Strategic Review of Fisheries Resources for the South Thompson – Shuswap Habitat Management Area

Version II

Prepared by:
Fraser Basin Council
200A – 1383 McGill Road
Kamloops, BC V2C 6K7

March 2016

Many people think of salmon as ocean creatures.
But they’re forest beings:
they’re born in a forest stream,
and they return to that same forest stream to renew the cycle of life.

- Gisele Martin, Tla-o-qui-aht First Nation member

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

The original project completed in 1997 was funded by DFO's Fraser River Action Plan (FRAP) and managed by Lidia Jaremovic. The 2016 update was coordinated by the Fraser Basin Council (FBC), with funding from the Government of Canada National Conservation Plan and the Thompson-Nicola Regional District.

The report represents a compilation and analysis of a wide variety of information sources. Fisheries production and habitat data were compiled from published and unpublished literature sources, and from interviews with fisheries management personnel.

1997 Version

Gordon Berezay (Ecolibrium Consulting Inc.) drafted the stock status; Bill Rublee and Wendy Chalmers (ARC Environmental Ltd.) compiled and prepared the sections of the report that described biophysical features, resource uses and watershed management issues and recommendations. Sigma Engineering Ltd. (1991) and Rood and Hamilton (1995) were the sources of much valuable information for the aforementioned sections.

Many DFO personnel also contributed to the 1997 report, including Gordon Kosakoski, Bob Harding, Byril Kurtz, Tim Panko, Heather Stahlberg, and Michael Crowe. MELP personnel involved in the report included Steve Maricle, Paul Doyle, Bob Grace, and Brian Jantz.

2016 Update

The update, contained in the pages that follow, required a review of the 1997 document and extensive research of published and unpublished literature from the last 20 years, online resources, and interviews with staff from DFO, provincial agencies (MOE, FLNRO, MOTI), Secwepemc first nations, and stewardship organizations. A full list of everyone who contributed to the report is listed at the end of this document. Where information from the 1997 version is still relevant, it is cited in the update as: (as cited in DFO, 1997).

Our thanks go to Bob Harding, Partnerships Coordinator at DFO for his overall guidance, support, contributions and enthusiasm for the project. We also thank the following people for their contributions to the update: Richard Bailey (Program Head, Coho/Chinook, DFO), Doug Lofthouse (Regional Enhancement Biologist, DFO), Chuck Parken (Program Head, Chinook and Coho Analytical Program, DFO), Pat Matthew (Fisheries Management Coordinator, Secwepemc Fisheries Commission), Sean Bennett (Senior Restoration Biologist, DFO), and the participants of the 11th Annual BC Interior Stewards Workshop. Shepherd Stewart (Imprint Communications) prepared the maps. Erin Vieira, Mike Simpson and Tracy Thomas at the Fraser Basin Council incorporated updates and prepared the report for publication.

Funding Acknowledgements

This project was undertaken with financial support from the following:

LIST OF ACRONYMS

AAC	Allowable Annual Cut
AHI	Aquatic Habitat Index
BCCA	BC Cattlemen's Association
BCTS	BC Timber Sales
CPR	Canadian Pacific Railway
CSRD	Columbia Shuswap Regional District
CU	Conservation Unit
DFO	Department of Fisheries and Oceans
DOE	Department of Environment (former)
ECA	Equivalent Clearcut Area
EFP	Environmental Farm Plan
FBC	Fraser Basin Council
FIM	Foreshore Inventory and Mapping
FPC	Forest Practices Code (former)
FRBC	Forest Renewal BC (former)
FRISP	Farmland Riparian Interface Stewardship Program (of BCCA)
FRPA	Forest and Range Practices Act
FSW	Fisheries Sensitive Watershed
HMA	Habitat Management Area
IWAP	Interior Watershed Assessment Procedure
MELP	BC Ministry of Environment, Lands and Parks (former)
MFLNRO	BC Ministry of Forests, Lands and Natural Resource Operations
MOE	BC Ministry of Environment
MOF	BC Ministry of Forests (former)
MOTH	BC Ministry of Transportation and Highways (former)
MOTI	BC Ministry of Transportation and Infrastructure
MPB	Mountain Pine Beetle
MSRM	BC Ministry of Sustainable Resource Management (former)
OCP	Official Community Plan
QEP	Qualified Environmental Professional
RAR	Riparian Areas Regulation
SHIM	Shoreline Habitat Inventory and Mapping
SLIPP	Shuswap Lake Integrated Planning Process (former)
SWPP	Source Water Protection Plan
TNRD	Thompson-Nicola Regional District
TSS	Temperature Sensitive Stream
WRP	Watershed Restoration Program (former)
WSA	Water Sustainability Act

EXECUTIVE SUMMARY

The Shuswap, Little Shuswap and Mara Lakes arguably comprise the most socially, economically and ecologically important large-lacustrine aquatic ecosystem in British Columbia (Ecoscape Environmental Consultants Ltd., 2009, 2011; Rosenau, 2014); thus, they are of great interest to many people including fisheries scientists and resource managers. The lakes and rivers within the South Thompson – Shuswap Habitat Management Area provide very important spawning, rearing and migration habitat for anadromous salmon; which in turn, are critically important parts of the freshwater, marine and terrestrial ecosystems, Secwepemc and Syilx traditions and culture, and commercial and recreational fisheries.

Sockeye, chinook, coho, and pink salmon are distributed throughout the South Thompson – Shuswap Habitat Management Area. The lower Adams River is perhaps the most well-known salmon habitat within the HMA, with a world-famous sockeye run and quadrennial festival; the South Thompson River, Little River, Salmon River, Eagle River and lower Shuswap River are also among the most important riverine spawning sites for sockeye, chinook and coho. Smaller creek systems such as Senn Creek and Bessette Creek provide critical spawning and rearing habitat for endangered Interior Fraser Coho in particular. Shuswap Lakes, and to a lesser extent Mara and Mabel Lakes also provide habitat for shore-spawning salmon and other salmonids.

Spawned salmon are an important source of marine nutrients to freshwater and terrestrial ecosystems. When spawned salmon die, their carcasses release nutrients, which take their place in the food web nourishing the fry and other organisms in and about the stream. Juvenile salmon within the HMA are an important food source for rainbow trout and lake char in the lakes and streams.

Salmon viewing has become an increasingly important economic and educational activity within the HMA. The quadrennial Salute to the Sockeye festival at the lower Adams River on dominant return years (2014) sees up to 200,000 visitors over a period of a few weeks, exposing visitors from around the world to the natural wonder of Fraser salmon, fostering appreciation for these important ecosystems and stewardship thereof, and injecting a significant amount of money into local economies. Further education takes place through community stewardship centres and classroom programs such as the well-established Stream to Sea program that sees school-children rearing salmon in a tank and subsequently releasing the fry into a stream.

Habitat Impacts

Habitat issues in the South Thompson – Shuswap are related to past and present land and water uses, and increasing development pressures that result in discrete and cumulative impacts on fish habitat. Generally speaking, British Columbia is a resource-based economy and the South Thompson – Shuswap HMA is no exception: forestry, agriculture and to a lesser extent mineral development are prevalent. Forestry and agriculture have a long history in the HMA and very significant detrimental impacts, some of which have caused irreparable damage to salmon stocks. The upper Adams River, Hiuihill Creek, Chase Creek, and Salmon River have been heavily logged in the past. Rates of cut, areas harvested (e.g., in riparian areas), and historical practices of transporting logs (i.e., via river corridors) have all taken a toll. The recent Mountain Pine Beetle epidemic has exacerbated impacts caused by forestry, with extensive salvage harvesting having taken place in some basins. The most common impacts to fish habitat from harvesting and associated road-building include the removal of riparian vegetation, landslides, channel de-stabilization, streambank erosion, increased sedimentation and aggradation, changes to the hydrological cycle, and greater fluctuations in stream temperatures.

Agriculture is prevalent in the valley bottoms of the South Thompson River, Salmon River, Eagle River, lower and middle Shuswap Rivers and their tributaries, and Chase Creek. While the footprint of agriculture is smaller than forestry, it is an intensive and ongoing resource use. Valley bottoms have been cleared of vegetation historically; some stream corridors have been re-planted and remediated, others present themselves as opportunities for restoration and increased stewardship. The agriculture industry, dairy farming in particular, has grown within the HMA in recent years. The impacts of agriculture include non-point source pollution (i.e., inputs of nutrients and sedimentation from fertilizers and manure), removal of streamside vegetation by grazing animals and cropping, trampling of streambanks by livestock leading to erosion and sedimentation, and diversion of water for irrigation. These have degraded the stream habitats and made them less suitable for migration, spawning, and juvenile rearing. High water demand, in particular, is a critical issue in some of the small streams within the HMA that are already prone to low flows; temperature- and streamflow-related fish kill events have occurred. Further mortality takes place as a result of improperly screened irrigation intakes. Agriculturally-sourced nutrients have recently been identified as a significant source, and one of the greatest threats to water quality in the lakes.

Urban development, primarily around the lakes and adjacent to river corridors, has increased the amount of impervious surface in the HMA. The result of this is altered hydrology, with increased peak flows and degraded water quality. Further impacts are caused by point sources of pollution such as wastewater treatment plants and storm drains, and non-point sources from septic tanks. Development on the lakes and associated activities such as filling, dredging, clearing of riparian vegetation, building infrastructure such as boat launches, docks and groynes all threaten the critical nursery habitat for rearing sockeye, chinook, and coho.

Further impacts to habitat are imposed by a hydro-electric dam on the middle Shuswap River. The Wilsey Dam has blocked salmon passage to upstream spawning and rearing habitat for over a century. This represents the one of the greatest opportunities for enhancement within the HMA; the multi-party Wilsey Dam Fish

Passage Committee has undertaken steps to understand the impacts of and enable fish passage at Wilsey Dam for both migrating adults and juveniles.

Linear developments, notably the Trans-Canada Highway and the Canadian Pacific Railway, are adjacent to the rivers and lakes in the valley bottoms of the HMA. The construction of these has resulted in channelization, in-filling, and encroachment all of which lead to reduced diversity of fish habitat. Their ongoing use and maintenance increases the risk of toxic spills, and increases sedimentation and point-source pollution via storm drains. Pending highway upgrades (i.e., four-laning segments of the Trans-Canada Highway) pose a risk to fish habitat. Short-term impacts may be experienced during construction (e.g., sedimentation and increased risk of spills); but more importantly, the long-term impacts of construction may decrease habitat space and availability. The Eagle River is a particular concern as it remains the most important coho-producer in the HMA and has excellent off-channel and wetland habitat types.

Invasive species, namely spiny-ray fish such as perch and zebra and quagga mussels, are a relatively new threat to salmon within the HMA. Perch have been reported in some of the large lakes and extirpated from small lakes as a method of preventing spread. Zebra and quagga mussels are not known to be present in the HMA. If any of these become established in the large lakes there is no treatment and the effects would be devastating.

Watershed Management Priorities

Generally, the landscape in BC in managed for multiple objectives such as timber, food production, water quality and quantity, fisheries, wildlife, settlement, and transportation. The resource development sectors in particular have improved drastically from what they were in recent history with new understanding of ecological interactions, better technology, societal expectations and pressures for low-impact development, and policies and regulations for environmental protection. While these sectors have improved, the demand for resource development has increased with the growing population.

Within the South Thompson – Shuswap HMA, the watershed management priorities are to protect habitat and prevent significant impacts caused by resource development, and to restore damaged habitat. The recently completed Foreshore Inventory Mapping and Sensitive Habitat Inventory Mapping projects for the lakes and large rivers in the HMA are useful tools for prioritizing protection and guiding restoration works. It should be acknowledged that protecting habitat from impacts has become increasingly difficult for fisheries management personnel with recent regulatory changes, shifting responsibility and authority away from government regulators onto resource management professionals.

Nonetheless, the most important habitat to focus on within the HMA is the South Thompson River for it's valuable chinook spawning grounds; Little River for its valuable spawning and migration habitat; Adams River for it's spawning habitat, and education and engagement values; Salmon River, particularly the lower reaches and the delta, for its spawning habitat and to protect the significant investment made in that watershed to date; Eagle River and it's small tributaries for spawning and rearing habitat particularly for endangered Interior Fraser Coho; the lower and middle Shuswap Rivers for their sockeye and chinook production; and small tributaries in the lower and middle Shuswap River basins for their coho spawning and rearing habitat.

Opportunities for habitat restoration exist throughout the HMA. A number of factors are considered in prioritizing sites for restoration, including the type and severity of impact, the value of the habitat, and the long-term benefits that can be achieved. Some potential restoration opportunities – such as on a creek fan – must give consideration to upland activities. Priority should also be given to periodically monitoring the effectiveness of completed restoration projects.

There are two significant enhancement opportunities within the HMA, both of which have been pursued for several years and whose efforts should continue. Rebuilding the once-dominant sockeye run in the upper Adams River with transplants is a priority; the next opportunity for broodstock collection may be in 2018 due to the spawner success in 2014. Additionally, fish passage into the middle Shuswap River beyond the Wilsey Dam – and successful out-migration of smolts – is another priority for enhancement in the HMA.

Education and stewardship continue to be very useful tools to increase awareness and appreciation of salmon and their habitat. Interpretive centres, educational programs and events, and industry groups and beneficial management practices need ongoing support and engagement. The latter, in particular, can yield some 'low hanging fruit' as it relates to increasing landowner stewardship and doing restoration works.

About this Document

This document is an update to the *1997 Strategic Review of Fisheries Resources for the South Thompson – Shuswap Habitat Management Area* that was prepared by the Department of Fisheries and Oceans Canada. The update was completed using the best available information from fisheries and other resource management personnel. The purpose of the updated *Strategic Review* is to document anthropogenic changes to freshwater salmonid habitat; it makes no assessment of developments being 'right' or 'wrong', it merely states where and how impacts have occurred.

Some important updates could not be completed within the specified time frame because of its complexity and personnel's inability to prepare it in time for publication. The incomplete information relates mostly to the state of fisheries resources within the HMA, salmon life histories, and production objectives; the understanding of chinook, for example, has grown vastly complex since the *1997 Strategic Review* was published. DFO has expressed their intent to complete such updates at a later date.

1. INTRODUCTION

The South Thompson – Shuswap Habitat Management Area (HMA) is located east of Kamloops within the Interior Plateau of the Canadian Cordillera (as cited in DFO, 1997). The tributaries to the HMA originate in east-central BC, in the Monashee Mountains and the Okanagan Highlands, and the total drainage area is 17,481 km^2 or approximately 7.5% of the total Fraser River watershed (Department of Fisheries and Oceans Canada, 1997) (See Figures 1 and 2).

The HMA is within the traditional territory of the Secwepemc Nation, and southern portions of the HMA are within the traditional territory of the Syilx (Okanagan Nation). First Nations assert title, rights and interests across the HMA. The *Constitution Act* (1982) affirms Aboriginal rights, and subsequent court decisions affirm First Nations' priority for fish and the existence of title and rights. Salmon is a very important part of First Nations culture and diet.

For the purposes of this report, the HMA is described by eight major sub-basins: the South Thompson and Little Shuswap Lake; Adams River and Lake; Shuswap Lake and small tributaries; Salmon River; Eagle River; lower Shuswap River; Mabel Lake; and middle Shuswap River. Another sub-basin exists, the upper Shuswap River, however there are no salmon there due to an impassable barrier (although historically there were).

Drainages in the southern half of the HMA have long stream sections that flow through flat valley floors, and the climate is generally warm and dry. Competition for resources in this area is high, with timber harvesting conducted in the uplands and intensive agriculture and settlement in valley bottoms. Residential development has increased in recent years, particularly along lakeshore areas. Recreation values are high, especially along the Shuswap, Mara and Mabel Lake areas as well as in many other small lakes in the HMA. Major transportation corridors, including the Trans-Canada Highway and the Canadian Pacific Railway follow the watercourses on their route through the HMA.

The context of this updated Strategic Review is to document the current state of salmonid fisheries in the South Thompson – Shuswap; it doesn't necessarily address the balance of social, economic and environmental considerations. Much of this report documents the anthropogenic changes to freshwater habitats of salmonids and how those changes have impacted stocks; this is not to say that resource use and development is all bad or should be reversed, it's simply stating how and where impacts have occurred. Recommendations are made in the context of how to strike the right balance of having healthy salmonid populations and habitats, and should be integrated with considerations given to social well-being and vibrant economies.

1.1 Disclaimer

This review is based on the best existing information from fisheries and other land use management agencies. Much of the presented information originated from published reports, unpublished works from the Department of Fisheries and Oceans Canada, and interviews with personnel from DFO, Secwepemc Fisheries Commission, BC Ministry of Environment, and BC Ministry of Forests, Lands and Natural Resource Operations. Land use data pertaining to timber harvesting, road densities, agriculture and range land use, urban land use, and water use was retrieved from the *Land and Resource Data Warehouse* and BTM1 (2015).

Some important updates to this document could not be completed within the specified time frame due to the complexity of the information and the inability of personnel to prepare it in time for publication. DFO staff have expressed their intent to complete updates on fisheries resources, conservation and protection, and resource restoration, as well as compile a comprehensive Appendix of photos in the near future.

