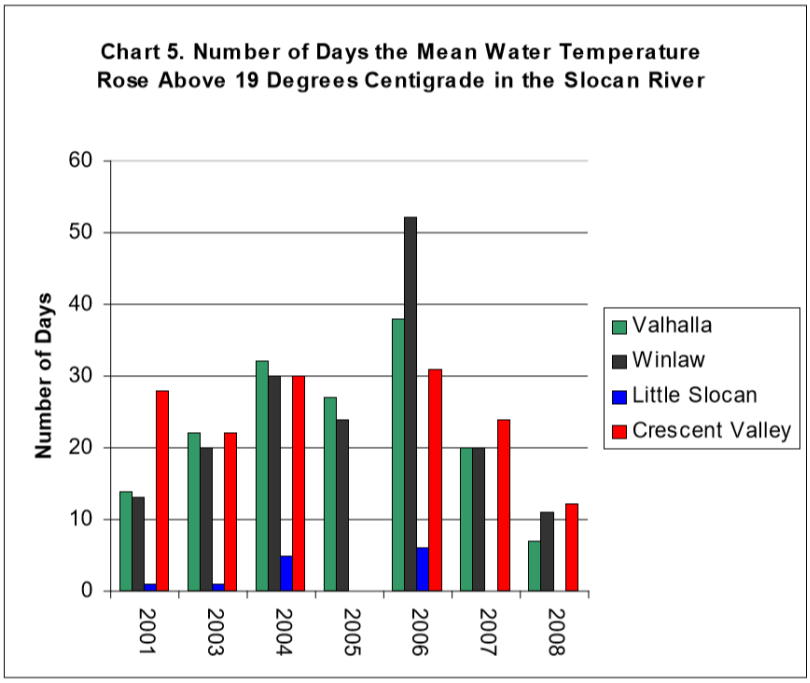


Figure 5 Excerpt from Slocan River Monitoring Report 2008

optimal thermal conditions on the population (Amec, 2016). Higher temperatures also encourage the growth of unfavorable algae and bacteria (Taylor *et al.*, n.d.), resulting in decreased water quality.

There are many contributing factors to rising water temperatures, such as continued loss of wetland and riparian areas in the floodplain for agriculture and residential development, logging of old growth in headwaters and riparian areas of tributaries, residential water use (reducing overall volume of cold-water inputs), and climate change.

Logging in Watersheds

In our area, forest industries utilizing Crown Lands have traditionally been main sources of employment for residents of the valley. Conventional industrial forest practises, as well as private-land clearing and timber harvesting, often result in negative impacts on terrestrial and aquatic ecosystems. The adverse impacts of forest harvest practices on water quality, fisheries and aquatic resources occur over long periods of time and space and are difficult to document or pinpoint to an exact location or occurrence (Silva, 1996). The impacts of logging on waterways is described in *Fish Habitat Assessment Procedures* prepared for the Ministry of Forests (Johnston *et al*., 1996) as:

- **Increased rate of sediment generation and delivery to the stream network**. Silt enters surface water, which reduces the productivity of the aquatic ecosystem by causing damaging changes to the physical structure of the stream channel, as well as through direct physiological effects on the biota.
- **Altered volume and timing of flows** due to clearcut logging a high elevation and for construction of road networks
- **Removal of the natural riparian vegetation and its replacement by vegetation with very different stand characteristics**, both of which may impair the functional role of the riparian zone.

Logging throughout the Slocan River watershed has drastically altered forest ecosystem composition and structure and has resulted in fragmentation, loss of old growth, and soil degradation (Silva, 1996). The most significant habitat degradation due to clear cutting has been of the riparian forests of the Slocan River floodplain, in the Lemon Creek drainage, and in the Little Slocan River drainage within the boundaries of Tree Farm License #3.

Timber harvesting continues today and continues to contribute to the loss, fragmentation and degradation of habitat in the Slocan River watershed. *An Ecosystem-Based Landscape Plan for the Slocan River Watershed* was developed by Silva Forest Foundation and provides the framework for sustainable forest harvesting in the valley.