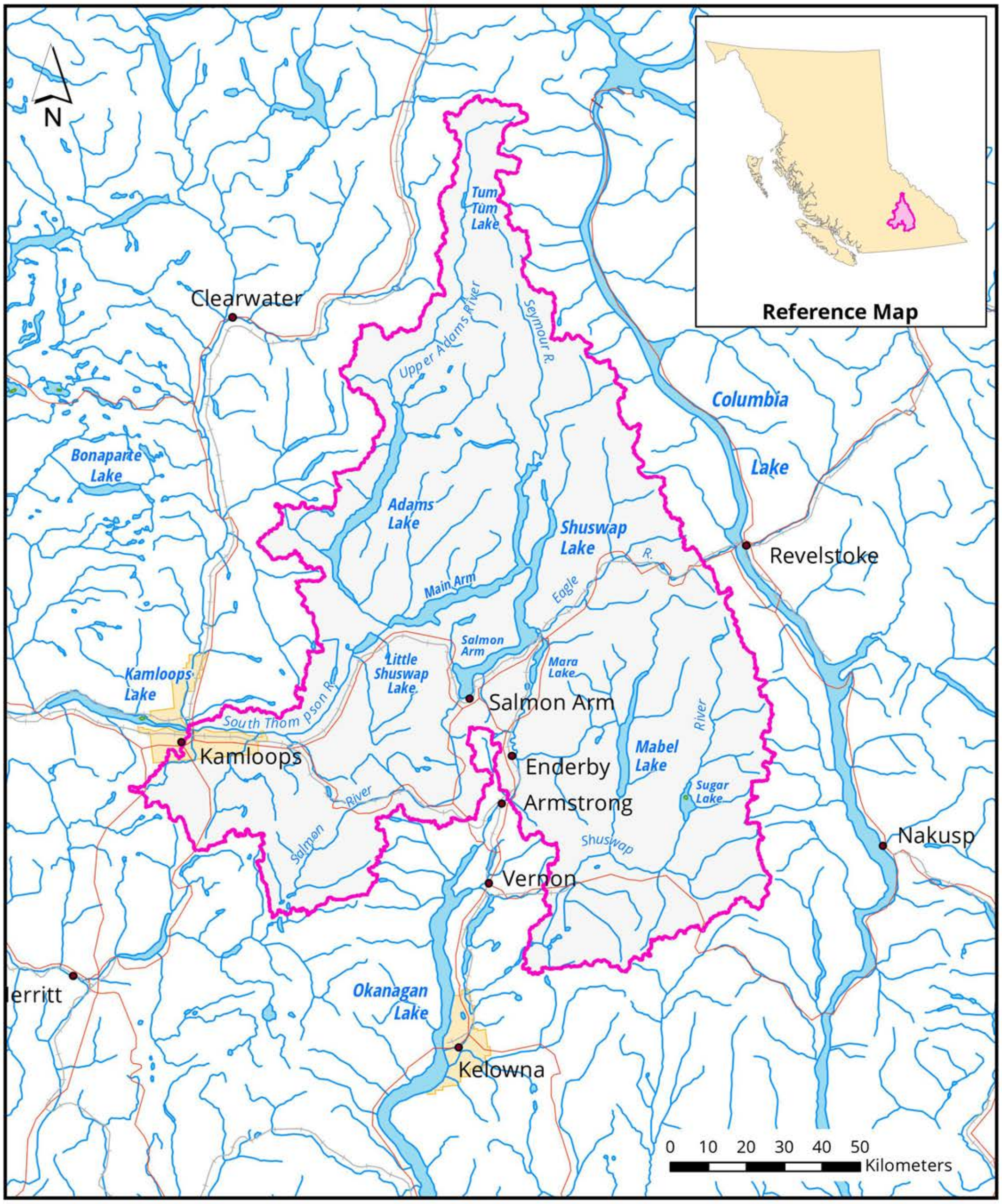

Figure 1. The South Thompson – Shuswap Habitat Management Area

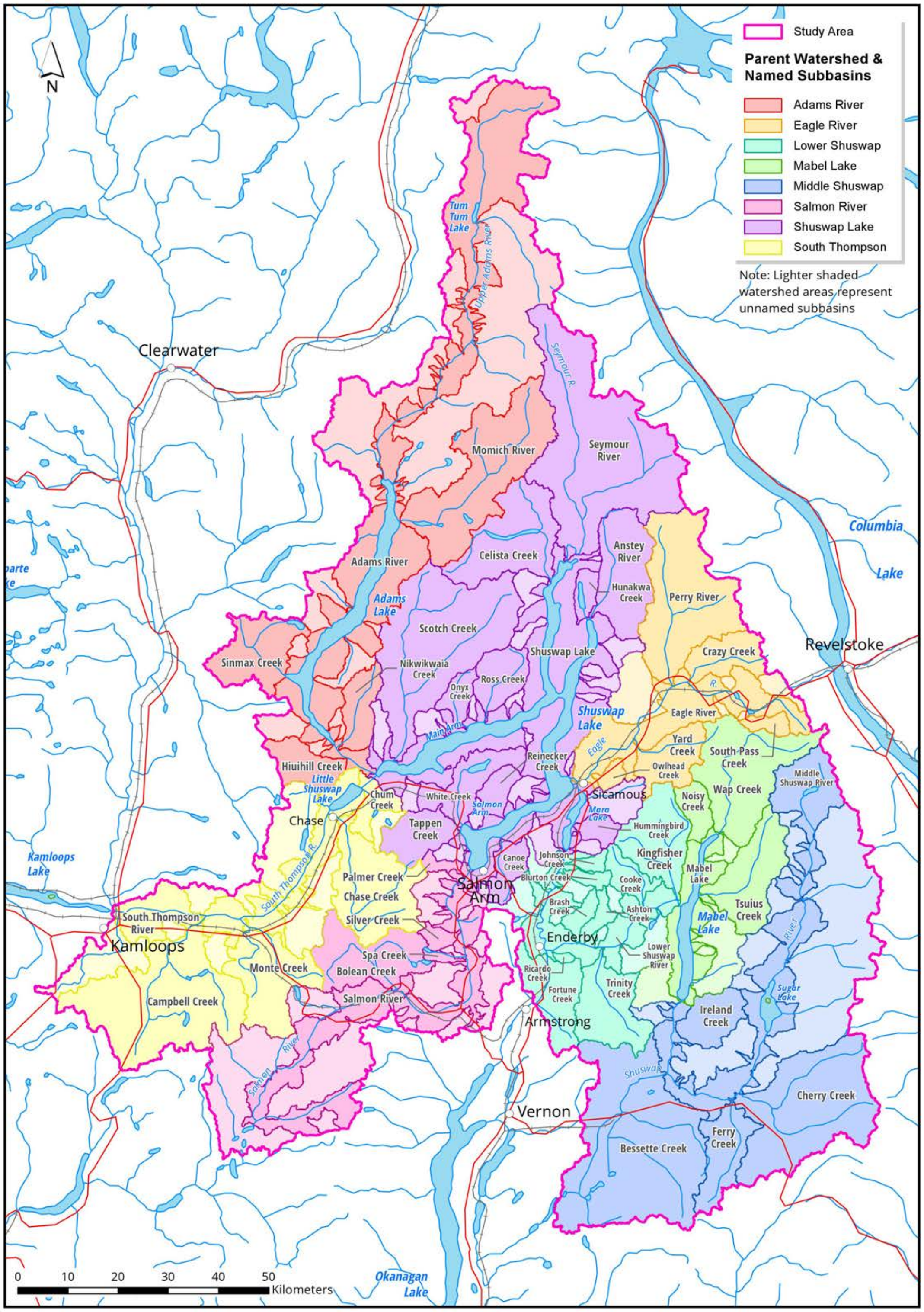

Figure 2. The eight major sub-basins of the South Thompson – Shuswap and sub-basins within

2. FISHERIES RESOURCES

Wild salmon are grouped into conservation units (CU); conservation units exist within a geographical habitat management area (HMA) and are the approximate equivalent to a population. According to *Canada's Policy for the Conservation of Wild Pacific Salmon, 2005,* a conservation unit is, "a group of wild salmon sufficiently isolated from other groups that, if extirpated is very unlikely to recolonize naturally within an acceptable timeframe, such as a human lifetime or a specified number of salmon generations" (Fisheries and Oceans Canada, 2005).

The South Thompson – Shuswap contributes significantly to salmon production in the Fraser Basin. The Adams sockeye population is one of the largest in the Basin. The Thompson coho stocks comprise approximately one third of the total Fraser coho production; chinook production in the Shuswap Lake tributaries is significant.

Resident fish species include rainbow trout, cutthroat trout, lake char, bull trout, kokanee, lake whitefish, mountain whitefish, and burbot. These fish provide recreational opportunities, especially in Shuswap Lake. Many non-sportfish are also found in the HMA's lakes and streams (e.g. carp, red-sided shiners, sculpins, suckers, leopard dace, longnose dace, northern squawfish, and peamouth chub).

2.1 Sockeye Salmon

Disclaimer: Section 2.1.x is largely an excerpt from DFO, 1997; a more complete update will be done by DFO staff in 2016.

The lower Adams River is the major sockeye producer in the area and the second largest in BC. Historically, this population was rivaled by the upper Adams run, but the latter was decimated in 1908 due to dam construction and has never recovered. The lower Shuswap River has become a major sockeye producer; other important runs include the Little and Seymour Rivers, Scotch Creek, and Shuswap Lake.

2.1.1 Life History

The South Thompson – Shuswap sockeye return to the Fraser River as early summer and late runs. The dominant stocks in the early summer run include Scotch Creek and Seymour River. The dominant stocks in the late run include Lower Adams and Little Rivers, Shuswap River (middle and lower), Shuswap Lake and South Thompson mainstem. Several streams have both the early and late run components (e.g. Anstey and Eagle rivers, and Scotch Creek).

The early summer run sockeye enter the lower Fraser in early July, with peak spawning in natal streams generally occurring in early to mid-September. The late run sockeye enter the lower Fraser in early September to early October with peak spawning generally observed in late October.

Fry typically emerge from late March to late May with peak emergence observed during the first two weeks of May (as cited in DFO, 1997). Fry generally migrate downstream into adjacent lakes to rear and overwinter, and subsequently migrate to sea as yearlings (as cited in DFO, 1997). Yearling sockeye begin to out-migrate from Mara, Shuswap and Little Shuswap lakes, and from the South Thompson River in June and early July; their migration in the South Thompson continues into August (as cited in DFO, 1997). The large numbers of yearlings observed in the lower Fraser in September suggests the arrival of the South Thompson – Shuswap sockeye smolts; these probably enter the Strait of Georgia considerably later than the April and May timing observed for most of the other Fraser yearling sockeye (as cited in DFO, 1997). Following a brief rearing period in the Strait of Georgia (as cited in DFO, 1997), the juveniles migrate predominantly northward, exiting the Strait by June or July (as cited in DFO, 1997), then migrate northward to rear in the Gulf of Alaska.

Sockeye generally mature at age four and exhibit a four-year dominance cycle. For most of the HMA's stocks, the dominant cycle is on the 2014 cycle line (i.e. 2014, 2018, etc.) with 2015 being the subdominant cycle, and 2016 and 2017 being the low cycles. Due to the fixed four-year age at maturity for most sockeye stocks, there is little overlapping between the cycles so that the large differences in spawner abundance between cycle lines are maintained.

2.1.2 Spawning and Rearing Habitat

Spawning distribution of sockeye salmon in the HMA is shown in Figure 3. The major sockeye spawning streams include the lower Adams, lower Shuswap, Little Scotch, and Seymour Rivers as well as lake-spawning populations in Shuswap Lake (see Figure 4). Shuswap Lake is also the major rearing area for most of the region's juvenile sockeye. Other lakes (Adams, Mabel, Mara, and Little Shuswap) are utilized for rearing as well, particularly the initial rearing stages prior to the movement of juveniles into Shuswap Lake.

Extensive studies on rearing sockeye, especially in Shuswap Lake, indicate a significant movement of juveniles within the lake system during the freshwater phase (as cited in DFO, 1997). The Adams River fry enter Shuswap Lake and migrate actively up-lake, mostly to the Main Arm but also to the Seymour, Anstey and Salmon Arms. Sockeye fry may also move downstream into Little Shuswap Lake, particularly with increasing flows in the South Thompson (as cited in DFO, 1997). The majority of these juveniles move back into Shuswap Lake throughout the summer, and by mid-August the greatest rearing densities are observed in the Main Arm near the Narrows; densities increase until November suggesting a continuous up-lake migration for these juveniles.

The nearshore zones of Shuswap Lake are very important for early juvenile rearing. By late May, juvenile sockeye in Shuswap Lake were distributed along both shores of the Main Arm, rearing in the nearshore areas until mid to late July, then moving into deeper offshore waters. The offshore movement coincided with nearshore water temperatures increasing above 16^0C (as cited in DFO, 1997).

Fry from the middle Shuswap River utilize Mabel Lake for initial rearing; this lake is considered a lesser contributor to the overall rearing production in the area (as cited in DFO, 1997). Mara Lake has very high rearing densities and is a major rearing area, especially for the Lower Shuswap stock. Little River sockeye and a portion of Adams River sockeye utilize Little Shuswap Lake for early rearing, but a large portion of these juveniles migrate back upstream into Shuswap Lake. Upper Adams sockeye presumably rear in Adams Lake prior to seaward migration. Movements of other sockeye stocks are less well known. However, the Seymour and Anstey sockeye juveniles likely rear, at least initially, in the Seymour and Anstey arms respectively. Other sockeye stocks likely utilize these waters as well, with the greatest rearing densities recorded in July. These juveniles may move upstream into the Little Shuswap Lake or utilize the Kamloops Lake for rearing.

2.1.3 Catches, Escapements and Escapement Trends

Catch estimates for Fraser sockeye are based primarily on the data that include catch, effort (vessels fishing), racial composition (scale analysis) and diversion rate (proportion of total run returning via the Johnstone Strait). Depending on the run size, Aboriginal fisheries on sockeye are conducted on various streams in the HMA;

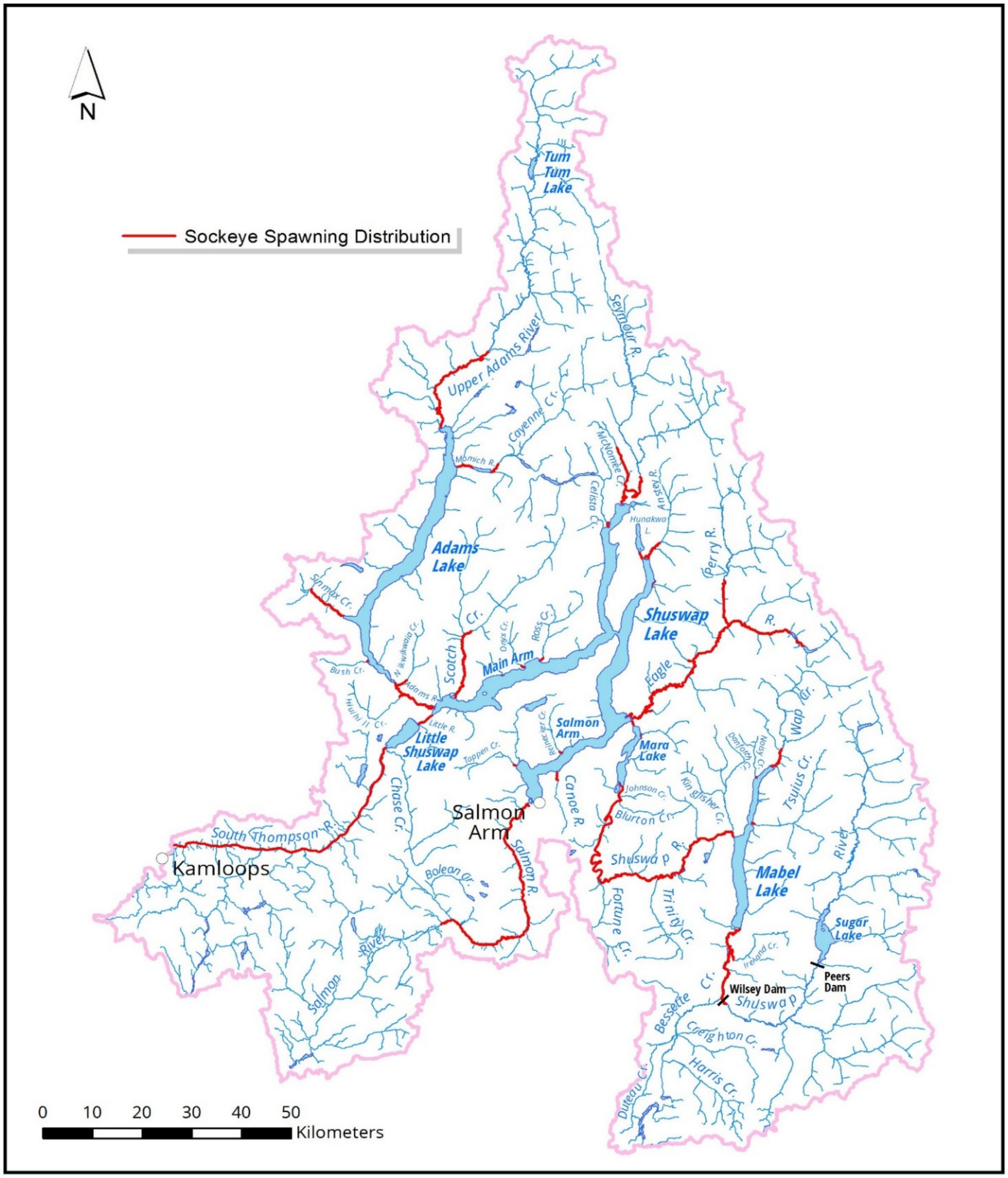

Figure 3. Spawning distribution of sockeye salmon in the South Thompson – Shuswap HMA

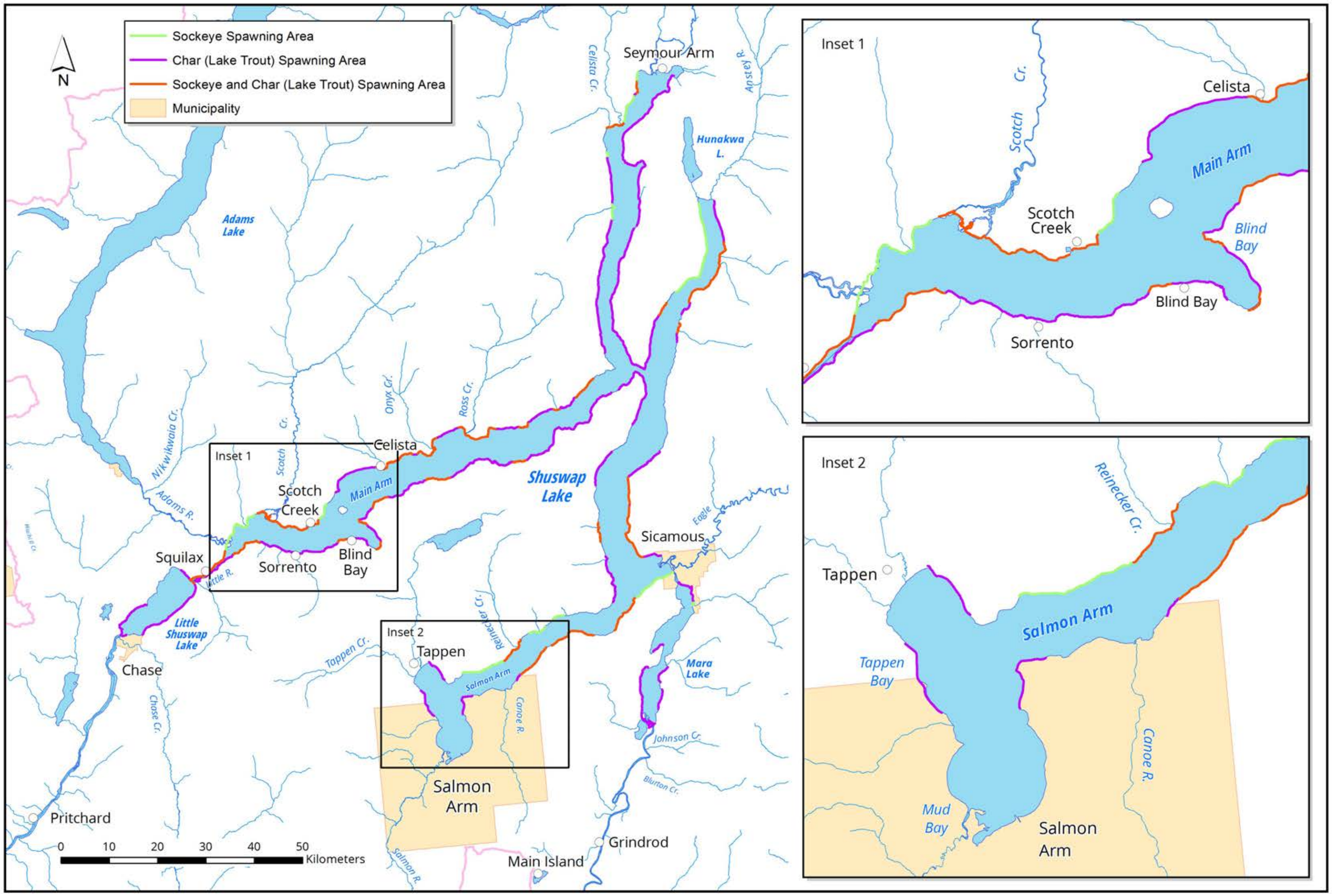

Figure 4. Lake-spawning habitat on Shuswap and Mara Lakes

however, the majority of the Aboriginal sockeye catch from this HMA are taken from the Fraser River mouth to North Bend, BC (as cited in DFO, 1997).

2.1.4 Habitat Productive Capacity

Sockeye productive capacity in the HMA depends to a large extent on the quantity and quality of the useable spawning area and the primary and secondary productivity of the rearing lakes. The DFO's Fraser River Sockeye Task Force developed the preliminary estimates of stream spawning and lake rearing capacities for Fraser sockeye. The total spawning capacity of the streams associated with the Shuswap, Adams and Mabel lakes was estimated at approximately 5.2 million spawners compared to the lake rearing capacity expressed in spawner equivalents) of approximately 6.8 million spawners.

2.1.5 Production Objectives

Current sockeye production objectives will be updated by DFO in 2016.

2.1.6 Enhancement Activities

The upper Adams sockeye has been identified as one of the best stock enhancement opportunities in the province. A number of enhancement activities have taken place, mostly coinciding with the dominant cycle (2014). In 1992, upper Adams River brood were reared at the Clearwater River Hatchery and 315,000 fry were released into the river the following spring; in 1996, over 30,000 sockeye spawners returned. That year, production increased and 1.3M fry were released into the river in 1997. An enrichment project took place on Adams Lake that year that involved application of fertilizer to the lake from May to September to improve juvenile rearing conditions. In 2000, a record 75,000 sockeye spawners returned to the upper Adams watershed. Fish culture activities were re-located to Shuswap Falls Hatchery, production increased again and the following spring a record 1.94M fry were released in the river. Additionally, an "off-cycle" enhancement project took place and 340,000 fry were released in 2002. The sockeye return in 2004 was disappointingly low: an estimated 13,500 spawners returned, thought to be due to unfavourable river conditions across the Fraser basin causing high mortality. Enhancement activities were attempted again in 2005, 2006 and 2008 but limited brood stock was available due to poor escapements. The most recent significant return was in 2014, an estimated 5,500 sockeye spawners returned to the river; 2018 may present an opportunity to re-commence enhancement (D. Lofthouse, pers. comm.).