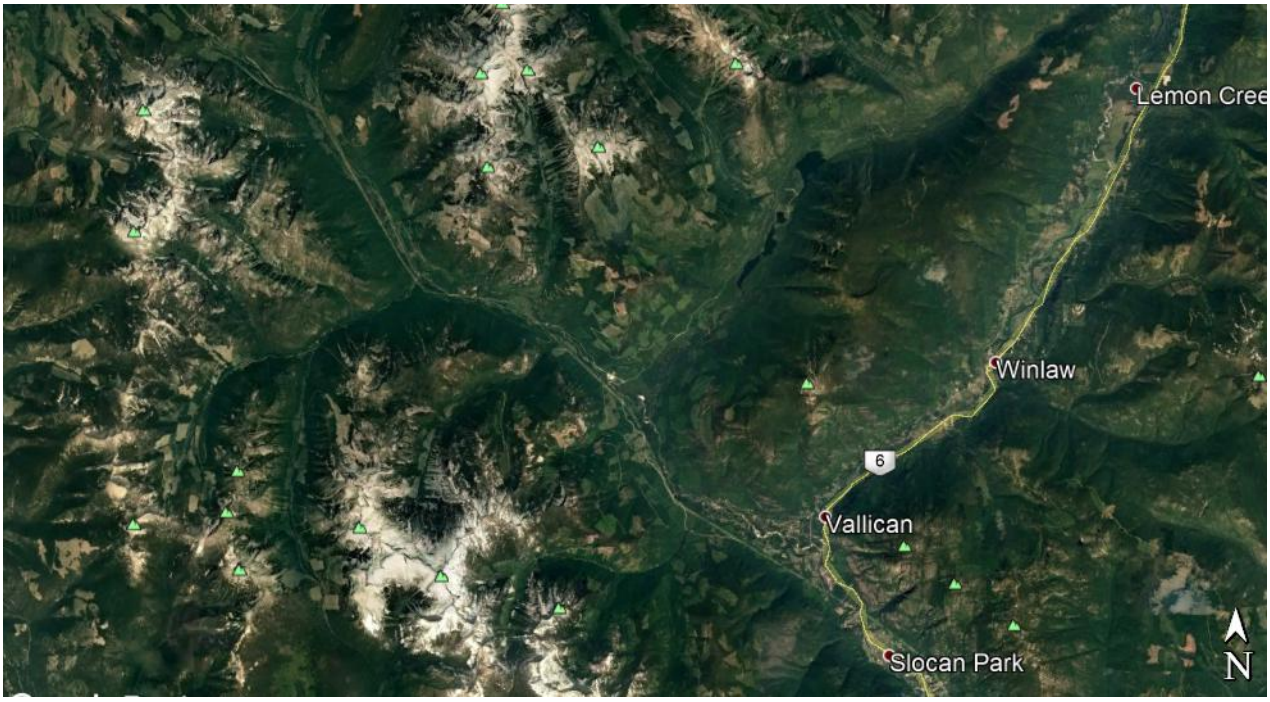


Figure 4 Satellite image showing cut blocks in TFL # 3

An Ecosystem-Based Landscape Plan for the Slocan River Watershed by Silva Forest Foundation can be found here:

http://www.silvafor.org/assets/silva/PDF/Plans/SVPlanFull1996toWebSepta2009.pdf

Water Shortages

As glaciers continue to recede and freezing levels rise, the effects of climate change will have a direct impact on water supply and water quality (Taylor et al, n.d.). Higher temperatures and decreased summer precipitation will cause prolonged and intense droughts that threaten water supply in small streams during periods of peak demand. Groundwater sources will also be affected if recharge rates decline.

Residential Development & Agriculture

Agriculture has been a part of the Slocan Valley landscape ever since Europeans first came to the area in the late nineteenth century. Clearing of riparian and wetlands areas for grazing has resulted in loss of habitat. Cattle grazing is known to have many adverse impacts on landscapes, such as soil compaction, proliferation of invasive species, and water pollution. In fact, large livestock can exert up

to ten times weight per unit area as a full-size bulldozer (Kipp, 2002). Today, subsistence and organic farming, which have less impact, are an important part of the Slocan Valley lifestyle.

Invasive Species

Invasive plants are often extremely vigorous and hard to control, and their presence often indicates a disturbance. The major threat posed by invasive plants is the loss of biodiversity and the eradication of native species. There are several invasive species occurring in the Slocan Valley, as identified by the Central Kootenay Invasive Species Society (CKISS). Species of growing concern are bull frogs that occur in neighboring regions, and other aquatic species that thrive in warm water like Didymo (*Didymosphenia geminate*) that is still fairly uncommon. Reed canarygrass *(Phalaris arundinacea)* is a well-established species that carpets a large area of the Slocan Valley floodplain and riparian areas. It was likely introduced in the Arrow region to control erosion when the Dams were built or for agricultural use. It is a prolific plant that is hard to eradicate, although some success has been achieved locally by replanting constructed wetlands with native species. There are dedicated societies, such as CKISS, that have developed best management practices for control or eradication of invasive species, and are government funded.

Landslides & Erosion

Landslides are events that can be caused by natural and anthropogenic factors such as precipitation, wildfires, erosion, clear cutting and mining. While landslides are hard to predict, key geomorphological features are warning signals for their occurrence. Stabilization efforts are costly and there is no guarantee that slopes won't continue to fail.

In the Slocan Valley, steep topography and narrow, rapidly eroding valley bottoms coupled with coarse textured, frequently well-drained, and highly variable soils (Silva, 1996), landslides will be a regular occurrence. There have been several catastrophic events that have led to property loss and damage to fish and aquatic habitats. Areas of particular concern are the Little Slocan Valley and Perry's Ridge where topography and inappropriate logging have taken place. Higher winter streamflows and increased precipitation caused by climate change are predicted to increase the risk of landslides (Taylor et al, n.d.).

Further information about Landslides and for Hydrologic Assessments of Perry's Ridge can be found on the Perry Ridge Water Users Association website at:

http://www.perryridge.org/

Tourism and Recreation

Tourism and recreation are an important part of the valley's economy. Recreation is also an important dimension of the quality of life for residents. Opportunities for both self-propelled and mechanized recreation and tourism that span all seasons in the valley are abundant. Boating on Slocan Lake is a

popular weekend activity and growing popularity of outdoor recreation pursuits such as backcountry skiing and snowmobiling, mountain biking, hiking and hunting are leading people further and further into the wilderness. The major impacts of increased tourism and recreational use are related to pollution caused by human refuse, littering and burning of fossil fuels, spread of invasive species, loss of habitat, and displacement due to increased human-wildlife interactions and expanding tenures.

Roads and Railways (incl. Rail to Trail)

Though the construction of new roads and railways along the Slocan River is not likely, existing corridors continue to present challenges to the ecological integrity of the river ecosystem because they act as barriers to wildlife, water and nutrients. Also, in multiple locations they've been constructed through riparian areas, reducing the options for riparian-area restorations. Today, the old rail bed has been transformed into the Rail to Trail - a high value multi-use trail that links the entire valley.

Wildfires

Wildfires have been naturally occurring throughout history and are in some instances necessary for forests to function at their full potential. However, as temperatures rise and summer moisture inputs decrease, it is predicted that wildfires will occur at more catastrophic levels that will degrade soil and water resources and negatively impact forest structure, composition and function (SIFCo, 2019).

Hydroelectric Development

The major impact of hydro development in this region is the loss of salmon due to the construction of Grand Coulee Dam, which has caused a decrease in nutrient inputs to ground and surface water, resulting in a less productive system in contrast to their historic condition (FWCP, 2014). There is currently no hydroelectric development within the entire Slocan Valley watershed, although some independent power projects are currently proposed.

Mining

Even though the amount of mining taking place in the area has drastically diminished, tailing ponds dispersed through the landscape. Depending on what has been mined and the minerals disturbed by the act of mining, tailing ponds can contaminate water by leeching heavy metals into water and in extreme cases can continue to threaten water quality today.

Research Gaps & Questionnaire

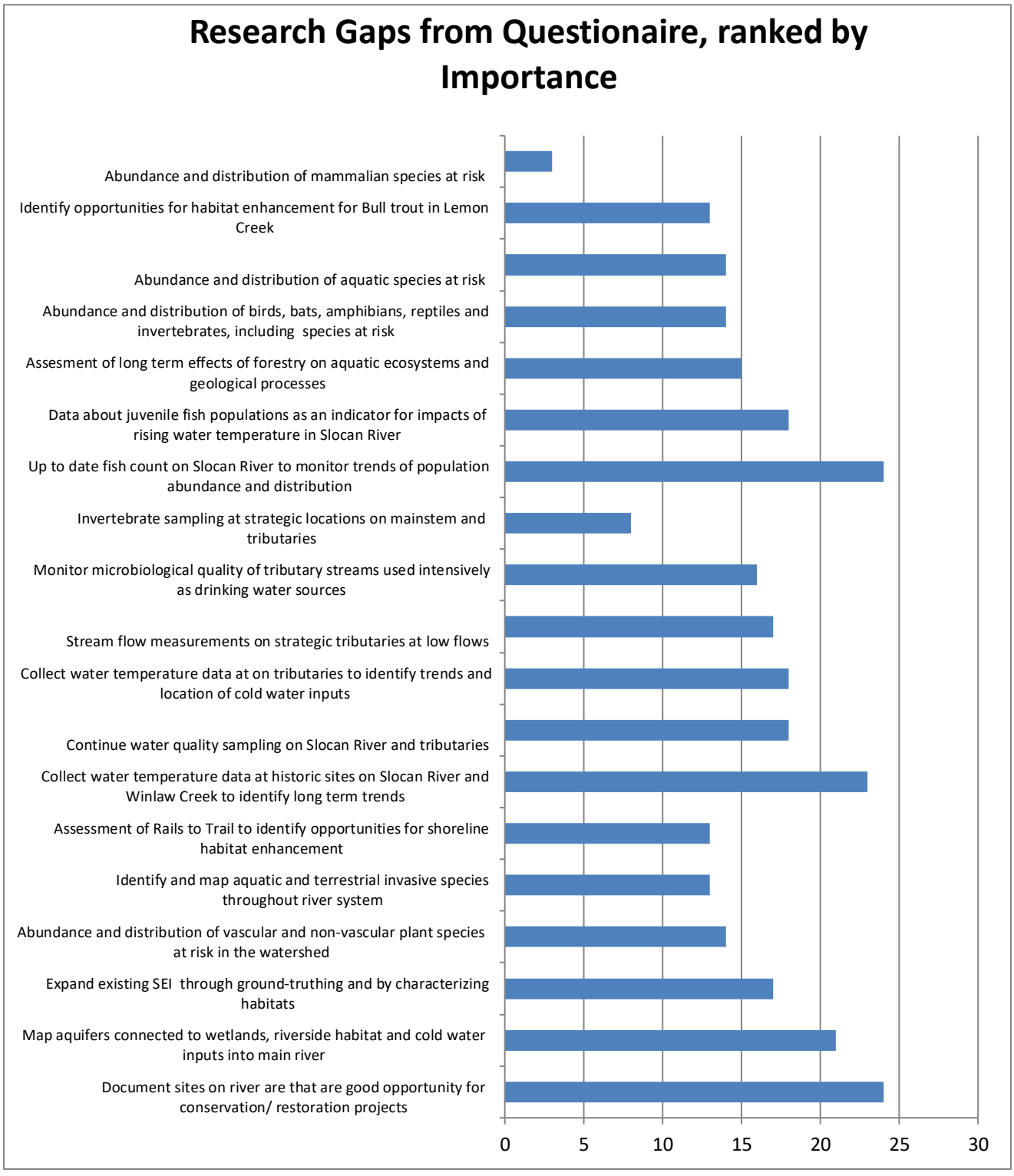
Research gaps were identified through a literature review of 105 reports dating back to 1994, as well as interviews with Jeff Burrows (of the Ministry of Fish and Wildlife), Crystal Lawrence (a local biologist and consultant at Amec), Jeremy Baxter (a local biologist and owner of Mountain Water Research), and Jennifer Yeow (microbiologist and owner of Passmore Laboratory). A questionnaire was also developed and sent out to additional local experts, scientists, and residents. The table below summarizes areas that require more attention and identifies whether a gap in knowledge is, a recommendation for action, or both:

Hydrology:	**Gap, Recommendation, or Both**
Collect current stream flow gauging data at historic sites to identify trends or changes in hydrological patterns.	Both
An up to date geomorphological assessment to follow up on recommendations made in 2005 and to see how the river has changed	Both
Ecosystems:	
Continue to locate and map small and ephemeral wetlands	Both
Ongoing assessments and stewardship of mapped wetlands at regular intervals	Recommendation
Meet with landowners throughout the valley to field verify and characterize habitat to further refine the SEI map product and improve accuracy	Recommendation
Work with the Conservation Data Centre to further refine criteria for the determination of sensitive ecosystems	Both
An assessment of the Rail to Trail to identify locations for culvert installations to restore the eastern shoreline habitat and maintain condition of the trail.	Recommendation
Water Quality and Temperature:	
Collect water temperature data at historic and strategic sites to identify any long term trends or changes to temperature regime and to identify cold-water inputs	Recommendation
Collect water quality data at historic and strategic sites to identify any long term trends or changes in water quality that includes periodic heavy metal testing	Both
Fish:	