2.2 Chinook Salmon

Disclaimer: The understanding of Interior Fraser chinook has grown vastly complex since 1997. Section 2.2.x will be reviewed and a detailed update will be conducted by DFO in 2016.

2.2.1 Life History

The majority of chinook in the South Thompson – Shuswap HMA return to spawn at ages four and five. Eggs incubate over the winter and fry emerge from mid-march through May. Different stocks may show different peak emergence and emigration timing (as cited in DFO, 1997).

Chinook exhibit two life history patterns (ocean type and stream type) based on the length of juvenile residency in freshwater. The ocean chinook rear in freshwater for several months and migrate to sea in their first fall; the stream chinook rear in freshwater for approximately one year and migrate to sea as yearlings (as cited in DFO, 1997).

Juvenile chinook rear primarily in the major lakes, with overwintering observed in Shuswap Lake and in downstream mainstem rivers; littler overwintering occurs in natal streams (as cited in DFO, 1997). Juveniles enter the Strait of Georgia during the spring or late summer, and leave the Strait via the northern or southern route, depending on the life history type. Ocean migration of all chinook extends into the Alaska waters where the fish rear to maturity.

Returning adults enter the lower Fraser from June through August (as cited in DFO, 1997). Those stocks with predominantly a stream type component (juveniles overwinter in freshwater) typically return to the lower Fraser before mid-July and constitute the spring run group (Eagle, Salmon, Seymour, and Anstey River chinook). Those stocks with predominantly an ocean type component, typically return to the Lower Fraser after mid-July and constitute the summer run group (Lower Adams, Middle and Lower Shuswap, South Thompson, and Little River chinook). Peak spawning occurs from late August to early November (as cited in DFO, 1997), with the spring run spawning earlier than the summer run.

2.2.2 Spawning and Rearing Habitat

Spawning distribution of chinook salmon in the South Thompson – Shuswap HMA is shown in Figure 5. Chinook spawn mainly in the South Thompson mainstem, including the Little River (between Shuswap and Little Shuswap lakes), and in the larger tributary streams of the HMA (lower and middle Shuswap, Adams, Eagle, and Salmon Rivers). In the South Thompson, chinook are concentrated from the outlet of Little Shuswap Lake downstream to Campbell Creek and throughout Little River. In the lower Shuswap River, chinook spawn downstream of Mabel Lake to Enderby, and in the middle Shuswap River they spawn downstream of Wilsey Dam (Shuswap

Falls) to Mabel Lake. In the lower Adams River, chinook spawn primarily from Shuswap Lake to the canyon, with lesser numbers upstream. Spawning also occurs in the upper Adams River above Adams Lake. In the Eagle River, chinook spawn below Griffin Lake; Salmon River spawning is scattered between Silver Creek and Falkland. Smaller populations spawn in the Seymour and Anstey Rivers below the falls at six kilometres and five kilometres upstream of the mouth, respectively. Chinook also spawn in Wap Creek and the Bessette watershed.

Rearing behaviour of juvenile chinook in the HMA is complex and not yet fully understood. Both the natal streams and the lake are utilized for rearing. The major lakes provide an important summer rearing habitat for the ocean type chinook and an overwintering habitat for the stream type chinook. Some populations also utilize the larger natal streams for overwintering.

The lakes are highly productive, as indicated by the estimated high growth rates (April to July) of juveniles rearing in the lake systems (as cited in DFO, 1997). It is assumed that this high productivity drives the ocean-type life history by enabling the under-yearlings to attain a sufficient size to allow salt water adaptation. In contrast, the early growth potential of juveniles in the less productive streams (Eagle and Salmon Rivers) is limited. These juveniles cannot achieve a sufficient body weight in their first year and remain to overwinter in freshwater.

Studies show that the Mabel, Mara, Shuswap, Little Shuswap Lakes provide an important rearing habitat for juvenile chinook. For example, in Mabel Lake, the shallow lake margins that support vegetation had large numbers of juveniles which originated from the middle Shuswap River (as cited in DFO, 1997). Other studies indicate that the ocean type juveniles heading for sea migrate from their natal streams into the lakes and into the South Thompson River by early August. For example, rearing densities in Mara and Shuswap Lakes increased from May to June then declined in July (as cited in DFO, 1997), while rearing densities in Little Shuswap Lake peaked in mid to late June, then declined in early August.

Compared to the high densities of under-yearlings, relatively low numbers of yearling and chinook were observed in natal streams and lakes where densities peaked in late April and early to mid-June, respectively. The low number of overwintering juveniles relative to the high density of under-yearlings is indicative of the dominance of the ocean-type life history for many chinook stocks in the HMA.

2.2.3 Catches, Escapements and Escapement Trends

Total catch estimates for Fraser chinook are not available due to limited coded wire tag (CWT) recoveries. Catch distribution, based on the available CWT data for selected enhanced stocks, differs for the ocean type and stream type chinook reflecting their different migration and rearing behaviours. The stream type chinook which tend to return relatively early to the lower Fraser (before July 15) and mainly via the Juan de Fuca Strait, are harvested primarily in the Northern and Southwest

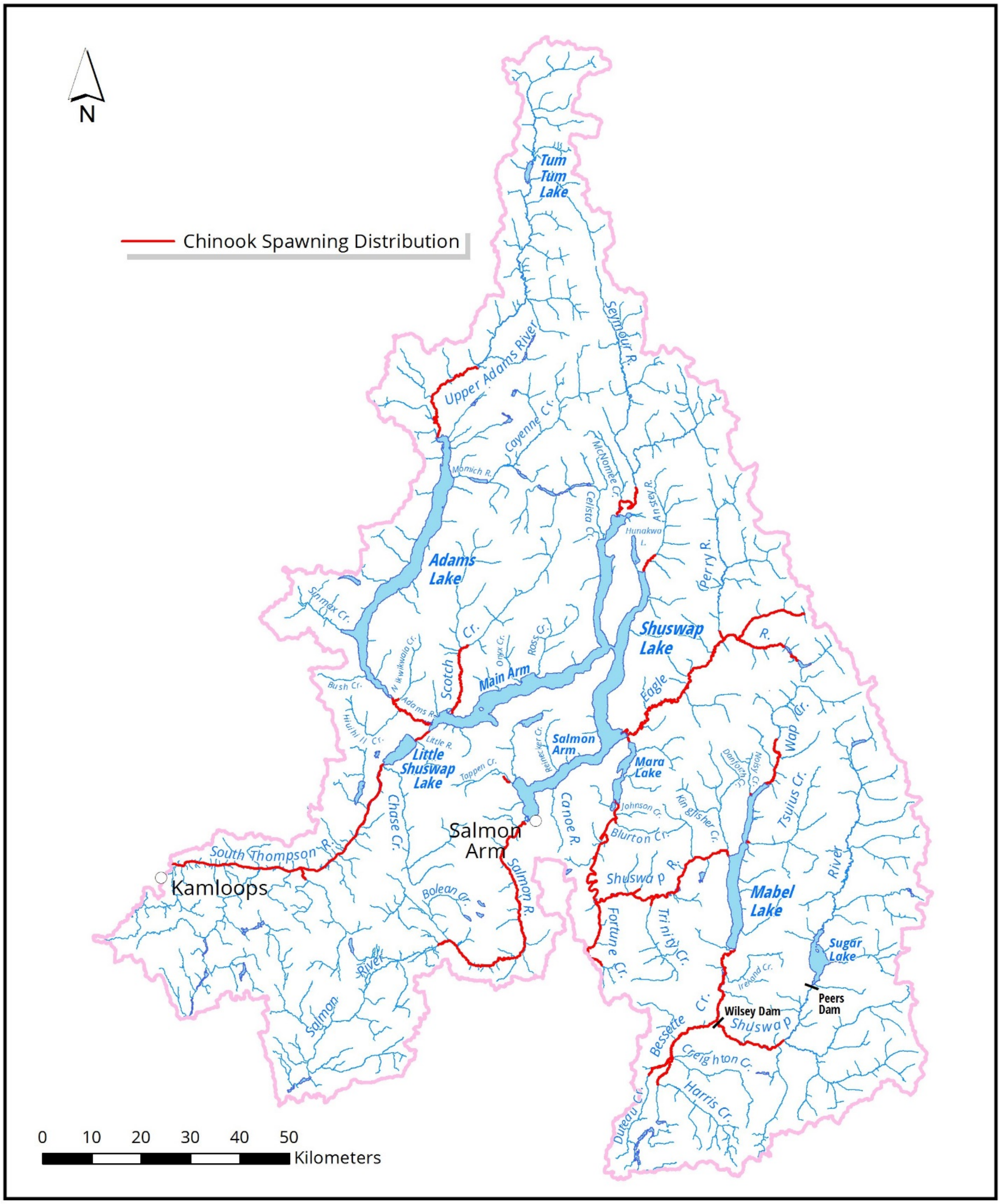

Figure 5. Spawning distribution of chinook salmon in the South Thompson – Shuswap HMA

Vancouver Island and the Strait of Georgia fisheries. By comparison, the ocean type chinook which tend to return later, mainly via the Johnstone Strait, are harvested primarily in the Alaska and Northern BC fisheries.

Chinook are harvested in the native fisheries mainly in the middle and lower Shuswap Rivers, with some catches also taken in the Salmon, Adams, Little and South Thompson Rivers (as cited in DFO, 1997). The recent annual native catch of chinook in the HMA was estimated at approximately 500 – 1,000 fish but the catch data are incomplete. Fishing effort estimates are not available for recent years but indication are that the effort has increased.

The Fraser in-river sport fishery on chinook was closed to retention in 1980 due to low escapements. As escapements increased, specific sport fisheries were opened (lower Shuswap River in 1986, middle Shuswap River in 1988). Currently, sport fisheries on chinook are also conducted on the South Thompson River and Mabel Lake. The Fraser River sport fishery has been monitored extensively through on-site surveys since 1984-1988 (as cited in DFO, 1997). During 1986 to 1993, the Shuswap sport fishery has averaged 460 chinook annually, with the Shuswap Hatchery fish contributing to the catch.

The largest producers are the ocean type populations. Chinook escapements from 1975 to 2015 are shown in Figure 6. Other significant producers are the South Thompson mainstem, middle Shuswap, lower Adams, Eagle, and Salmon Rivers. The total escapements have increased significantly since the early 1980s, from a low of approximately 8,000 in 1982 to 34,000 in 1992, and a high of more than 180,000 in 2015. This rebuilding trend is likely attributed to a series of actions initiated through the Pacific Salmon Treaty (1985) to reduce the overall harvest rates on chinook, along with previous conservation measures taken by DFO.

Under the Canada-US Pacific Salmon Treaty of 1985, Canada and the US were committed to halt the decline of chinook escapements. Rebuilding goals were arbitrarily set at double the average escapements for the 1979-1982 base period (for some stocks, the goal was set at double the 1984 escapement estimate). Stock rebuilding was to be achieved by reducing the exploitation rates by 15% through management actions in the ocean fisheries (troll, net, and sport). The Adams and Shuswap Rivers (middle and lower) stocks have met or exceeded the targets. For the middle Shuswap, both the management actions and the significant enhanced returns are responsible for stock rebuilding. The escapement targets have not been achieved for the stream type Eagle and Salmon River stocks or for the Little River stock; these populations are showing a declining trend in recent years.

2.2.4 Habitat Productive Capacity

The total productive capacity (stable population abundance under conditions of no fishing) of chinook habitat in the South Thompson – Shuswap HMA is shown in Table 1.

Table 1. Chinook salmon habitat production capacity in the South Thompson - Shuswap HMA

Stock Name/River(s)	**Median**	**SE (of Srep)**
South Thompson (lower Thompson, South Thompson, Little, Lower Adams)	270,229	24,531
Lower Shuswap	34,726	1,958
Middle Shuswap	10,297	551
Bessette	2,624	210
Eagle	5,034	362
Salmon at Salmon Arm	5,291	378
Seymour	1,245	116

Historically, determining habitat productive potential required an extensive habitat assessment of the lakes and streams in the area. Parken *et al.* developed an allometric model to predict Smsy and Srep from the watershed area; it can generate biologically-based escapement goals, rooted in fish-production relationships, for data limited stocks over a broad range of environments (C.K. Parken, 2006). High productivity of the Shuswap, Mara, and Mabel Lakes, and their heavy utilization by juvenile chinook suggest that the rearing habitat is abundant (as cited in DFO, 1997).

The overall productive capacity of the HMA is dependent on maintaining the spawning and rearing habitats. Water withdrawal, agricultural activities resulting in loss of riparian cover, and lake and river shore development have impacted the productivity of the watershed, and must be carefully managed to ensure the long-term health of these stocks. It is also noteworthy that interspecific competition may occur between chinook and sockeye juveniles since the two species utilize similar rearing areas in Shuswap Lake. Therefore, rebuilding of one species may limit the potential of the other. This possibility needs to be addressed when developing rebuilding strategies (as cited in DFO, 1997).

2.2.5 Production Objectives

Historically, significant enhancement efforts for chinook have been expended in the HMA. The Eagle River Hatchery, located east of Malakwa, had the capacity to produce approximately 5,400 adults to catch and escapement (as cited in DFO, 1997). This facility was operated from 1984 to 1993 mainly to enhance Eagle and Salmon River chinook, but was subsequently closed due to financial constraints and poor release to adult survival rates (generally <0.6%) (D. Lofthouse, pers. comm.).

In the late 1980s and early 1990s, the Eagle River Hatchery conducted a transplant of lower Shuswap Chinook into the upper Adams River. Following five consecutive years of hatchery releases, enhancement ceased, allowing initial transplant success to be evaluated along with any future natural production to be assessed. From brood year 2000 onward (that point from which any returns would be from natural

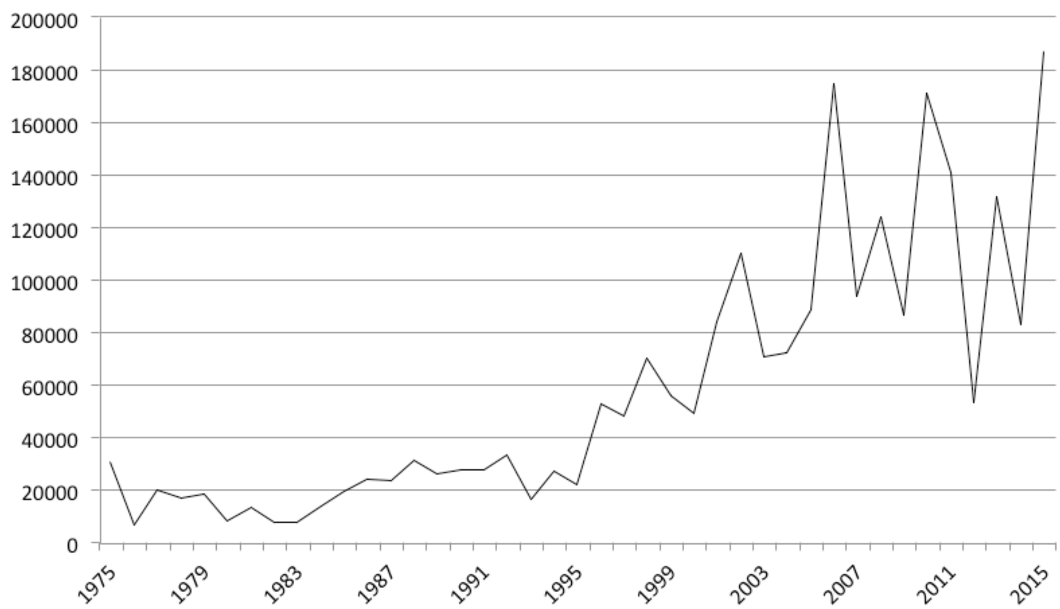

Figure 6. Chinook salmon escapement in the South Thompson – Shuswap HMA from 1975 to 2015

spawning), the stock has persisted, with escapements to the spawning grounds fluctuating from a 25 – 240 adults (D. Lofthouse, pers. comm.).

The Shuswap Falls Hatchery, located east of Lumby, has been enhancing both middle and lower Shuswap River chinook since 1984. This facility has the capacity to produce approximately 14,000 adults to catch and escapement (Cross et. al., 1991), with average release to adult survival rates near 1.0%. Production levels by stock have varied over the past three decades. Given its importance as a Pacific Salmon Treaty indicator stock, since 2009 facility production has been weighted ~75%/25% in favour of lower Shuswap. All production is as 0+ smolts, with yearly totals being in the range of 650,000 to 700,000. Recent average enhanced contribution rates are ~ 7% for the lower Shuswap stock and ~53 % for the middle Shuswap (D. Lofthouse, pers. comm.).

Kingfisher Hatchery, located east of Enderby, has been involved in the culture of lower Shuswap chinook for more than three decades. Since 2000, numbers of juveniles released have ranged from 38,000 to 225,000 per year and have taken the form of unfed fry, fed fry, and 0+ smolts (D. Lofthouse, pers. comm.).

The Spius Creek Hatchery near Merritt has been enhancing the Salmon River chinook stock continuously since 1994. The stabilization in escapement levels combined with other stocks competing for rearing water and space has led to a change in the enhancement strategy; starting in 2011 the strategy for Salmon River chinook was changed from release of a yearling smolts to fed fry. Since 2000, the enhanced contribution rates for this stock have ranged from a low of 10% to a high of close to 45% (D. Lofthouse, pers. comm.).

2.2.6 Enhancement Activities

The focus of enhancement activities has been habitat rehabilitation and restoration, with various projects proposed and undertaken by the DFO Resource Restoration Program and others. These include habitat complexing (i.e. installation of root wads, log bundles, tree revetments, creation of artificial riffles), planting of riparian vegetation, and cattle fencing to maintain bank stability.

Several projects, including groundwater rearing and spawning side channels, were proposed for the Adams, Salmon and middle Shuswap Rivers, and Duteau Creek (as cited in DFO, 1997). To date, side channels have been developed on the lower Adams River and preliminary reconnaissance conducted on the Duteau Creek. Many stream restoration projects are being undertaken in the Salmon River watershed to restore riparian cover, stabilize banks, enhance stream habitat, and promote farming and ranching practices that maintain stream habitat.

2.3 Coho Salmon

Disclaimer: Section 2.3.x is largely an excerpt from DFO, 1997; a more complete update will be done by DFO staff in 2016.

In 2002, the Committee On the Status of Endangered Wildlife In Canada (COSEWIC) designated the Interior Fraser population of Coho as *Endangered*. The designation was based on significant declines in the population (>60%) and changes to both freshwater and marine habitats as well as overexploitation. Further, COSEWIC was concerned that fishing pressure, habitat loss, and the use of hatcheries would further threaten recovery and as a result, Interior Fraser coho are at serious risk of becoming extinct (COSEWIC, 2002).

More than 30 streams in the HMA have known populations of spawning and rearing coho salmon (as cited in DFO, 1997). The major producers (>1,000 spawners) are the Eagle and Salmon Rivers; other important producers (>100 spawners) include the Adams River (upper and lower), Shuswap River (middle and lower), the Bessette Creek system, and Wap Creek.

2.3.1 Life History

There are five genetically distinct populations of Interior Fraser Coho identified in the Conservation Strategy for coho salmon: Fraser Canyon, Lower Thompson, South Thompson, North Thompson, and Mid-Upper Fraser, and within each population, there are one to three sub-populations identified. These populations map almost directly onto the currently identified five conservation units (CU) for Interior Fraser Coho. This overview refers to the South Thompson conservation unit of the Interior Fraser.