Document additional spawning areas in the Slocan area and replicate historic surveys to provide additional insight and add clarity to the uncertainty in estimates of the adult spawning population	Gap
Studies about the abundance and distribution of Umatilla dace and short head sculpin	Gap
Up to date fish count of the main river at the reach level to replicate historic surveys and to monitor trends of population abundance and distribution	Gap
Study of water temperature in relation to juvenile fish to evaluate the effects of increasing water temperature due to climate change	Recommendation
Map sites on river are that are good opportunity for conservation/ restoration projects (eg. downstream of Lemon Creek)	Recommendation
Continued monitoring of Lemon Creek to document its value for fish and wildlife and to properly manage logging practices and protect sensitive species from development pressure.	Both
Studies regarding the effects of extensive logging on fish habitat on the Little Slocan River watershed	Recommendation
Studies to assess absence of Bull trout in the Little Slocan River despite the presence of high quality spawning habitat	Both
Invertebrates:	
Additional benthic invertebrate sampling at historic sites to get reliable baseline data and strengthen the understanding of the benthic community, especially in mountain, disturbed, challenged and newly created wetlands.	Both
Further studies to examine correlation between population trends for Rainbow trout, key invertebrate species including Mayflies, Stoneflies and Caddis flies, and water temperature	Gap
Plants and Wildlife:	
Additional inventories/surveys about birds, bats, amphibians and reptiles in the Slocan Valley	Recommendation
Inventories/surveys of mammals in the Slocan River watershed	Gap
Species at Risk	
Studies that focus on under-inventoried areas, namely vascular and non-vascular plants, amphibians and invertebrates, and complement previous studies (such as those completed for the Western Skink, Lewis Woodpecker, and the extensive fish inventory work).	Gap
Invasive Species:	
Additional surveys or map of invasive species in the Slocan River watershed to understand extent of distribution	Recommendation
Domestic Use and Drinking Water:	
Collect current flow data at low flows on creeks used for agriculture and drinking water to monitor changes in discharge patterns and the possibility of water shortages.	Recommendation

Monitor microbiological quality of tributary streams used intensively as drinking water sources	Recommendation
Landslides:	
A landslide hazard map to show likely regions where landslides could occur throughout the watershed.	Recommendation
A study on the effects of timber harvest on landslides, erosion, water temperature, water storage and aquatic habitat	Recommendation
Data Management	
Centralized data housing and retrieval system for all data collected including digital data and maps	Recommendation

The questionnaire was sent out to ten additional experts who were asked to rank research gaps in order of importance and is attached as Appendix C. Results of the survey were then compiled, ranked, and are summarized in the table below:


Research Gaps from Questionaire, ranked by Importance
Abundance and distribution of mammalian species at risk
Identify opportunities for habitat enhancement for Bull trout in Lemon Creek
Abundance and distribution of aquatic species at risk
Abundance and distribution of birds, bats, amphibians, reptiles and invertebrates, including species at risk
Assesment of long term effects of forestry on aquatic ecosystems and geological processes
Data about juvenile fish populations as an indicator for impacts of rising water temperature in Slocan River
Up to date fish count on Slocan River to monitor trends of population abundance and distribution
Invertebrate sampling at strategic locations on mainstem and tributaries
Monitor microbiological quality of tributary streams used intensively as drinking water sources
Stream flow measurements on strategic tributaries at low flows
Collect water temperature data at on tributaries to identify trends and location of cold water inputs
Continue water quality sampling on Slocan River and tributaries
Collect water temperature data at historic sites on Slocan River and Winlaw Creek to identify long term trends
Assessment of Rails to Trail to identify opportunities for shoreline habitat enhancement
Identify and map aquatic and terrestrial invasive species throughout river system
Abundance and distribution of vascular and non-vascular plant species at risk in the watershed
Expand existing SEI through ground-truthing and by characterizing habitats
Map aquifers connected to wetlands, riverside habitat and cold water inputs into main river
Document sites on river are that are good opportunity for conservation/ restoration projects
0
5
10
15
20
25
30

Summary of Recommendations from Literature, Interviews and Questionaire

1. Identify opportunities and carry out riverside restoration in the floodplain in order to mitigate increasing water temperatures, provide/improve fish habitat, protect water quality, and stabilize banks. Opportunities for restoration include:
    - building wetlands,
    - tree planting in riparian areas,
    - re-opening side channels, and
    - instream enhancements.

2. Identify opportunities and carry out riverside restoration in tributary creeks in order to mitigate increasing water temperatures, provide/improve fish habitat, protect water quality, and stabilize banks. Opportunities for restoration include:
    - building wetlands,
    - tree planting in riparian areas, and
    - protecting old growth and trees in headwaters.

3. Restrict development of houses, roads, logging, hydroelectric, and trails in riparian areas in the watershed (Slocan River and in tributaries).

4. Monitor fish populations and spawning in order to identify any changes or long term trends. Additionally, expand the study to target juvenile trout, inter-population dynamics, and species at risk to monitor for impacts of increasing water temperature.

5. Monitor water quality and temperature at strategic sites to identify any changes or long term trends and analyze data that has been collected to date. Convey the information to the public through education programs with school and community groups, and newspaper articles to raise awareness and promote stewardship.

6. Restrict the blocking off of side channels and the use of rip-rap on shorelines in order to mitigate erosion and bank stability, protect habitat for juvenile fish, and improve flood control.

7. Manage rail trail for aquatic values through bankside restoration. Opportunities for restoration include:
    - instream enhancements,
    - strategically placed culverts to maximize cold-water inputs and address erosion.

8. Conduct flow measurements on small tributary creeks and source water creeks in order to monitor changes to flow regime and the potential impacts of climate change on water availability.

9. Field verify Sensitive Ecosystems Inventory data to further refine map and improve accuracy. Expand to include habitat characteristics and shoreline and aquatic values.

Conclusions

This report documents the history and types of activities that have impacted the Slocan River Watershed as well as the risks and threats that currently challenge ecological integrity. While human and climatic changes have altered habitats and, at times, resulted in degradation, there are still functioning, intact ecosystems that have proven to be resilient over time.

The literature review and interviews revealed that although we have carried out informative assessments, the data collected has not been used or integrated into watershed management strategies. Perhaps the most focused effort has been fisheries reviews related to compensation projects where specific enhancement goals were set. Here, we have tended to focus on species of commercial interest rather than a range of species at risk. Similarly regarding invertebrates, we are now focusing on mosquitos. Fortunately, for this work a biologist who understands the importance of species diversity for overall population health is involved. With climate change, population increases and increased demand for water, we have a clear challenge to manage for a broader range of wildlife values and endangered species.

Slocan Valley residents feel strongly about maintaining ecosystem health and tend to support environmental initiatives. For this reason, there exists an opportunity to create a watershed governance model whereby ecosystem-based management guidelines are agreed on and enacted through collaboration with regional and provincial governments, conservation groups and local knowledgeable citizens.

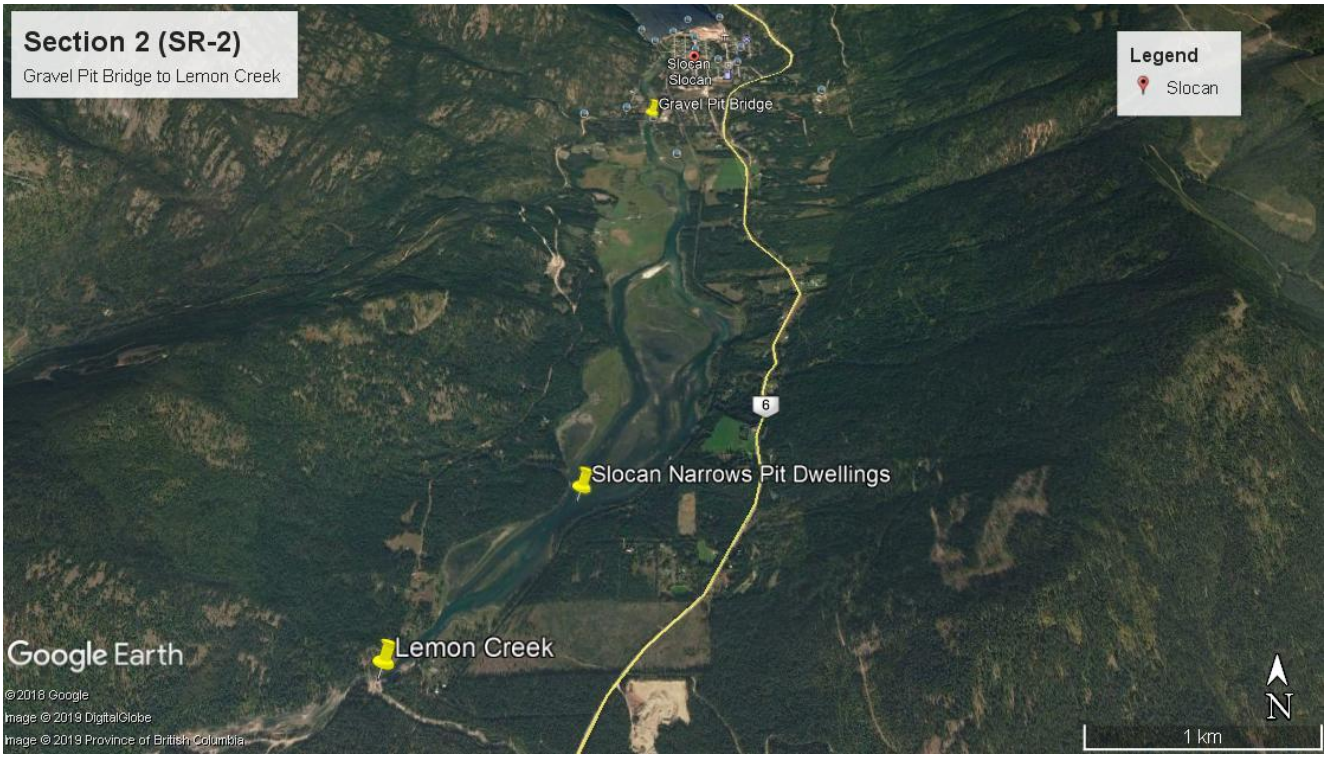
Appendix A: Six Sections of Slocan

For the purpose of this study the Slocan River has been broken down into seven sections separated by ecological zones and stream characteristics. This information is based on local knowledge, satellite map imagery and studies done in the past. It should be noted that source water creeks are present throughout. Section 7 is comprised of functional wetlands throughout ecosystems in the valley.