The South Thompson Coho stocks return to the lower Fraser from late August through October (as cited in DFO, 1997). Adults reach their natal streams from mid-October and spawn until mid-December (as cited in DFO, 1997). Coho return to spawn predominantly at age three (as cited in DFO, 1997). Fry emerge from late March through late May and early June (as cited in DFO, 1997) and the juveniles remain in freshwater at least one year. They rear initially in natal streams, then may move downstream to rear and overwinter in other rivers and lakes.

Studies suggest that seaward migration of overwintered yearling coho is initiated by early May and continues into July. For example, yearling coho were generally captured in the Adams, Eagle, Salmon, and Shuswap rivers during mid-April to early May, but not later (as cited in DFO, 1997). Yearling coho that had overwintered in streams or in Shuswap Lake were most abundant in that Lake in late May and early June (as cited in DFO, 1997). A directed seaward migration of marked yearlings of Shuswap Lake was observed in June and early July (as cited in DFO, 1997), while the peak catch of yearlings in the Thompson River at Spences Bridge was noted in late May and early June (as cited in DFO, 1997).

2.3.2 Spawning and Rearing Habitat

Spawning distribution of coho in the HMA is shown in Figure 7. Coho are widely distributed in the accessible streams, with spawning occurring in the slower-flowing side channels of larger streams (lower Adams and middle Shuswap Rivers), in the upper Adams River above and below Tum Tum Lake, and in many small streams tributary to Shuswap Lake and Lower and Middle Shuswap rivers. The South Thompson mainstem and Little River are used primarily as migration corridors.

Juvenile coho may rear in natal streams and in downstream rivers and lakes (primarily Shuswap Lake). It is estimated that 65% of the under-yearling coho originating from middle Shuswap River and Bessette Creek migrated downstream by the end of May; the remaining juveniles reared in the mainstem and smaller tributaries. Sampling in streams and Mabel Lake resulted in very few recoveries, suggesting that the fry migrate downstream into lower Shuswap River and Mara and Shuswap Lakes (as cited in DFO, 1997).

There is little suitable rearing habitat for juvenile coho in the middle Shuswap mainstem (as cited in DFO, 1997). During the summer, these juveniles move into Bessette Creek and suitable side channels characterized by low velocity and the presence of debris cover. The Duteau, Harris and Creighton Creeks (tributaries to Bessette Creek) also supported significant juvenile coho populations but these were of natal origin (as cited in DFO, 1997). Each system may be suitable or not, depending on groundwater availability and resulting temperatures (R. Bailey, pers. comm.).

A significant dispersal of under-yearling coho occurs in Shuswap Lake from adjacent major watershed during May. The main lake rearing areas are adjacent to spawning streams and along lake migration routes (as cited in DFO, 1997). Initially, juveniles rear in the littoral areas of Shuswap Lake where planktonic and benthic prey organisms are abundant. After mid-July, the juveniles move offshore, probably to avoid high water temperatures (>16^0C) and take advantage of the abundant food supply in deeper waters (as cited in DFO, 1997).

Under-yearling coho from Salmon River utilize the Salmon Arm basin only during late April and early May (as cited in DFO, 1997). The shallow waters of the basin are characterized by high water temperatures and turbidity, making them unsuitable for juvenile coho. Consequently, these juveniles migrate into other Shuswap Lake basins.

Overwintering coho have been noted in the larger streams including the Adams, Seymour, Eagle, Salmon and Shuswap Rivers. In addition, coho move into groundwater-fed off channels, lakes, groundwater ponds and old oxbows to overwinter. Oxbows often need rising water associated with the freshet to re-

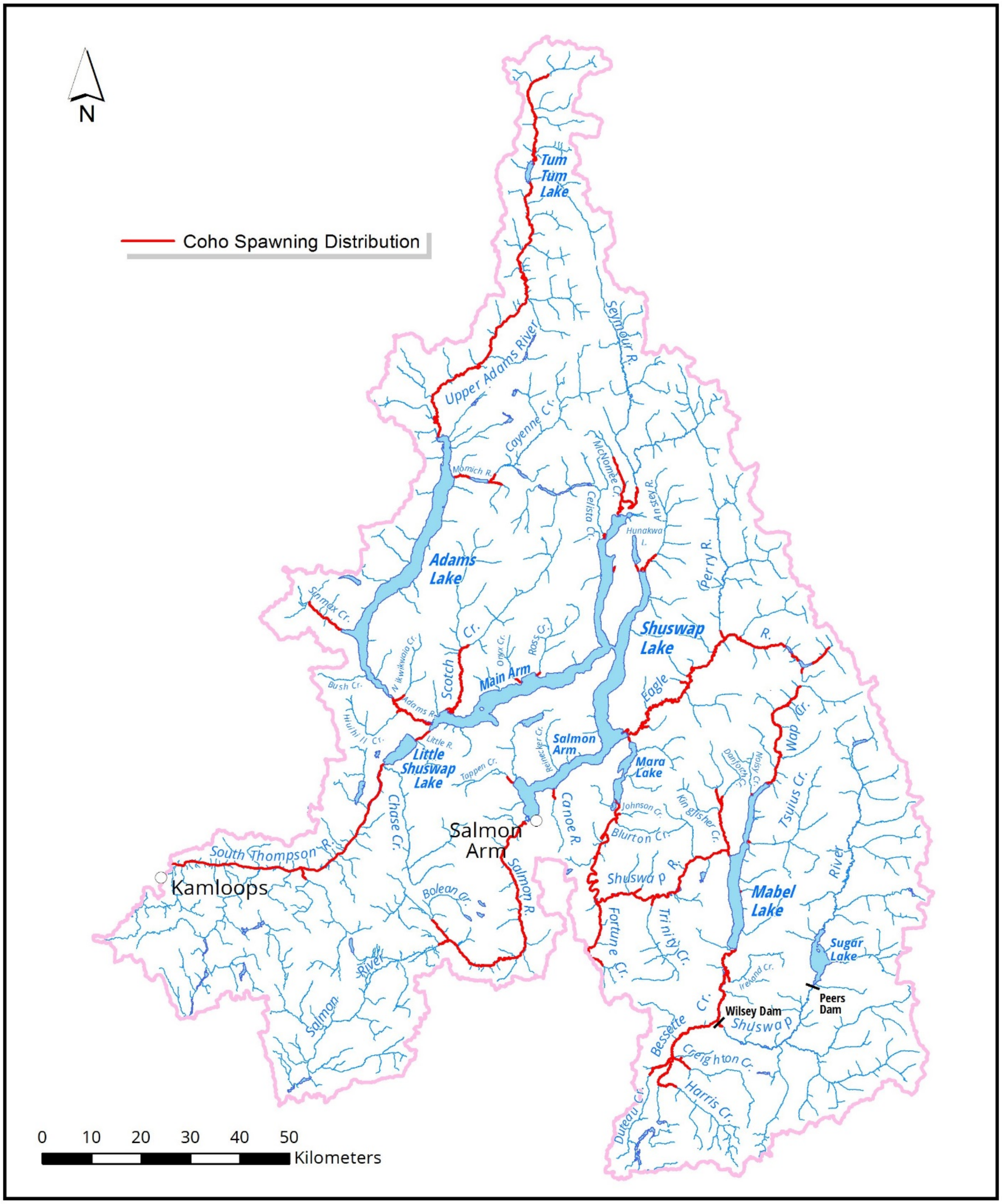

Figure 7. Spawning distribution of coho salmon in the South Thompson – Shuswap HMA

connect them and allow the fish out into the river to migrate downstream (R. Bailey, pers. comm.)

The smaller tributaries may provide only summer rearing habitat due to low winter flows and lack of suitable winter habitat. The juveniles are believed to migrate into the lower mainstems or lakes to overwinter. These habitats are characterized by flooded plains and off channels during high water which provide a vital, early rearing habitat for these stocks.

2.3.3 Catches, Escapements and Escapement Trends

In response to the decline of coho abundance in the 1990s, DFO implemented several fisheries management measures that significantly reduced the harvest of Interior Fraser Coho. Since 1998, there have been no commercial or recreational fisheries targeting Interior Fraser Coho. Where there are fisheries that occur in areas and during timeframes where Interior Fraser coho may be present, the commercial catch has been restricted to non-retention of coho; recreational fisheries have been restricted to non-retention, and First Nations harvests have been constrained, although some harvest has occurred when identifiable surplus exists. In addition, several strategies have been implemented to reduce incidental coho mortality including barbless hooks and revival tanks (Fisheries and Oceans Canada, 2014).

The 2010-2012 generation of wild coho salmon escapement to the Interior Fraser River watershed averaged 36,000 fish (Fisheries and Oceans Canada, 2014). Figure 8 shows coho escapements from 1975 to 2014.

2.3.4 Habitat Productive Capacity

The overall habitat productive capacity for coho in the South Thompson – Shuswap HMA is not known. However, production models may assist in determining the potential level of coho production.

In another analysis, the rearing potential of streams in the HMA was graded as poor, good or excellent, and smolt bio-standards applied to each category (as cited in DFO, 1997). Historical production models were based largely on the studied coastal streams and may not be directly applicable to the interior streams where winter conditions may be limiting and the rearing production in Shuswap Lake is significant. To predict the productive capacity of the HMA, extensive studies on the life history of the area's coho stocks need to be conducted to determine extend of natal stream and lake rearing for each conservation unit. In addition, areas with suitable rearing habitat must be measured, and the data applied to the models.

The life history of coho populations in the HMA is relatively complex due to the lake rearing behaviour. It is important to determine which factors trigger this stage, and to what extent the overall coho production depends on Shuswap Lake. The extensive shoreline (approximately 400 km) of this lake system undoubtedly provides major coho rearing opportunities and contributes significantly to the overall coho rearing potential in the HMA.

Historically, overfishing contributed to low spawner abundance and habitat degradation through water removal, low instream flows, and high water temperatures, poor water quality, loss of riparian vegetation, bank erosion and loss of off-channel habitat undoubtedly reduces the capacity of many streams to produce coho.

2.3.5 Production Objectives

There are no production objectives for coho; however, the Canadian Science Advisory Secretariat reviews have proposed lower and upper benchmarks based on the number of spawners that are required to recover population to in one generation in the absence of fishing (Sgen) and 80% of spawners at maximum sustained yield (Smsy). The Wild Salmon Policy Biological Status Assessment for Conservation Units of Interior Fraser River Coho Salmon has the lower and upper benchmarks for South Thompson-Shuswap coho at 2,511 and 4,735 respectively. Ideally, coho escapements meet or exceed the upper benchmark (R. Bailey, pers. comm.).

2.3.5 Enhancement Activities

The Eagle River Hatchery enhanced coho stocks from the Eagle and Salmon Rivers from 1983 to 1994. Since that time, Spius Creek Hatchery has continued to enhance Salmon River coho, with significant rebuilding during the 2000-2015 period.

Enhancement of Eagle River coho was re-initiated for stock assessment purposes starting in 2009, with staff from Spius Creek Hatchery conducting all adult/juvenile transport and fish culture activities. Eagle River releases are all coded-wire tagged (D. Lofthouse, pers. comm.). Releases at Salmon and Eagle Rivers are small compared to production releases from lower Fraser facilities. Staff were unable to capture sufficient broodstock from Eagle River in 2014, thus only the Salmon River will receive hatchery-origin juveniles in 2016 (R. Bailey, pers. comm.)

In response to declining escapements, Shuswap Hatchery initiated coho enhancement with both the middle Shuswap and Bessette/Duteau stocks in 2000. Following one complete cycle of releases, in 2004 middle Shuswap enhancement ceased, while releases of both fry and smolts into the historically more important coho-producing Bessette/Duteau watershed continued. Significant rebuilding was experienced for approximately a decade; in 2013 coho enhancement out of the Shuswap Hatchery ceased (D. Lofthouse, pers. comm.).

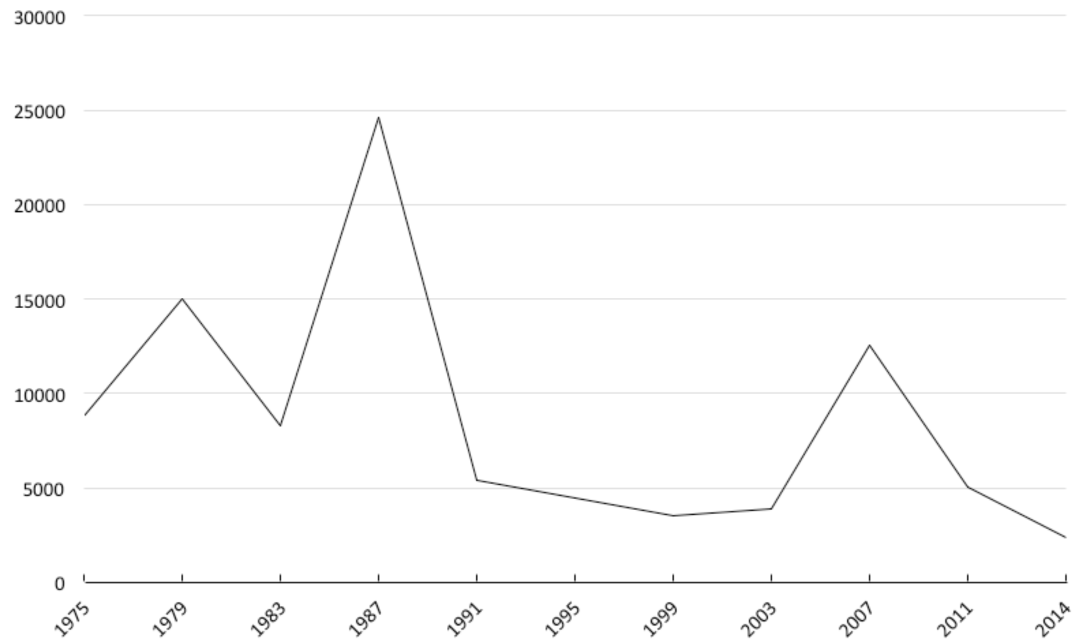

Figure 8. Coho salmon escapement in the South Thompson – Shuswap HMA from 1975 to 2014

2.4 Pink Salmon

Disclaimer: Section 2.4 is largely an excerpt from DFO, 1997; a more complete update will be done by DFO staff in 2016.

Historically, the upper Fraser pink stocks constituted the largest pink salmon populations in the Fraser watershed (as cited in DFO, 1997). This species has been recorded in many tributaries to Shuswap Lake (Salmon River, Tappen Creek, Scotch Creek, and Canoe Creek). The Hell's Gate landslide of 1913 completely blocked pink spawner access to streams above the Fraser Canyon. Subsequent remedial work and construction of fish-ways, resulted in pinks returning to the streams in the area. However, stock rebuilding has been slow and pink salmon abundance in the HMA remains low. Pink spawners have been observed in this area only since the mid-1960s, presumably the result of natural reintroduction.

Generally, pink fry start migrating to sea shortly after emergence (about mid-April), and enter saltwater by late April For the first few weeks, the juveniles stay close to shore in very shallow waters of the Strait of Georgia (as cited in DFO, 1997), then leave the Strait by mid-July to rear in outside waters. Pink salmon mature at age two, with the Fraser populations spawning predominantly on the odd year cycle. Fraser pinks return to natal streams in September and October with peak spawning occurring in mid-October (as cited in DFO, 1997).

Pink spawning streams are shown in Figure 9. The Adams River is the largest pink stock in the HMA. Spawners were recorded since 1965, with a maximum of around 4,000 spawners observed in 1979; spawning was concentrated in the middle and lower reaches of the River, with significant spawning occurring in the side channels. In the South Thompson River, a maximum 1,560 spawners were reported in 1981; spawning is concentrated about 2 km below Little Shuswap Lake. In Little River, pink spawners have been reported since 1975, with a maximum of 2,730 observed in 1977; spawning is scattered throughout the River. A very small stock is present in the lower Shuswap River with spawners recorded since 1975. Also, the Anstey River has a very small stock with spawners recorded since 1983.

Pink salmon in the HMA are of minor importance in the commercial and Aboriginal fisheries due to their low abundance. There is no estimate of the habitat productive capacity for these stocks; however, there is no reason to believe that it is limiting. The DFO production objectives since the 1980s have been to reduce the harvest rates on Fraser pink salmon to increase escapements. These actions will help rebuild the HMA's pink stocks, possibly to much higher levels of abundance than the present.

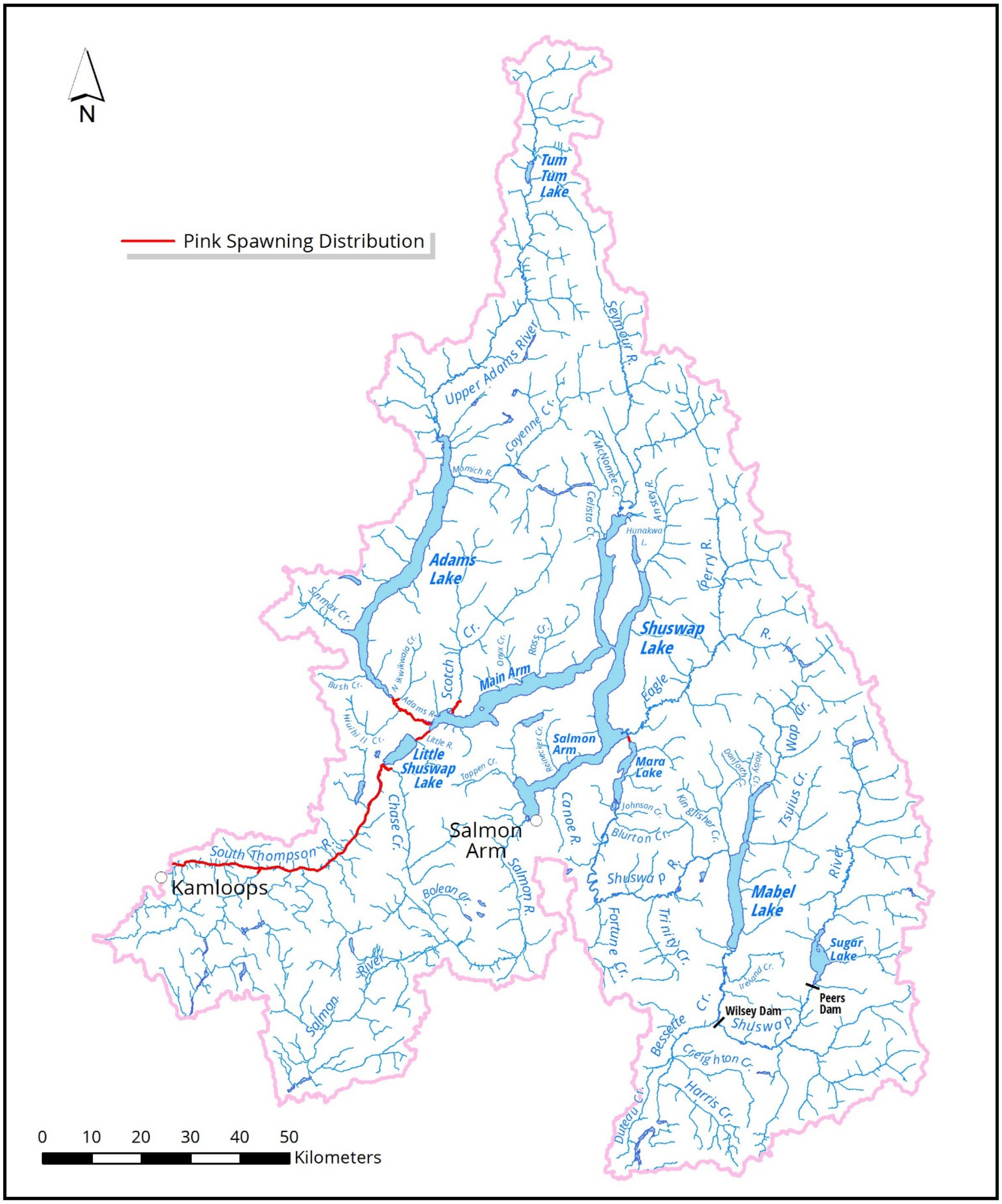

Figure 9. Spawning distribution of pink salmon in the South Thompson – Shuswap HMA

3. BIOPHYSICAL FEATURES

The productive capabilities of lakes and streams are determined by the physiography, climate, and hydrology of the area. The HMA falls into four physiographic land units: the Thompson Plateau, Shuswap Highland, Monashee Mountains, and Okanagan Highland (see Figure 10). These four land units are within the Interior Plateau of the Canadian Cordillera (as cited in DFO, 1997).

The biogeoclimatic ecological classification system (BEC) is based on vegetation, climate and physical site characteristics such as slope. There are seven BEC zones identified within the HMA: Interior Mountain-heather Alpine, Engelmann Spruce – Subalpine Fir, Montane Spruce, Interior Cedar-Hemlock, Interior Douglas Fir, Ponderosa Pine, and Bunchgrass (see Figure 11).

Much of the valley bottoms, particularly along the South Thompson River, lie within the Bunchgrass BEC zone. The open grassland habitat was the first to be colonized and cultivated; the grasses were ideal for grazing and this led to the establishment of the cattle industry in the HMA. Due to the dry climate, irrigation is necessary to produce a good growth of crops.

Settlements and transportation corridors have been established along the waterways. Historically, timber for building was accessed along the shallow benches or along river valleys, mostly within the Interior Douglas Fir BEC zone. Some parcels of land in the valley bottoms were cleared for agriculture. To date, all wooded BEC zones in the HMA have undergone harvesting, notably the Interior Cedar Hemlock and Montane Spruce BEC zones located upland from major waterways.

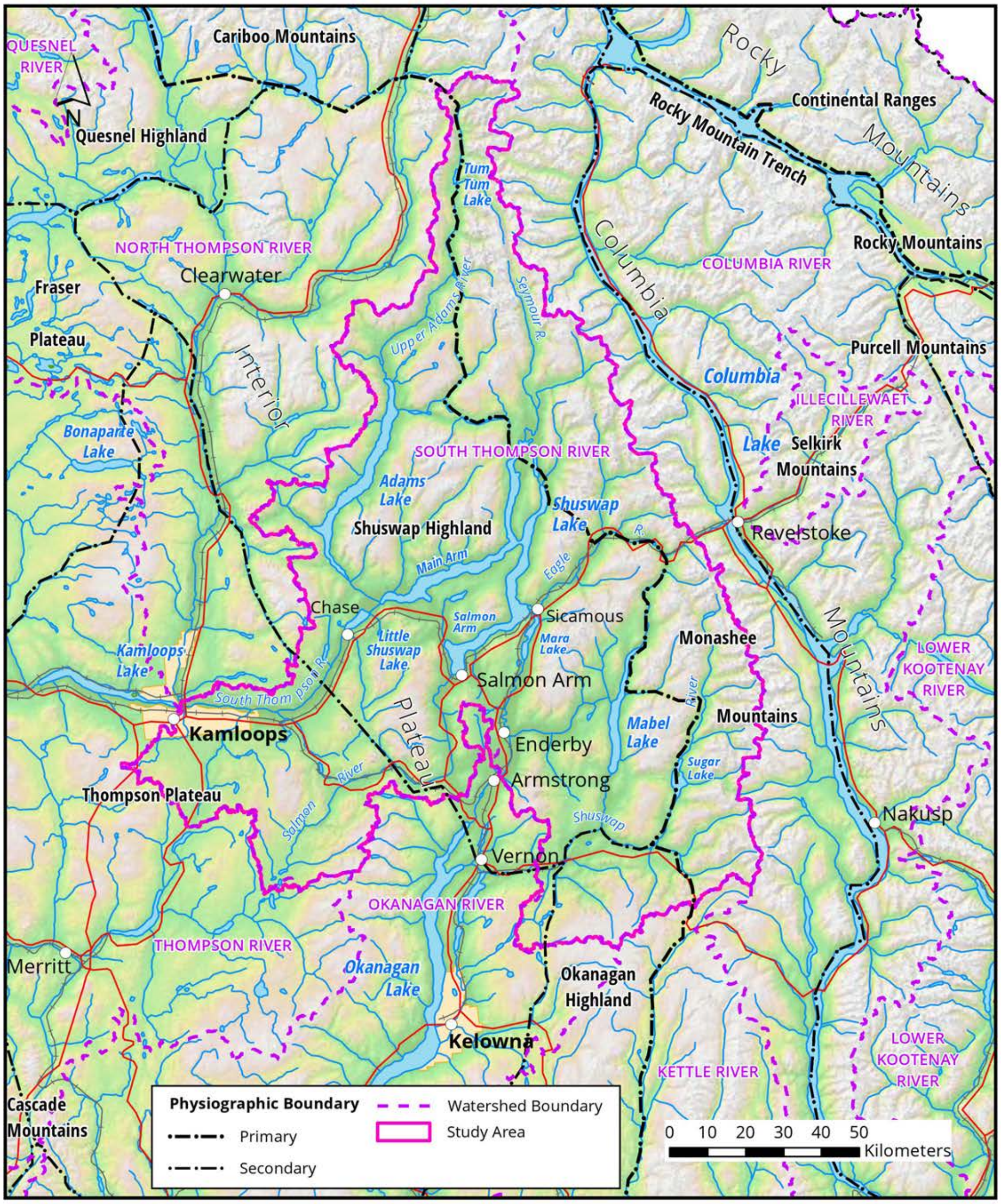

Figure 10. Physiographic land units within the South Thompson – Shuswap HMA

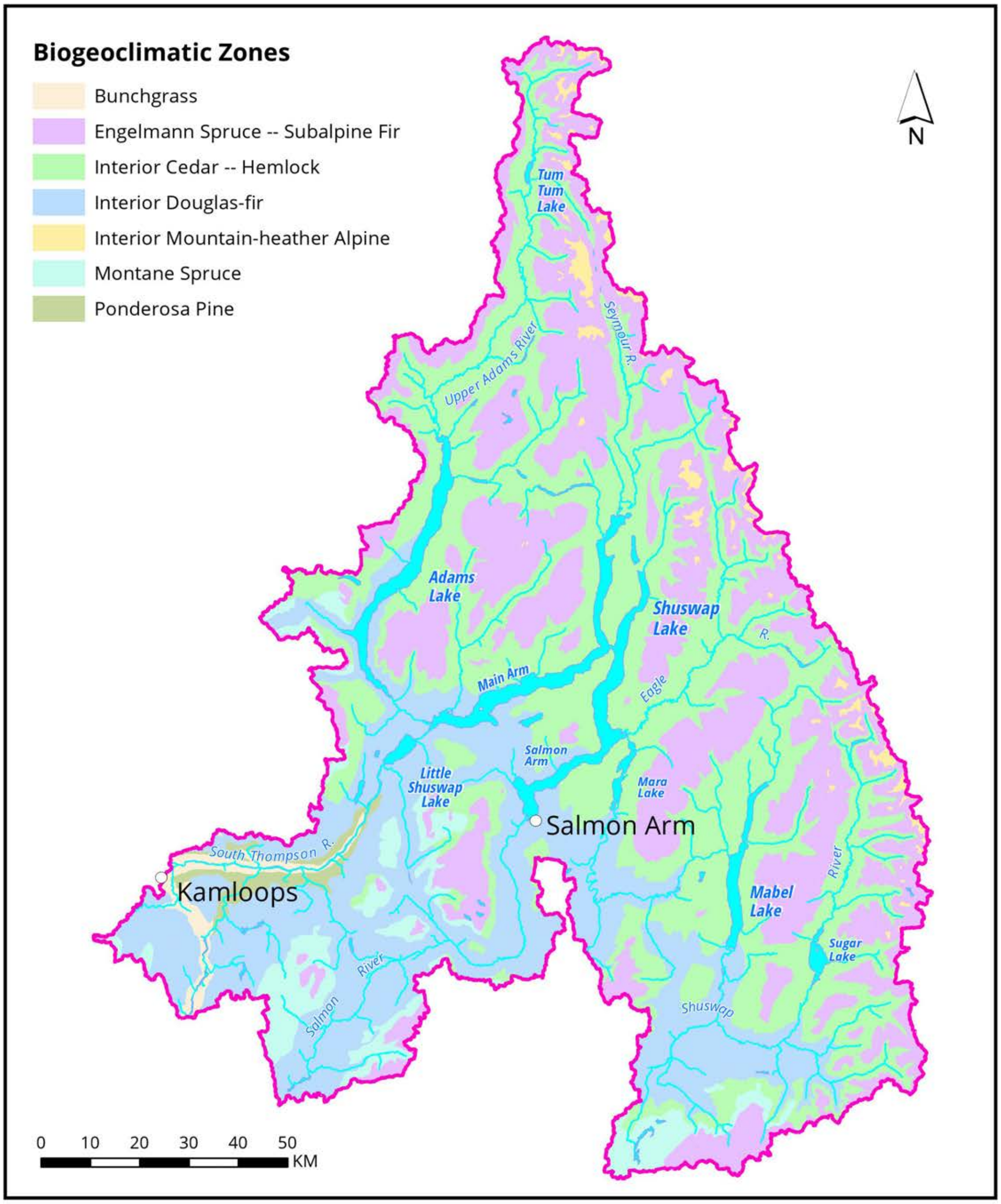

Figure 11. Biogeoclimatic Zones within the South Thompson – Shuswap HMA

3.1 Physiographic Descriptions

Thompson Plateau

The Thompson Plateau and the margins of the Shuswap Highland and Okanagan Highland have similar features. The flat or rolling terrain has resulted in the creation of numerous lakes and streams. Streams in this region have low-gradient channels and small-to-moderate drainage areas, the largest of which is the South Thompson drainage downstream of Little Shuswap Lake. Climate in the region is characterized by low precipitation (400 mm) and low snowpack (80-120 cm), the latter of which creates a short spring run-off period. Streams in this region are prone to freezing in late fall, and in summer they reach fairly warm temperatures, sometimes exceeding 18C which is the upper threshold for stream-dwelling salmonids.

Shuswap Highland and Okanagan Highland

The majority of the HMA is within the Shuswap Highland physiographic land unit; the northern-most small portion of Okanagan Highland is adjacent to the Shuswap Highland and is described similarly. There is a gradual increase from the flat or rolling terrain of the Thompson Plateau to the steep, jagged peaks of the south Cariboo and the Monashee mountains. Large river valleys and drainage basins, such as the Adams River, Middle Shuswap River, and Shuswap Lake, characterize the region. Headwater streams are typically steep, with confined channels and cobble-boulder substrate. Climate in the region is mixed. In the southern part of the region it is characterized by low precipitation (500 mm) and low snowpack (120 cm); however, these amounts are substantially higher in the northern part of the region depending on proximity to the Cariboo and Monashee mountains. Streams in the northern part of the region freeze earlier winter, warm up later in summer, and are generally less productive. The potential for rain-on-snow events in this region can result in large storm events.

Monashee Mountains

The Monashee Mountains are characterized by steep, jagged peaks and ranges. The streams in this region flow into several major salmon producing systems (e.g., Seymour, Eagle, and Shuswap Rivers). The headwaters of these tributaries are typically small, narrow, and contain few lakes. Only the lower reaches are used by fish. The highest levels of precipitation (800 mm) and snowfall (400 cm) in the HMA occur in this region. Streams have extended spring-summer run-off period. Due to glacial melt and steep terrain, high stream turbidity can be observed over the summer period; this is mitigated downstream by the influence of larger lakes. Water temperatures are the coolest in this region.

3.2 Regional Hydrologic Regime

Streams in the HMA generally display hydrologic regimes typical of the British Columbia interior in that they are characterized by a snowmelt hydrograph. The peak flow usually occurs in June, with timing (from May to July) and volumes of peak discharge determined by snowpack volume and weather conditions during the melt period (as cited in DFO, 1997; Dobson, 2016). The HMA displays a hydrologic regime with a wide range of regional variability that reflects the biogeoclimatic zonation: the pattern is for increasing precipitation in the more mountainous north-east, and drier conditions in the flatter, low-lying south and west areas.

The headwaters of the northern and eastern basins (e.g., Adams, Seymour, Eagle) drain areas of high snowfall and sustained snowmelt, and have numerous small glaciers present. These contribute a late-summer glacier melt. The incidence of late-summer low flows is less common than in other basins of the HMA. In the southern and western basins, agriculture is predominant and creeks are subject to water withdrawals for irrigation. Water from Bessette Creek is diverted out of the Shuswap watershed into the Okanagan by Greater Vernon Water Utility for irrigation and domestic use (Regional District of North Okanagan). Several creeks in this part of the HMA (e.g., Fortune, Bessette, and Duteau Creeks) experience extremely low flows during the growing season.

The HMA contains several of the largest lakes in the British Columbia interior (i.e.., Shuswap, Adams, Mara, and Mabel) that have a significant influence on the hydrology of their outlet streams. The mainstem South Thompson and Adams Rivers demonstrate this influence with sustained late summer and winter flows, and a dampening of the snowmelt peak flows.

Most streams in the HMA, except those reaches below major lake outlets, develop winter ice cover ranging from two to four months in duration.

4. CHANGING REGULATORY AND FUNDING CLIMATES

4.1 Changes to Regulatory Frameworks Since 1997

4.1.1 Forest Harvest Operations

In 1995 the *Forest Practices Code of British Columbia* (FPC) was introduced to regulate forest harvesting operations. The Act was a significant piece of legislation for managing resource use on Crown Lands. In 2004, the generally 'prescriptive' regulatory regime of the FPC was replaced with a more 'results-based' approach introduced under the current *Forest and Range Practices Act* (FRPA). A significant change is that the provincial government is no longer responsible for reviewing documents, plans and prescriptions. Although they issue cutting permits and road permits, they don't review them or have the oversight they once had under the FPC. Essentially, operational procedures are governed by professional reliance, and regulated by the resulting environmental outcome.

Under FRPA, two provincial designations have been introduced for the forest and agriculture industries to protect watersheds with important fish values:

- Fisheries Sensitive Watersheds (FSW) have significant fisheries values and watershed sensitivity. Results and strategies must be identified in agreement holders' Forest Stewardship Plans that are consistent with management objectives set by the Minister.
- Temperature Sensitive Streams may be designated if trees are required adjacent to the stream to manage the temperature for the protection of fish. The designation may be applied to a portion of a stream and for a finite period of time.

The former *Forest Practices Code* required that a Watershed Assessment Procedure (WAP) be completed for all community watersheds and for all watersheds with high-value fisheries that were jointly requested by MELP and MOF. The results of the WAP would guide forest development planning and ensure that timber harvesting did not negatively impact watershed values (Ministry of Forests). The *Forest Practices Code* was in force at the time of the *1997 Strategic Review*, and WAPs were completed, underway, or recommended for some of the basins in the HMA.

4.1.2. Federal Fisheries Act

Recent changes to the *Fisheries Act* came into effect on November 25, 2013. The focus of the amendments was meant to protect the productivity of recreational, commercial and Aboriginal fisheries (Fisheries and Oceans Canada, 2015). The changes to the *Fisheries Act* were designed to address the following:

- "Focus the Act's regulatory regime on managing threats to the sustainability and ongoing productivity of Canada's commercial, recreational and Aboriginal fisheries;
- Provide enhanced compliance and protection tools;
- Provide clarity, certainty and consistency of regulatory requirements through the use of standards and regulations; and
- Enable enhanced partnerships to ensure agencies and organizations that are best placed to provide fisheries protection services to Canadians are enabled to do so" (Fisheries and Oceans Canada, 2015).

Administrative changes have occurred, which are not addressed in this document, however it should be noted for context that DFO staff have discontinued reviewing forest and water referrals and have withdrawn from watershed planning processes.

At the time of this update, the *Fisheries Act* is under review again.

4.1.3. Water Sustainability Act

For over a century, a number of laws have governed the use and activities in and around water in British Columbia:

- *Water Act* (1909) – one of BC's oldest pieces of legislation and the primary legislation governing water, it regulates allocation and licensing of surface waters and controls activities in and around streams to protect fish and aquatic habitats
- *Water Protection Act* (1994) – prohibits dams on the Fraser River and prevents inter-basin diversions, thereby protecting flows and migration routes for salmon
- *Fish Protection Act* (1997) – designates a small number of streams as 'sensitive' and provides management options to protect in-stream flows. In 2005, *Riparian Area Regulations* (RAR) were enacted under the *Fish Protection Act*; RAR protects riparian areas while facilitating urban development that embraces high standards of environmental stewardship. RAR calls on local governments to protect riparian areas on privately-owned lands during residential, commercial and industrial developing by ensuring a Qualified Environmental Professional (QEP) conducts an assessment of proposed activities.
- *Forest and Range Practices Act* (2004) – governs land use activities on Crown lands. FRPA includes provisions for Fisheries Sensitive Watersheds and Temperature Sensitive Streams designations (see Section 4.1.1 for more information).

In 2009, the BC Ministry of Environment began a process of *Water Act* Modernization. In 2014, Bill 18 was given royal assent. This repealed most of the *Water Act*, enacted the *Water Sustainability Act*, and subsumed most of the *Fish*

Protection Act and renamed the remaining portions of the latter under the *Riparian Areas Protection Act.*

The *Water Sustainability Act* (WSA) and an initial set of regulations were brought into force in February 2016. The WSA continues to regulate the use and diversion of surface water, under Crown 'ownership', with rights granted through water licenses on a "first-in-time, first-in-right" scheme (FITFIR). Some important new provisions under the WSA include:

- Groundwater protection regulation and licensing
- Consideration of environmental flow needs (EFN) in deciding on an application for a new diversion/withdrawal
- Declaration of a temporary protection order during times of significant water shortages in an area. The critical environmental flow threshold (CEFT) would be determined for streams within the area and that would supercede existing water rights granted through the first-in-time-first-in-right scheme (except for basic household needs).

EFN is the volume and timing of water required for the proper function of an aquatic ecosystem; it is different for each river and stream. CEFT is the minimum flow required for an aquatic ecosystem, below which significant or irreversible harm is likely to occur. This is the level to which existing licences are regulated (not against the EFN). CEFT supersede existing rights in the FITFIR regime, except for basic household needs.

Regulation and policy development for the Water Sustainability Act is ongoing.

4.2 Availability of Government and Third-party Funding

Funding programs offered by different orders of government as well as third parties such as foundations, trusts, and other grant-making organizations have changed since the 1997 Strategic Review was written. These changes are reflected in the introduction and sun-setting of funding programs, the amount of funds available, eligible applicants, priorities and objectives to be met by funded projects, and requirements for matching funds with other funds or in-kind contributions.

In the 1990s, funds were relatively readily available for activities such as monitoring, assessments, and restoration works. Programs such as the Watershed Restoration Program, Forest Renewal BC, and Fisheries Renewal BC funded these activities.

In recent years, funds have been available through the federal Habitat Stewardship Program since 2000 (administered by Environment Canada), the Recreational Fisheries Partnership Program since 2013 (administered by the Department of Fisheries and Oceans), and the Fish Habitat Restoration Initiative since 2014 (administered by Aboriginal Affairs and Northern Development Canada). Generally, each of these government programs has requirements to be met in terms of eligible applicants and projects, species or habitat that will be improved or impacted, and requirements for matching funds.

There are several non-government and third-party grant-making organizations that fund fisheries projects in BC. Within the South Thompson – Shuswap, the most commonly accessed funds come from the Pacific Salmon Foundation, BC Conservation Foundation, and Habitat Conservation Trust Fund. Additionally, BC Hydro administers the Fish and Wildlife Compensation Fund in partnership with the Province and DFO.

5. RESOURCE USES

Fish and fish habitat are affected by environmental events that alter hydrological regimes and physically disturb the environment. Generally, fish populations reach certain equilibria around the natural disruptive events and the stocks remain productive. However, human resource use tends to increase the incidence of disturbances and increase the risks to fish production. Resource use conflicts in the HMA are increasing with expanding populations. Past actions are no longer acceptable and must be modified to minimize watershed impacts and sustain the fisheries resources in lakes and streams.

The following sections describe some resource uses within the HMA and identify areas where development activities are affecting or have the potential to affect fish and fish habitat. Table 2 and Figure 12 provide an overview of impacts by different land uses and events to the sub-basins of the HMA.