Slocan Lake Outflow to Gravel Pit Bridge

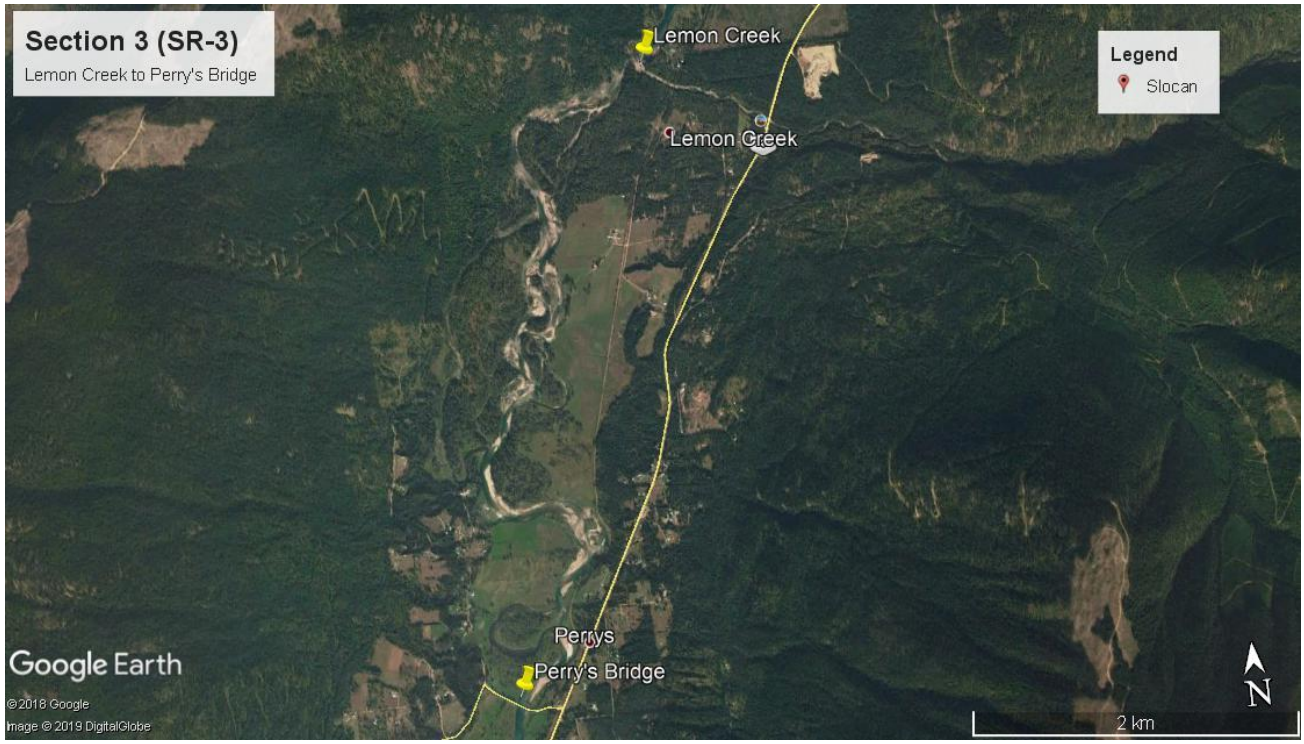
This reach starts at the outflow of Slocan Lake and flows south for approximately 1.5 km. It supports a diverse population of fish and wildlife. It is mainly channelized and both east and west banks are constrained by roadways and private property. There is potential for increased boating traffic in the lake that might lead to negative environmental impacts downstream. Rainbow trout are known to spawn at bridge.

Gravel Pit Bridge to Lemon Creek



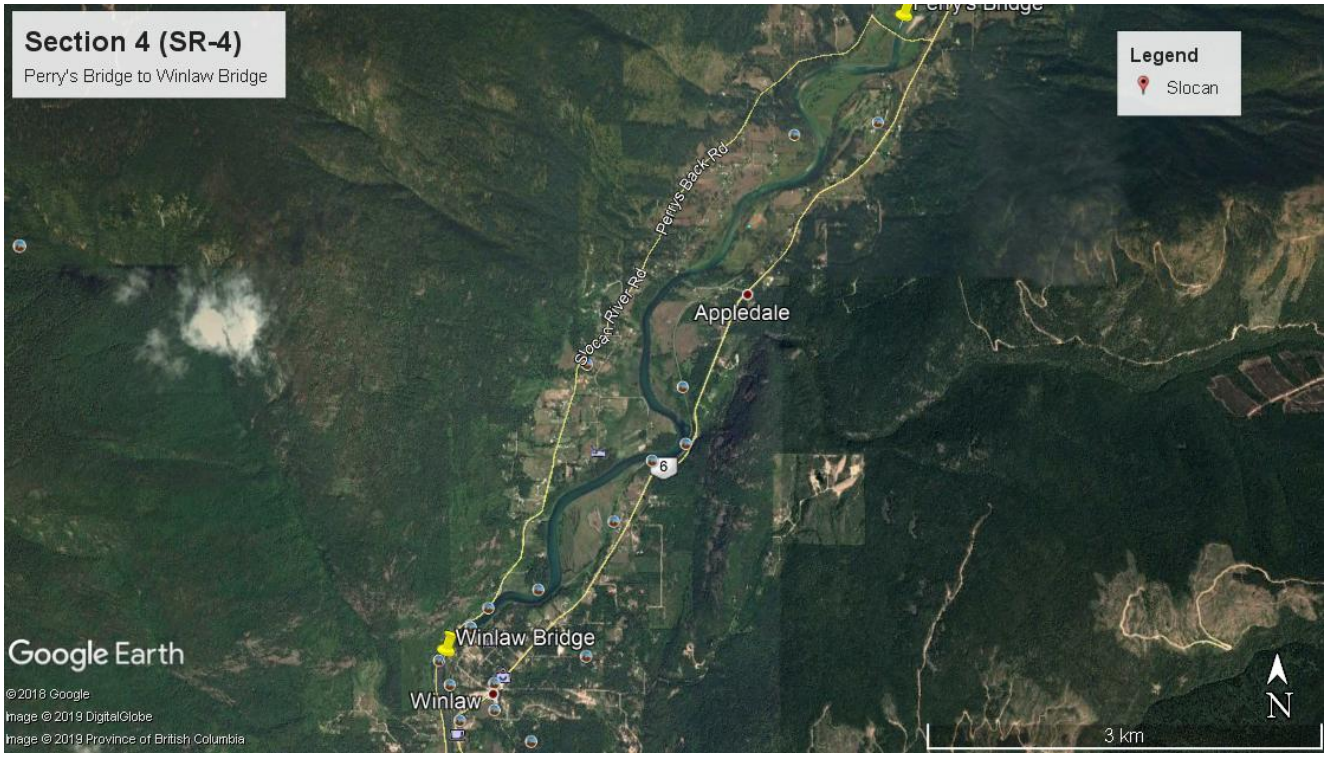
This reach is characterized as broad and shallow with braided sections. Due to the Lemon constraint and human activities (logging and agriculture) it tends to flood in spring and remain channelized in winter. It is approximately 6 km long and because it is shallow, water warms up during summer months. It is similar to a lake ecosystem and provides abundant food for birds and pike minnow, but not for cold-water fish (trout). There are two archeological sites located near the lower end of the stretch. In the winter, the islands in the channel provide habitat for migrating flocks of Tundra and Trumpeter swans.

Lemon Creek to Perry's Bridge



This reach has been identified as having the highest quality and the most diverse aquatic habitat found on the river. It is meandering over approximately 6 km's with intact islands, gravel bars, functional side channels and spawning gravel. It is also an area of cold-water refuge due to input from of Lemon Creek. It is unbound by roads and is moderately impacted human Large tracts of riparian areas in this section have been cleared for farming and grazing of animals. Lemon Creek itself is heavily impacted by logging in its mid to lower reaches, however its high elevation head waters are protected by Kokanee Park. In a recent study, resident populations of Bull Trout were identified in this system

Perrys Bridge to Winlaw Bridge

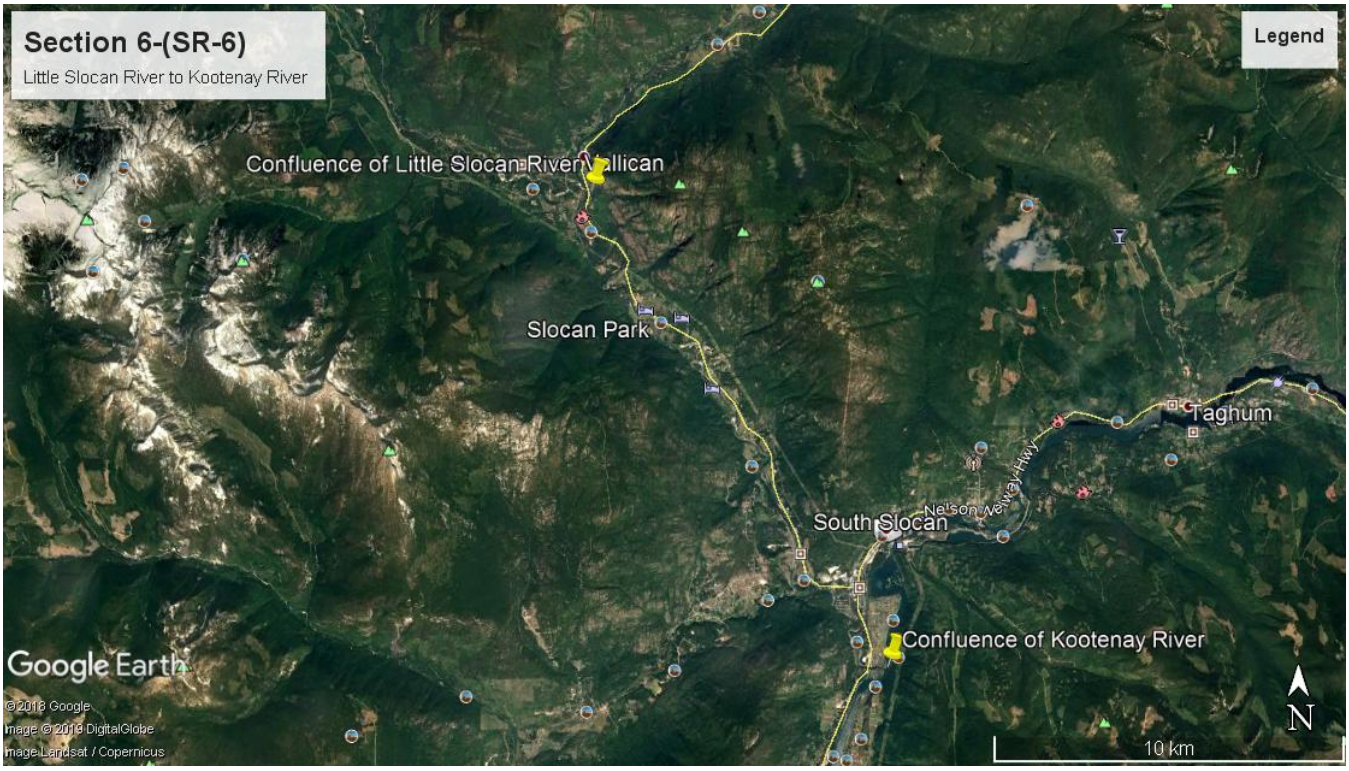


In this reach water slows down, becomes more channelized, and aquatic habitat quality decreases. East and west banks are primarily residential acreages and agricultural lands. There is logging in both Trozzo and Winlaw Creek watersheds which are important cold-water inputs into Slocan River. Some riparian areas are intact and functional and there are several current and completed riparian and wetland restoration projects on private land in this section. The Winlaw rapids are known to contain cold-water fish (trout).

Winlaw Bridge to Little Slocan River

This reach is approximately 11km's long and is characterized by minimal human impact and long continuous tracts of intact riparian areas. It has some functional side channels. Habitat diversity increases and water flow picks up. The instream restoration project at Cougar Bluffs has been successful in providing habitat for cold-water fish

Little Slocan River to Kootenay River



This reach is downstream of the Little Slocan/Carlson Slide. The first slide occurred in 1997 and more recent activity has been on-going. In 2018, a slide affected water quality (turbidity) in the main river downstream. The Little Slocan watershed continues to be heavily logged although it is home to sensitive ecosystems and species at risk. It is also an important cold-water input to the Slocan River. This reach of the main river has some functional side channels and riparian corridors but begins to be channelized again below Kosiansic's farm.