Table 2. Gross areas and proportions of land uses by each of the eight major sub-basins of the HMA

Watershed	**Gross Area (ha)**	**Agriculture**		**Range lands**		**Urban**		**Other**	
		Area (ha)	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**
Adams River	333,365	1876	0.56	101	0.03	112	0.03	33,1277	99.37
Eagle River	124,976	2478	1.98	0	0	359.1	0.29	122,140	97.73
Lower Shuswap	118,469	14,840	12.53	270	0.23	510	0.43	102,848	86.81
Mabel Lake	102,779	89	0.09	0	0	83	0.08	102,607	99.83
Middle Shuswap	303,381	10,848	3.58	1817	0.60	197	0.07	290,519	95.76
Salmon River	156,424	14,033	8.97	5597	3.58	130	0.08	136,664	87.37
Shuswap Lake	398,612	11,667	2.93	269	0.07	3297	0.83	383,379	96.18
South Thompson	210,117	18,606	8.85	38,991	18.56	2286	1.09	150,234	71.50
TOTALS	**1,748,1223**	**74,437**	**4.26**	**47,045**	**2.69**	**6974**	**0.40**	**1,619,668**	**92.65**

Note: Data is derived from Baseline Thematic Mapping Present Land Use Version 1 Spatial Layer, updated in 2014.

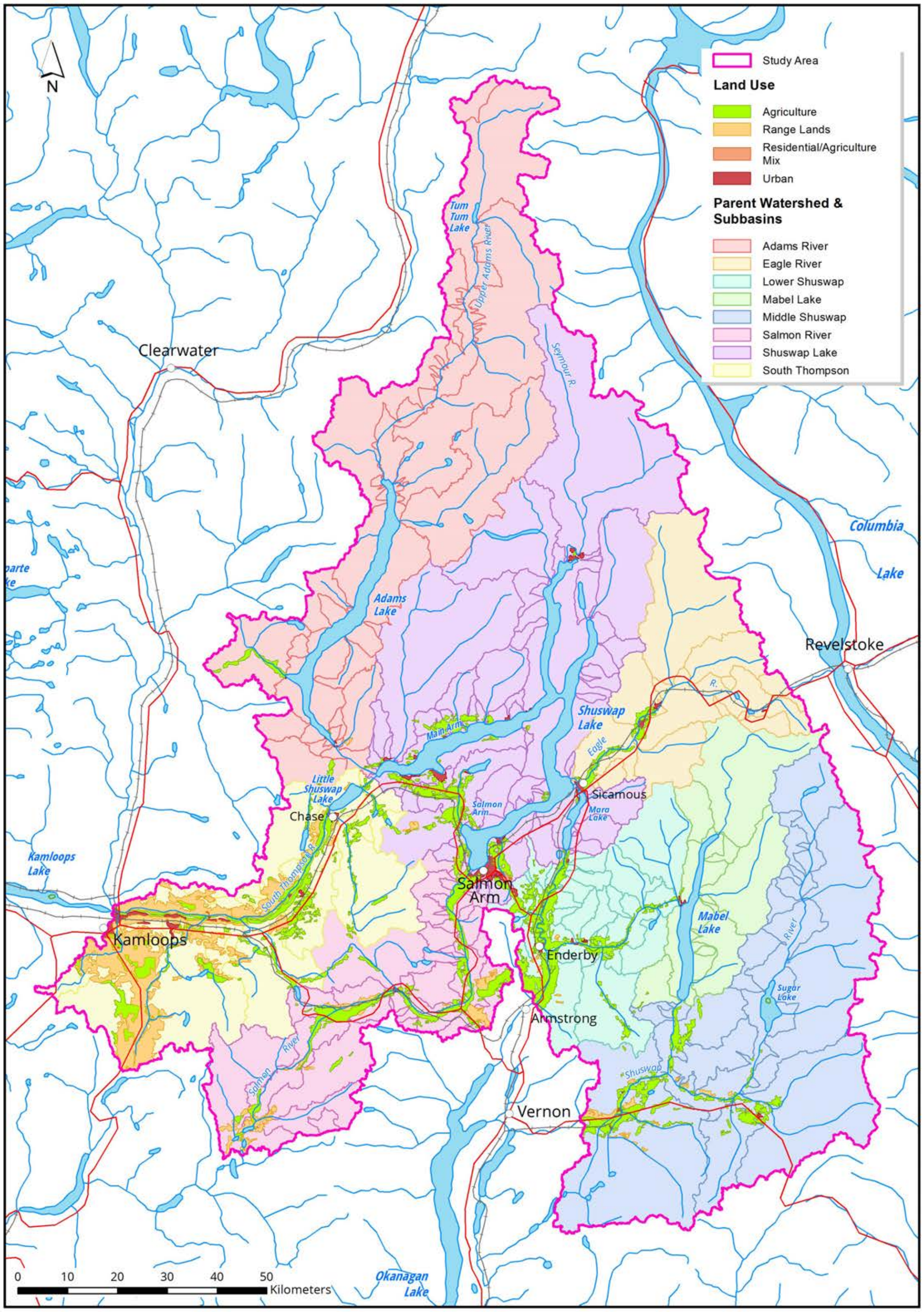

Figure 12. Agriculture, range, and urban land uses within the eight major sub-basins of the South Thompson – Shuswap HMA

5.1 Forestry

The administration of forestry activities is the responsibility of the Province, and done mostly by the Ministry of Forests, Lands and Natural Resource Operations through provincial laws and regulations (see Section 4.1). The South Thompson – Shuswap HMA falls within the Thompson – Okanagan Forest Region, and within two natural resource districts: Okanagan Shuswap, and Thompson Rivers (see Figure 13.)

Forest tenures are granted for forest management activities on Crown lands in a variety of formats to the forest industry. The most common is in the form of forest licenses to forest products companies: Canfor, West Fraser Mills, Tolko, Interfor, Canoe Forest Products, Stella Jones, and Gorman Brothers are the largest operators within the HMA. Area-based tenures, such as tree farm licences, woodlots, and community forests are also granted in exclusive defined areas. BC Timber Sales (BCTS), part of MFLNRO, has a mandate to provide the cost and price benchmarks for timber harvested from public land in British Columbia. BCTS operates within the HMA in two business areas: Kamloops, and Okanagan – Columbia.

5.1.1 Existing Resource Use

Allowable annual cuts for each Timber Supply Area since the 1980s to present is listed in Table 3.

Since the *1997 Strategic Review* was completed, a significant mountain pine beetle (MPB) epidemic occurred that killed the majority of mature pine trees in the BC Interior. Table 4 outlines the impact of the MPB and the amount of forest harvesting from 1995 to present for each major sub-basin of the HMA; Figure 14 illustrates forest harvesting since 1995. It's important to note that MPB impact and forest harvest are not mutually exclusive.

Table 3. Allowable Annual Cuts for Kamloops and Okanagan Timber Supply Areas (excluding area-based tenures)

Kamloops TSA (#11)		**Okanagan TSA (#22)**	
Effective Date	**AAC**	**Effective Date**	**AAC**
1981	2,350,000 m^3/yr	1989	2,700,000 m^3/yr
1 Jan 1989	2,412,280 m^3/yr	1992	2,615,000 m^3/yr
1 Jan 1994	2,416,680 m^3/yr	1993	2,804,000 m^3/yr
1 July 1996	2,679,180 m^3/yr	1 Jan 1994	2,615,000 m^3/yr
1 Jan 2003	2,682,770 m^3/yr	1 Jan 1996	2,615,000 m^3/yr
1 Jan 2004	4,352,770 m^3/yr	1 Aug 2001	2,655,000 m^3/yr
1 June 2008[1]	4,000,000 m^3/yr	1 Jan 2006	3,375,000 m^3/yr
		29 Feb 2012	3,100,000 m^3/yr

[1] Timber Supply Review was initiated for Kamloops TSA in 2015; a decision is expected in Spring 2016

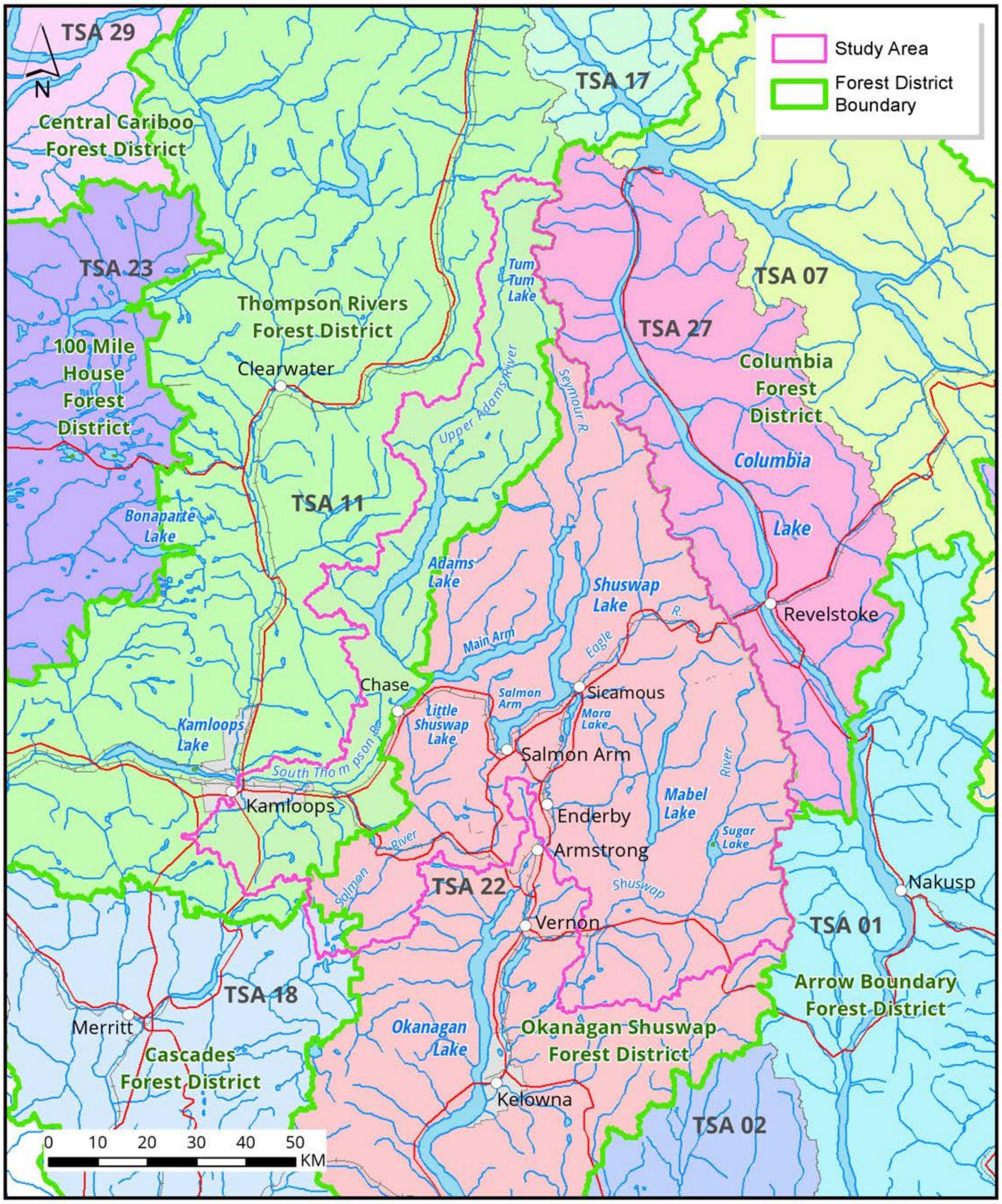

Figure 13. Forest Districts and Timber Supply Areas within the South Thompson – Shuswap HMA

Table 4. MPB impacts and forest harvesting since 1995

Watershed	Gross area (Ha)	Area MPB (ha)	% MPB	Area forest harvesting 1995-present (ha)	% Forest harvesting
South Thompson	210,117.18	31,830.70	15.15	35,122.47	16.72
Adams River	333,365.49	21,606.21	6.48	30,615.31	9.18
Shuswap Lake	398,611.75	8830.97	2.22	31,044.45	7.79
Salmon River	156,423.75	35,042.29	22.40	35,648.34	22.79
Eagle River	124,976.38	1307.23	1.05	8257.46	6.61
Lower Shuswap	118,468.82	2724.41	2.30	9334.64	7.88
Mabel Lake	102,779.02	2255.43	2.19	5808.82	5.65
Middle Shuswap	303,380.54	19,811.74	6.53	25,293.17	8.34
Total Area:	**1,748,122.93**	**123,408.97**		**181,124.66**	**10.36**

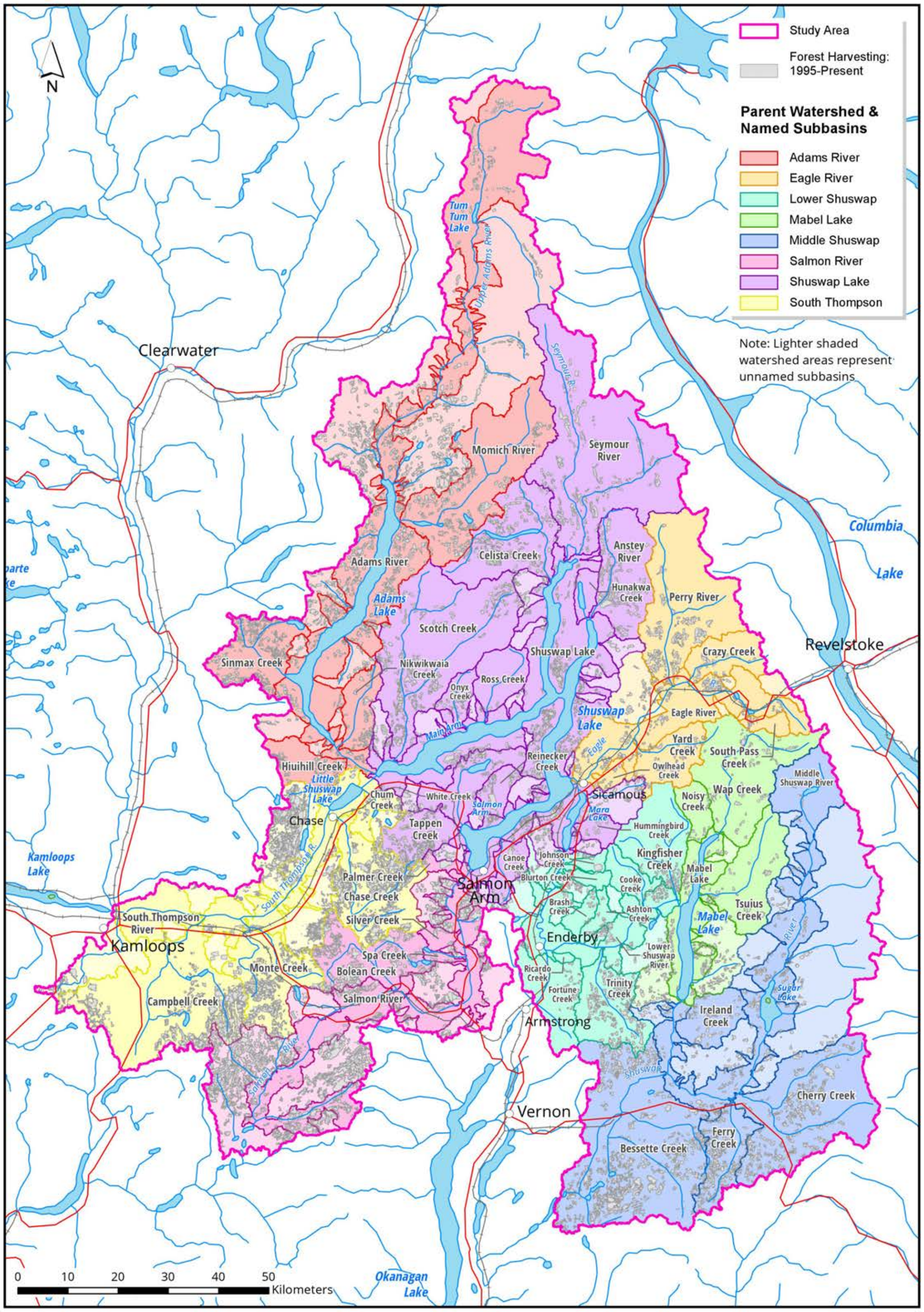

Figure 14. Forest harvesting in each major sub-basin of the South Thompson – Shuswap HMA since 1995

For perspective, the maximum volume of red-attack in Kamloops TSA was 8.7 million m^3 in 2006, in the previous year was 6.2 million m^3; the maximum volume of red-attack in the Okanagan TSA was 1.6 million^3 in 2007, in the previous year it was 1.3 million m^3 (see Figure 15).

5.1.2 Impacts on Fishery Resources

Of interest and importance to salmonids is the amount of area harvested by watershed and the amount of road building. Many of the watersheds in the HMA contain valuable salmon spawning and rearing habitats which are susceptible to stream changes and sedimentation from upstream logging activities. Watersheds with over 20% of their area logged are at risk to changes in peak flows due to altered snow accumulation and melt patterns. In addition to hydrological changes, changes in sediment transport, hillslope stability and channel stability due to road building and harvesting activities affect fish habitat. The impacts of logging on streams and their fish populations include changes in flows and water temperatures; changes in nutrient and dissolved ion concentrations; increased erosion and landslides; loss of large woody debris from stream beds; and changes in input of leaf detritus when riparian vegetation is removed. Furthermore, fish diversity is greater in basins with relatively low timber harvest levels (≤25% of basin area harvested) than in basins with high harvest levels (>25% of area harvested) (as cited in DFO, 1997).

The construction of logging roads can lead to increased sedimentation to water courses; generally, higher road densities yield higher sedimentation but that isn't always the case. Many factors affect sedimentation including road gradients, terrain stability, climate, ownership and maintenance, and age. Old roads built prior to the *Forest Practices Code*, for example, were built to a lower standard (P. Belliveau, pers. comm.).

Changes to forest cover, whether natural or human-caused, have impacts on stream flow, nutrient loadings coming off a site and sediment delivery. Natural causes include insect and disease infestations, forest fires and wind-throw events. The most common human-caused changes are as a result of timber harvesting and road building. All of these factors impact the hydrologic regime of a stand or watershed.

The BC MFLNRO Land Management Handbook 66, the Compendium of Forest Hydrology and Geomorphology, states that hydrologic recovery of forest stands is the recovery or return to pre-disturbance hydrologic regime. Hydrologic recovery depends on many variables: tree and understory species present, tree spacing, tree density, crown closure, elevation, aspect, climatic characteristics, site topography; also, hydrologic recovery changes as a forest stand matures and changes over time (BC Ministry of Forests, Lands and Natural Resource Operations, 2010). As such, it is difficult to apply general rules about hydrologic recovery, however surrogates to infer hydrologic recovery have been used, notably stand height and crown closure. The Watershed Assessment Procedure Guidebook suggests that recovery starts at

3m average stand height, and is 90% recovered when stand height reaches 9m, for a stand with crown closure from 50% to 70% (BC Ministry of Forests, Lands and Natural Resource Operations, 1999). Different areas of the HMA have different site indices and climactic conditions; it may take less than 10 years to reach 3m average stand height in some areas, or 20 years or more in other areas.

Equivalent clearcut area (ECA) is a measure of what areas are acting like a clearcut; this could include areas where timber was harvested, but also natural disturbances such as wildfires and pest or disease outbreaks. Assessing the ECA for the individual watersheds and sub-basins would be a useful exercise; in fact this has likely been done for many watersheds by hydrologists. These reports are typically completed for forest licensees and BCTS, and are not publicly available. However, some ECAs were calculated through Watershed Assessment Procedures that were completed with public funds in the 1990s; some of these results are noted in Section 6. ECA for an area takes into account the hydrologic recovery of an area over time.

Within the HMA, 11 sub-basins are designated Fisheries Sensitive Watersheds (FSW): Anstey, Eagle, Perry, Yard, Scotch, Seymour, Bessette, Cherry, Sitkum, Upper Shuswap, and Wap (see Figure 16). Generally speaking, FSW objectives are to maintain the natural streambed conditions, water quality, quantity and timing of flows, and minimize the cumulative effects of primarily forestry activities. Forest licensees and BCTS must include results and strategies in their Forest Stewardship Plans (FSPs) on how they will address the objectives in FSW-designated watersheds.