Appendix B: Recommendations for Future Sampling

Pages 42-43 excerpt from AMEC Slocan River Rainbow Trout Habitat Enhancement and Slocan River Riparian Restoration Program Interim Program Evaluation 2015 Update 1.0

Submitted to:
Columbia Expansion Power Corporation

6.1 Rainbow Trout Habitat Enhancement Program

Reach level monitoring:

- Use five person snorkel survey crews consisting of experienced snorkel observers.
- Conduct single pass surveys of all index and non-index reaches as replicates are not required.
- Include the observer efficiency estimate specific to the Slocan River during future fish abundance analysis and reporting.

6.2 Riparian Restoration Program

Survivorship monitoring:

- All plantings should be done using large stock and marked for future relocation. And,
- The total number of plantings added to the site should be recorded immediately after planting for future comparison.

Stream bank assessment monitoring:

- Blank field sheets should be used when completing stream bank assessments to minimize observer bias.
- The field sheets should immediately be converted to spreadsheet form and entered into the project database.
- Assessment procedure and variables as described by CPC (2009) should be reviewed before completing assessments.

Vegetation plot assessment monitoring:

- Review Koning (1999) prior to completing assessments to ensure correct procedures are followed.
- Digitize and create a database for the vegetation plot assessment cards if restoration sites will be analyzed on an individual basis during the final program review.

General:

- Consider directing project effort toward major or side channel restoration projects in areas which provide suitable habitat for RB. Opportunities have been identified in Corbett (2011) and Durand (2013).
- Direct annual funding toward maintenance of existing projects.

6.3 Stewardship Activities

- Review the data types acceptable to quantify stewardship engagement in the Slocan River watershed with Fisheries and Oceans prior to initiating the final program review (i.e. those activities funded by CPC such as descriptive, summaries of landowner engagement and Streamkeepers activities, community survey, etc.).
- Ensure annual water temperature monitoring is conducted by Streamkeepers in the Winlaw reach of the Slocan River.

Appendix C: Gap Questionnaire

Terrestrial, Wetland & Riparian		Ranking
1	Expand and update existing Sensitive Ecosystem Inventory through ground-truthing and by characterizing habitats	
2	Identify and map aquatic and terrestrial invasive species throughout river system	
3	Map aquifers connected to wetlands, riverside habitat and cold-water inputs into main river	
4	Assessment of Rails to Trail to identify locations for culverts that would allow for transfer of water and nutrients to shoreline habitat and maintain condition of trail	
5	Document sites on river are that are good opportunity for conservation/ restoration projects (eg. downstream of lemon creek)	
6	Abundance and distribution of vascular and non-vascular plant species at risk in the watershed	
Water Quality, Quantity and Temperature		Ranking
1	Invertebrate sampling at strategic locations on mainstem and tributaries	
2	Continue water quality sampling on Slocan River and tributaries: Winlaw, Trozzo, Little Slocan, Lemon	
3	Collect water temperature data at historic sites on Slocan River and Winlaw Creek to identify long term trends	
4	Water temperature measurements at strategic sites on tributaries to identify trends and location of cold-water inputs	
5	Monitor microbiological quality of tributary streams used intensively as drinking water sources	
6	Stream flow measurements on strategic tributaries at low flows	
Geomorphology		Priority
1	Updated geomorphology/hazard assessment of Slocan river and tributaries (Rate Priority: High, medium, low)	

Fish & Wildlife		Ranking
1	Abundance and distribution of birds, bats, amphibians, reptiles and invertebrates, including species at risk, and their habitat characteristics	
2	Abundance and distribution of mammalian species at risk in the corridor including mountain goats, grizzly bear, wolverine, and caribou, and their habitat characteristics	
3	Abundance and distribution of aquatic species at risk including Umatilla dace, short-head Sculpin, Bull trout, and Westslope cutthroat trout, and their habitat characteristics	
4	Identify opportunities for habitat enhancement for Bull trout in Lemon Creek	
5	Fish Habitat Assessment Procedure (FHAP) of Slocan river, Little Slocan and Lemon creek to assess long term effects forest harvest practices on aquatic ecosystems and geological processes	
6	Data about juvenile fish populations as an indicator for impacts of rising water temperature in Slocan River	
7	Up to date fish count on Slocan River to monitor trends of population abundance and distribution	
Data Management		
1	Centralized data housing and retrieval system for all data collected including digital data and maps *	
2	Centralized location for general public to enter wildlife observations	

Conservation Management Strategies:		Ranking
1	Protect critical habitat and islands through land purchases or conservation agreements with land owners and work with government to create more parks/conservation areas	
2	Replant native grasses, shrubs and trees in high risk land slide areas and at existing bank stabilization projects to mitigate further loss of habitat due to erosion	
3	Monitor, mitigate and treat invasive species in wetlands, riparian areas, and along shorelines throughout lower watershed	
4	Work with forest licensees and land owners to protect headwaters, recharge areas, and fish habitat sites on tributary creeks (e.g. Bull trout habitat in Lemon creek, install large woody debris on Winlaw Creek)	

5	Work with Rails to Trails Society to maintain and enhance wildlife values, address erosion, protect wetlands and ensure that culverts are functioning, and increase public awareness	
6	Advertise the benefits of maintaining riparian vegetation and wetland areas to private land owners living nears streams and the river, and offer to help plant trees	
7	Public education leading to referendum about the benefits of conservation tax whereby people pay small amount through taxes to support conservation projects	
8	Monitor adult fish populations to identify any trends, and expand data that targets juvenile fish populations to monitor potential impacts of rising water temperatures due to climate change	
9	Implement a school based water quality monitoring program for educational purposes. The program would include temperature, water chemistry and invertebrates	
10	Education regarding a conservation covenant for river side landowners as incentive towards stewardship	

Other important gaps or action items that have been missed, or any other comments:

Briefly, what is your favorite thing about the Slocan River watershed? What do you think makes it unique?

* currently being developed in collaboration with Selkirk College

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