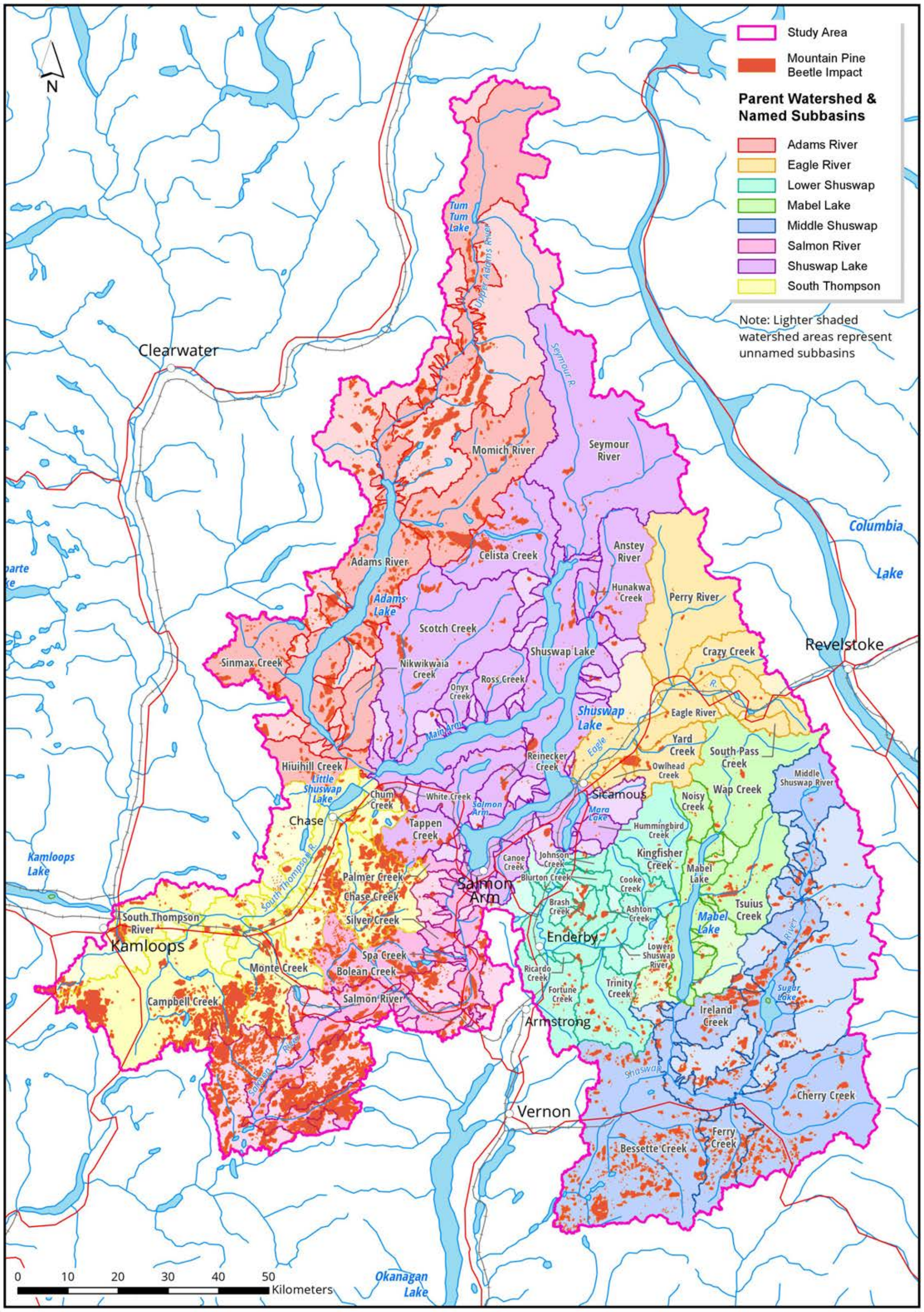

Figure 15. Impact of Mountain Pine Beetle within the South Thompson – Shuswap HMA

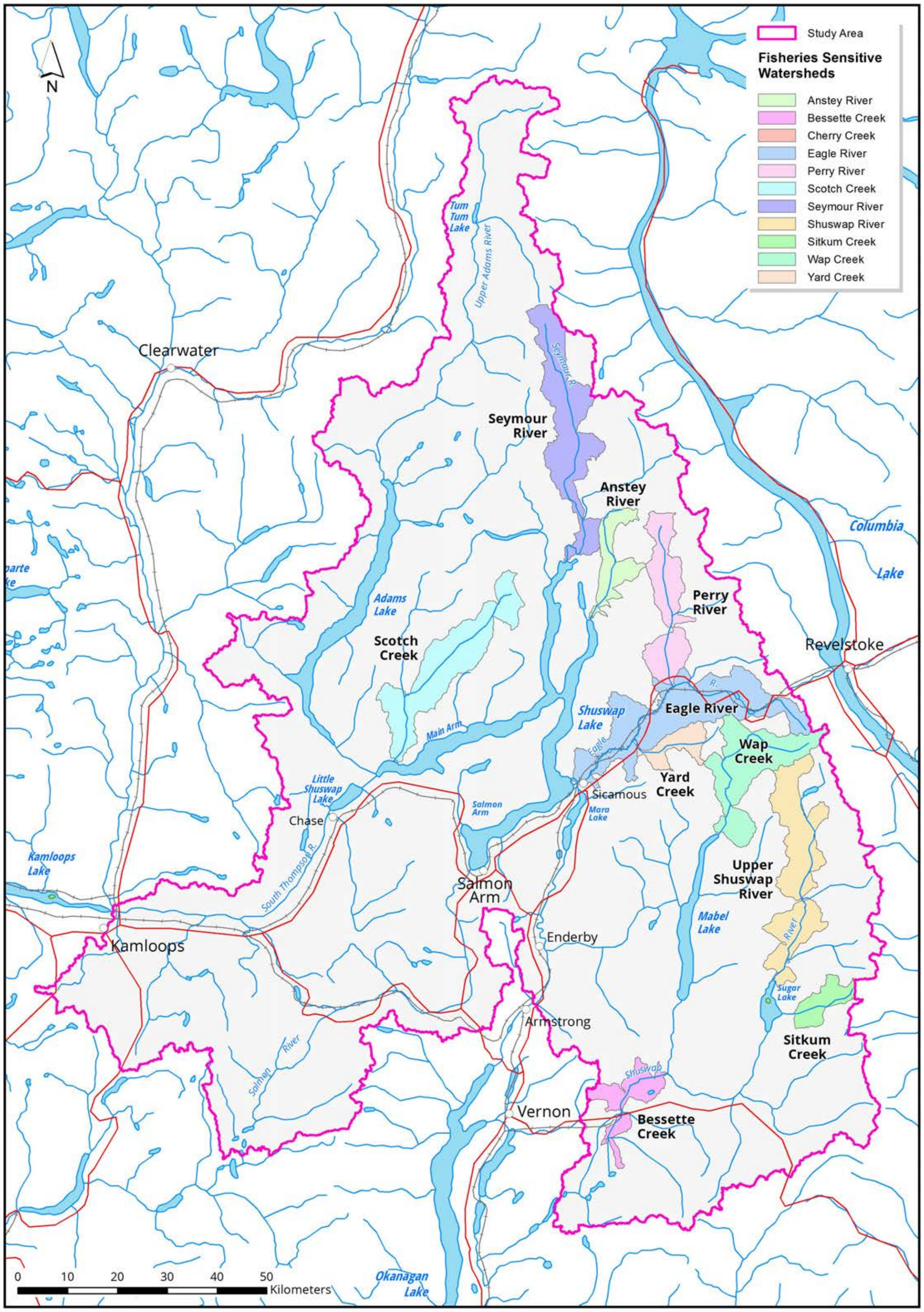

Figure 16. Designated Fisheries Sensitive Watersheds within the South Thompson – Shuswap HMA

5.2 Agriculture

Land clearing – both historic and present day – associated with agriculture affects stream habitat by decreasing streambank stability, increasing erosion, changing temperature regimes, and altering nutrient input dynamics (as cited in DFO, 1997). Livestock access to streams degrades riparian vegetation along streams, while run-off from feeding grounds and cultivated cropland reduces water quality. In addition, water withdrawal for irrigation reduces instream flows to the detriment of spawning and rearing fish and invertebrate populations.

While land clearing for agriculture does have adverse effects on salmonids and their habitats as compared to the original state of the land, there is potential for the maintenance of ecological goods and services through agricultural activities. Other land use activities, such as residential, urban and industrial land development, are more permanent in their impacts on salmon habitat.

5.2.1 Existing Resource Use

Agricultural activity in portions of the HMA is intensive, particularly along the South Thompson corridor and in the arable lands to the south of the Shuswap Lake system, the Salmon River valley and Shuswap River basin. Other areas with agriculture include Chase Creek, Eagle River, and Sinmax Creek. Cattle grazing, feed crop production, and dairying are the main agricultural activities. Other agricultural activities in the HMA include poultry and egg farming, fruits and vegetables, livestock (other than cattle), viticulture, Christmas trees and turf. Ginseng was grown in the South Thompson corridor in the recent past but production has declined since the *1997 Strategic Review*.

Beef cattle grazing takes place on Crown and privately owned rangelands during summer and fall, and herds overwinter on the home ranches typically in valley bottoms. Dairy farms are also typically located in valley bottoms. Feed for livestock is generally produced on the farm using sprinkler irrigation. In the case of dairy farms, supplemental feed is imported. Manure generated on the farm is used as a soil conditioner, thereby reducing or eliminating the need for farms to use commercial fertilizers. There have been some concerns about manure-spreading practices and impacts to water quality if not done in the proper timing window.

Table 5 provides an estimate of agriculture activities and land uses in the three most impacted sub-basins, the Shuswap, Salmon and Eagle River watersheds (McDougall, 2014).

Table 5. Estimated number of dairy and poultry farms in the Shuswap, Salmon and Eagle River watersheds

	Dairy	Commercial poultry
Shuswap River		
Upper section: Mabel Lake to Enderby	5	0
Lower section: Enderby to Mara	23	4
Fortune Creek: Armstrong to Enderby	15	7
Salmon River		
Middle section: Westwold to Silver Creek	3	1
Lower section: Silver Creek to Salmon Arm	13	5
Eagle River		
	3	0
Totals	**62**	**17**

McDougall notes that dairy farms crop approximately 1 acre per milking cow. The estimated 62 dairy farms multiplied by the provoincial average dairy herd size of 135 milking cows is 8,370 dairy cows and approximately 8,370 acres of land in production in these portions of the HMA.

Table 6 provides an overview of the animal unit month (AUM) limits (a measure of cattle-grazing capacity on Crown lands) for the Shuswap and Salmon River watersheds.

Table 6. AUM limits for Shuswap and Salmon River watersheds

	AUMs limit
Shuswap River watershed: upstream of Mabel Lake	2,847
Shuswap River watershed: downstream of Mabel Lake to Mara Lake	1,900
Salmon River watershed	15,804

Within the portion of the HMA that is within the Columbia Shuswap Regional District, agricultural production has grown in area from 14,712 ha in 1996 to 19,767 ha in 2011; the largest increases in types of production for that time period are hay crops, field crops and greenhouse vegetables. In 2011, there were 616 operating farms reported (Sustainability Solutions Group, 2014).

Local governments have led the development of agriculture area plans (AAPs) since approximately 2010. The purpose of these documents is typically to enable and/or attract a viable, sustainable, local agriculture economy. AAPs may make special provisions for environmental stewardship or sensitive areas. Within the HMA, there are three agriculture plans:

- Kamloops Agriculture Area Plan (City of Kamloops, 2013)
- Shuswap Agriculture Strategy (Sustainability Solutions Group, 2014)
- Regional District of North Okanagan Regional Agriculture Plan (Regional District of North Okanagan, 2015)

5.3 Water Use

Water demand in the HMA is immense, and can be attributed to the population density, high irrigation demand and semi-arid climate. Acquiring information pertaining to water supply, in-stream flows, environmental needs and water licensing was difficult, as the information wasn't readily available[2]. Therefore, the update to this section is minimal.

Figure 17 shows the locations of points of diversion within the HMA.

5.3.1 Hydro-electric development

Within the HMA, there is on BC Hydro project on the Shuswap River and several small hydro projects (as cited in DFO, 1997). The BC Hydro project on the Shuswap River consists of the 13m high Peers Dam at the outlet of Sugar Lake, and the 30m high Wilsey Dam and accompanying Shuswap Falls Generation Station located near Lumby. The project was originally licensed and built in 1929, refurbished in 1942. New penstocks were constructed in 1994 and the flow-release control was improved. The facility generates power for the surrounding area.

The Shuswap River does not have a typical regulated flow regime since the Peers Dam is undersized for the river and a large proportion of the annual freshet flow is spilled. Water levels in Sugar Lake fluctuate up to 7m annually and the reservoir is managed to a full pool by late summer. Timing and magnitude of summer spills have altered natural flow patterns, possibly impacting fish populations in the middle Shuswap River above Wilsey Dam (e.g., emergent rainbow trout fry) (Department of Fisheries and Oceans Canada, 1997).

The Wilsey Dam creates a barrier to salmon passage on the middle Shuswap River. There have been efforts to enable passage for migrating salmon upstream of the dam and downstream smolt migration. See Section 6.8 for more information.

5.3.2 Governance

A critical new development impacting water use is the implementation of the provincial *Water Sustainability Act* (WSA) in February 2016. Of particular importance to salmonids and their habitat is the protection and regulation of groundwater and new provisions for environmental flows needs and critical environmental flow thresholds. See Section 4.1.3 for more information.

[2] At the time of this update, provincial staff were heavily focused on responding to the drought of 2015 thus they were unable to provide specific information on water use

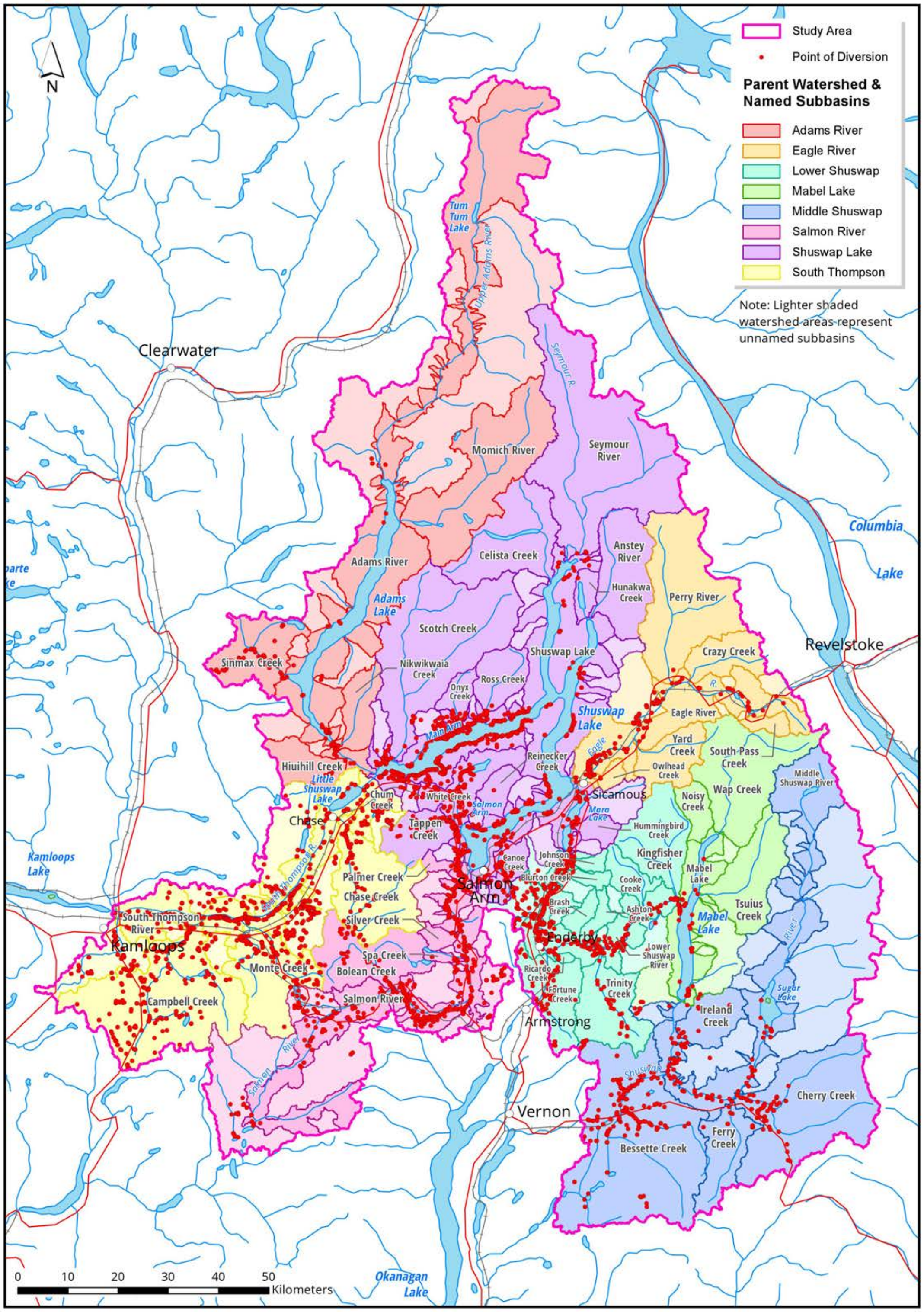

Figure 17. Points of diversion within the South Thompson – Shuswap HMA

5.4 Water Quality

Water quality concerns arise from many activities in the HMA including agriculture, forestry, urban settlement (storm water and wastewater), and industry. The impacts from these include sedimentation, nutrient loading, chemical and bacteriological contamination, and toxic spills.

Water quality conditions in the HMA vary considerably from basin to basin due to different land and resource uses, different climatic and geologic conditions and times of year. In the past, the South Thompson mainstem had good water quality, but higher turbidity and nutrient levels were noted downstream near Kamloops, possibly due to influences from agriculture and settlement in that area. It's been determined that Chase Creek is the primary source of sediments in the South Thompson River (as cited in DFO, 1997).

5.4.1 Current Conditions

Historical data for Shuswap Lake indicates that generally, the water quality in the lakes has been good. In recent years, some areas of Shuswap and Mara Lakes have shown signs of nutrient enrichment. The Shuswap River and Salmon River in particular carry a significant load of nutrients to Mara Lake and Shuswap Lake, respectively. The Salmon Arm wastewater treatment plant, which discharges into Salmon Arm Bay, and the City of Enderby wastewater treatment plant, which discharges into the Shuswap River, are point-sources of nutrient inputs (Northwest Hydraulic Consultants, 2014; Shuswap Lake Integrated Planning Process, 2014).

The Shuswap River contributes an estimated 39,900 kg Total P per year to Mara Lake, over 98% of which is attributed to agriculture and range. It also contributes an estimated 507,400 kg Total N to the lake, of which 47% is attributed to agriculture and 47% is attributed to timber harvesting and forest fires. The Salmon River contributes an estimated 22,200 kg Total P per year to Shuswap Lake, over 98% of which is attributed to agriculture and range. It also contributes an estimated 359,000 kg Total N to the lake, of which 37% is attributed to agriculture and 59% is attributed to timber harvesting and forest fires (Tri-Star Environmental Consultants, 2014).

Recent water quality monitoring has also indicated temporary increases in nitrogen following a dominant or sub-dominant sockeye return. This is due to the release of nutrients from salmon carcasses as they decompose in near shore areas of the lakes and rivers (Shuswap Lake Integrated Planning Process, 2014). Nitrogen released from timber harvesting and forest fires is also known to be a temporary effect that lasts a few years (Tri-Star Environmental Consultants, 2014).

Turbidity and sedimentation is of particular importance to salmonids. This is monitored at several locations within the HMA, primarily for drinking water purposes, however the data is difficult to acquire.

There is ongoing concern over potential toxic spills into salmon-bearing waters resulting from train derailments or industrial accidents. The risk is considerable since highways and railways follow valley bottoms and run along rivers and lakeshores. There is considerable industrial development in these areas as well, including the South Thompson mainstem near Kamloops, Salmon Arm Bay, Tappen Bay, and Canoe. Source water protection plans are mandated by the BC Ministry of Health and carried out by local governments for assuring safe drinking water, but the benefits of these plans and their strategies extend to all aquatic life. The City of Kamloops has completed a source water protection plan, and others are underway for the Village of Chase, District of Sicamous, and City of Enderby.

5.5 Population, Settlement, Recreation and Transportation

5.5.1 Existing Resource Use

Assessing the population within the confines of the HMA is challenging because boundaries are not congruent with watershed boundaries of the HMA. For example, the City of Kamloops is a significant population and is partially within the HMA; the majority is downstream of the HMA and for this reason has been excluded from the population estimate. All other smaller populations that are partially within the HMA are included in the population estimate. Table 7 outlines the census information from 1996 and 2011.

Table 7. 1996 and 2011 census information

Jurisdiction	1996 census	2011 census
CSRD 'C'	6379	7662
CSRD 'D'	4033	4047
CSRD 'E'	1551	1335
CSRD 'F'	2492	2368
Salmon Arm	14,859	17,464
Sicamous	2827	2441
RDNO 'D'	2919	2848
RDNO 'E'	1050	939
RDNO 'F'	4264	3938
Enderby	2754	2932
Lumby	1689	1731
TNRD 'L'	2915	3049
TNRD 'O'*	3460	1335
TNRD 'P'	4948	3620
Chase	2460	2495
TOTALS	**58,600**	**58,204**

* Incorporation of the Barriere in 2007 impacted population numbers

Settlement and residential development extends along the South Thompson River, Chase Creek, Salmon River, Eagle River, lower Shuswap River, and Bessette Creek. Residential and other developments are also centered along the lakeshore areas of Shuswap Lake, Mara Lake and Mabel Lake, and to a lesser degree Little Shuswap Lake and Adams Lake. Settlement areas include Kamloops, Tk'emlups te Secwepemc, Chase, Adams Lake Indian Band, Little Shuswap Lake Indian Band, Salmon Arm, Neskonlith Indian Band, Sorrento, Sicamous, Falkland, Enderby, Splatsin, Lumby and Cherryville. Note that each first nation may have multiple reserves within the HMA. Figure 18 illustrates settlement areas within the HMA.

Major transportation corridors include the Trans-Canada Highway and the Canadian Pacific Railway, both of which run parallel to the South Thompson River, the Salmon Arm shoreline and the Eagle River. Highway 97 runs parallel to Mara Lake and segments of the Salmon and lower Shuswap River; Highway 6 runs parallel to segments of the middle Shuswap River.

The Shuswap Lake system is the focus of a wide range of recreational activities and the foundation of a significant tourism economy. Boating, houseboating, water skiing, fishing, and paddling are the primary recreational pursuits on the lakes. There are 11 marinas and 1704 summer wet-moorage spots. There are three major houseboat operators with 178 houseboats in their combined fleet as of 2011 (Peak Planning Associates, 2012).

Recreation management planning has occurred throughout the HMA. A draft recreation management plan for Shuswap, Little Shuswap Mara and Adams Lakes was prepared through the Shuswap Lake Integrated Planning Process (Peak Planning Associates, 2014), but most of it has not been implemented to date. It sets out goals and strategies pertaining to clean water, sensitive habitats, and clean beaches. The Regional District of North Okanagan has also led the development of the Shuswap River Watershed Sustainability Plan that includes components of recreation management (Regional District of North Okanagan); this is described in more detail in Section 6.6.

5.5.2 Impacts to Fishery Resources

Urban developments increase the amount of impervious surface area in a watershed and can affect the hydrology by increasing overland flow and flood peaks. Residential development degrades water quality by point source pollution such as storm water and wastewater inputs, and non-point source inputs via septic seepage.

Upland developments have had a significant impact on fish habitat in the lakes and rivers. Land clearing and stream diversions have resulted in upland and foreshore erosion and water quality degradation. Foreshore habitat is directly impacted by dredging and filling, and the constructions of marinas, boat launches, break-waters, retaining walls and groynes. These activities result in the removal of foreshore substrate and riparian vegetation, which hare vital for maintaining habitat for spawning and rearing.

Foreshore Inventory Mapping (FIM) and Sensitive Habitat Inventory Mapping (SHIM) projects have been completed for many areas of the HMA including the South Thompson River, Little Shuswap Lake, Shuswap Lake, Eagle River, lower Shuswap River, and Mabel Lake (Ecoscape Environmental Consultants Ltd., 2009; 2010; B. Harding, pers. comm.). These projects provide a useful overview of the relative importance of different segments of foreshore habitat for each water body and details of impacts to foreshore habitat. They are described in more detail in Section 6.

Transportation corridors can encroach on stream channels. Often rip-rapping is used for channel containment and causes a reduction of channel complexity through

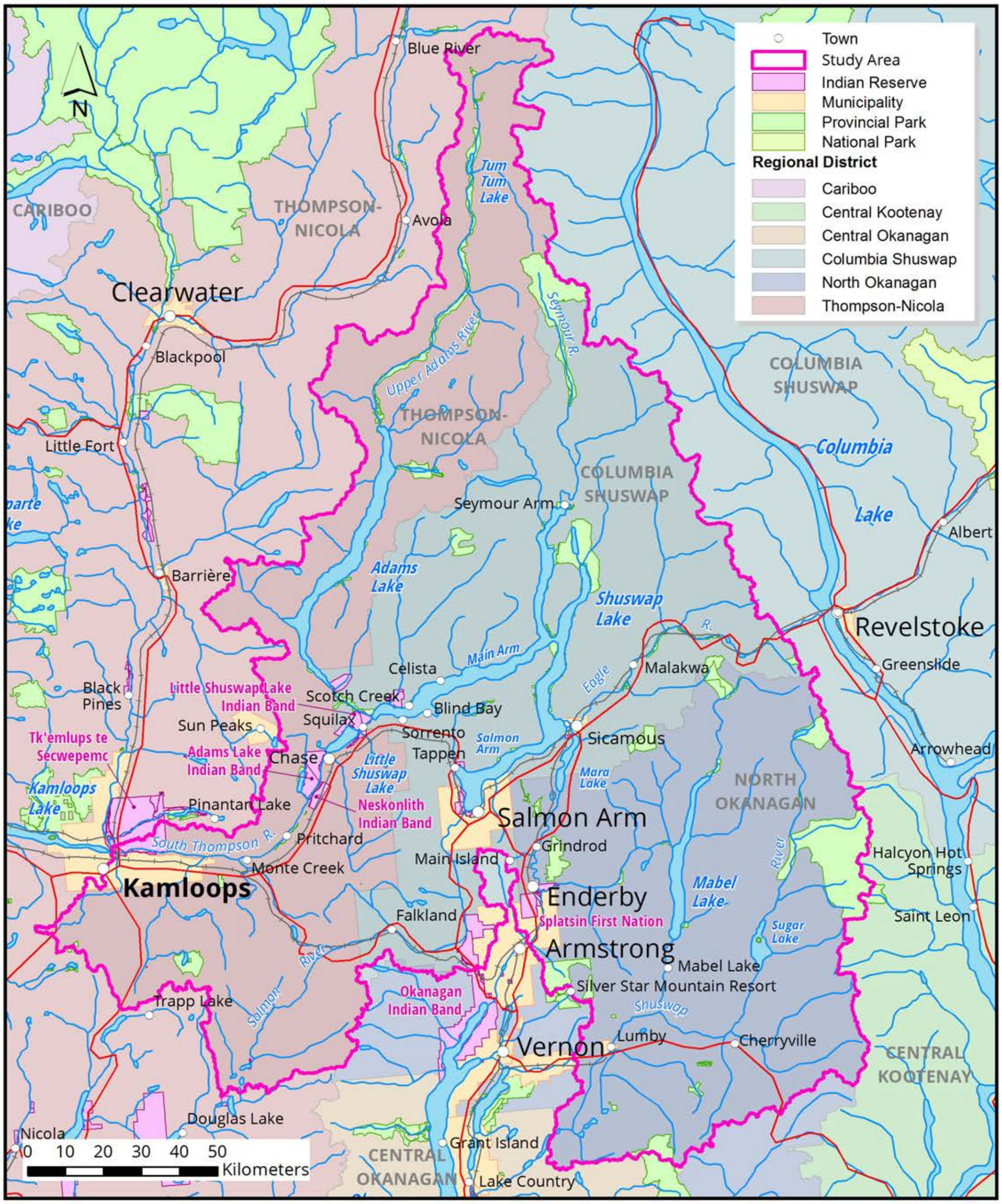

Figure 18. Settlement areas within the South Thompson – Shuswap HMA

the loss of side channels and off-channel habitat. This has occurred adjacent to the Trans-Canada Highway along the South Thompson and Eagle Rivers (Department of Fisheries and Oceans Canada, 1997). Road and highway maintenance introduces water pollutants such as sand and salt, and increases the risk of accidents and resulting toxic spills.

Highway construction and upgrades have been ongoing in the HMA for several years, with further expansions planned for the immediate future. Twinning segments of the Trans-Canada highway east of Kamloops and replacing old bridge structures are a priority for the BC Ministry of Transportation and Infrastructure. These are described in more detail in Section 6.

5.6 Mining

Mineral related impacts in the HMA have not been significant due to limited mining activity, particularly near important salmon bearing streams. There are currently no operational metal mines in the HMA. Industrial mineral mines within the HMA include Harper Ranch (limestone) and Falkland (gypsum) (BC Ministry of Energy and Mines, 2015).

Ruddock Creek in the upper Adams River drainage is a proposed underground lead-zinc mine; it's currently in the environmental assessment process (Imperial Metals, 2016). Ajax Mine is a proposed open-pit copper and gold mine immediately south of Kamloops, in the Peterson Creek sub-basin of the Thompson River watershed; it's also currently undergoing an environmental assessment (M. Simpson, pers. comm.).

Figure 19 illustrates existing and proposed mineral developments within the HMA.

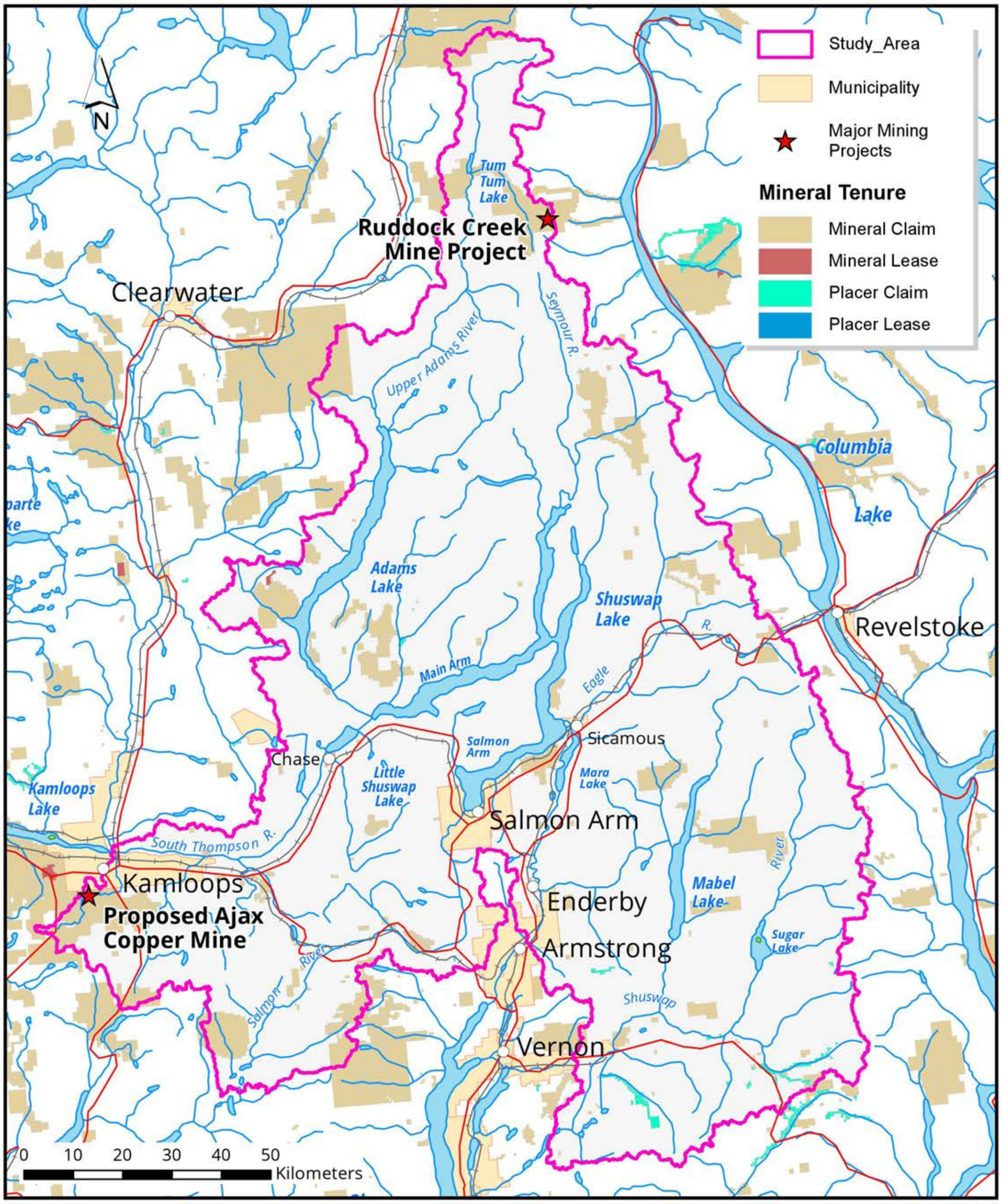

Figure 19. Mineral development within the South Thompson – Shuswap HMA

6. WATERSHED MANAGEMENT ISSUES AND RECOMMENDATIONS

The watersheds in the South Thompson – Shuswap HMA are influenced by a variety of landscapes and climatic conditions, as described in Section 3. Landforms range from flat or rolling terrain to steep, jagged mountains; climatic conditions range from very dry to high levels of precipitation. Rivers and streams are products of their drainage basins and are affected not only by physical and hydrological conditions, but also by land use practices within the watershed. Many of the activities discussed in Section 4 have affected fish habitat by altering or degrading the riparian ecosystem or stream channel, degrading water quality, and increasing erosion or sedimentation. The severity of the impact depends on the activity and on the sensitivity and resilience of the stream and its watershed.

The priority in ensuring protection of the fisheries resources in the HMA is to protect and manage stream ecosystems including the uplands, riparian zones, and floodplains of rivers and lakes. In watersheds where impacts have already occurred and are damaging fish habitat, the natural water and sediment regimes and riparian communities need to be restored. However, restoration alone cannot be a substitute for vigorous stewardship of riparian and aquatic ecosystems.

Monitoring escapements to salmon streams throughout the HMA is imperative to managing the stocks and ensuring adequate spawner returns. This is particularly important Interior Fraser Coho, which have been in decline and are listed as *Endangered* by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC, 2002).

The remainder of Section 6 will describe the management issues and recommendations for the HMA; one sub-section for each of the eight major sub-basins and their tributaries (South Thompson; Adams; Shuswap Lake; Eagle; Salmon; lower Shuswap; Mabel Lake; and middle Shuswap). They are presented beginning at the downstream end of the HMA at the Thompson River, going upstream through each major sub-basin. Tables listing management strategies for each sub-basin and its tributaries are listed at the end of each sub-section.

6.1 South Thompson System

The South Thompson sub-basin includes Little River (from the outlet of Shuswap Lake), Little Shuswap Lake, Chase Creek and the South Thompson mainstem to Kamloops. The sub-basin is within the Interior Douglas Fir, Ponderosa Pine, and Bunchgrass biogeoclimatic zones. The region's primary land uses are urbanization and settlement, agriculture, recreation, and linear development. The Village of Chase and Adams Lake Indian Band Sahhaltkum Reserve 4 are situated along Little Shuswap Lake, near the outlet of the lake and the confluence of Chase Creek. The Trans-Canada Highway, Canadian Pacific Railway, and City of Kamloops are adjacent to the watercourse.

6.1.1 South Thompson River

The South Thompson River is a moderately sized river that flows from Little Shuswap Lake to Kamloops, where it meets the North Thompson River; from that point onward it is known as Thompson River. The river is buffered by flows from the Shuswap Lake system. The mean monthly discharge is 293 m^3/s with a maximum and minimum mean monthly discharges of 452 m^3/s and 171 m^3/s, respectively (Government of Canada).

Fishery resources in the South Thompson River are extremely high. The river has a significant escapement of chinook and fall run sockeye, as well as pink salmon. The chinook stock in the South Thompson is one of the largest in the HMA, comparable only to the lower Shuswap River. This may partially be attributed to the excellent spawning substrate in the river (Department of Fisheries and Oceans Canada, 1997).

In addition to providing extremely important spawning habitat, the river also serves as a migration corridor for adult salmon en route to spawning grounds upstream and for out-migration of smolts. The mainstem and lower reaches of tributary streams also provide early rearing habitat for juvenile chinook and transient rearing habitat for downstream migrants. The river provides excellent habitat for rainbow trout which feed on salmon eggs, fry and smolts.

The river habitat between Kamloops and Monte Creek was mapped, assessed and rated as to its importance to fish populations in 1994 by Envirowest Consultants Ltd.; that study was revised to include shoreline habitat classifications in 1996. These studies indicated that 83% of the streambank had been altered (as cited in DFO, 1997).

In 2015, a Sensitive Habitat Inventory and Mapping project (SHIM) was completed for the entire length of the South Thompson River (i.e., from the outlet of Little Shuswap Lake at Chase to the confluence of the North Thompson River). The SHIM project created a map of the river with an Aquatic Habitat Index (AHI). The full SHIM and AHI report were not available at the time this document update was prepared; however they will be publically available mid-2016.

The losses of riparian vegetation, as documented by shoreline assessments done in 1994 and 2015, create a major impact to fish habitat. This includes increased erosion and sedimentation, loss of large woody debris input, and reduction in shade and shelter. A decrease in riparian cover also reduces detrital input and insect drop. Further disturbance to the riparian areas has been caused by ATV use in off-channel areas of the river. The South Thompson is the site of historical log drives and dredging, the residual effects of which remain and negatively impact Chinook spawning areas (B. Harding, pers. comm.).

Agriculture is a predominant land use throughout the valley bottom and benches above the river. Cattle grazing, crop production (i.e., hay and corn), vegetables and viticulture are among the most common agriculture activities. Impacts of agriculture include degradation of water quality through non-point source pollution, clearing of riparian vegetation, trampling by cattle, and bank erosion. An additional impact created by agriculture is fish mortality by improperly screened and/or improperly installed irrigation intakes (i.e., installation via open trenching across a stream bed through clay increases sedimentation).

Urban development is prevalent along the river, mostly within the City of Kamloops. This includes industrial development, riverfront settlement, and parks. The impacts of these include increased impervious surfaces which increase overland flow, turbidity, and point-source pollution via storm sewers; clearing of riparian vegetation; and recreational use and disturbance. Additionally, erosion of the riverbanks is attributed to motorized watercrafts on the South Thompson River.

Linear developments (i.e., highways, roads and railways) follow the river corridor on the north and south sides. Within the South Thompson basin, road density is 2.43 km/km^2. Linear developments have resulted in containment of the channel by bank protection, primarily rip-rap. This type of stabilization, while providing some habitat value, can also result in an overall reduction of habitat complexity. The proximity of linear developments to watercourses also heightens the possibility sediment flushes and hazardous spills that may result in fish mortality (as cited in DFO, 1997; B. Harding, pers. comm.). However, the presence of linear developments adjacent to the river may also offer some protection as it prevents further development in some locations (i.e., for residential or commercial use).

Segments of the Trans-Canada Highway have been under construction since 2001 (i.e., structural replacements and four-laning). Most recently, there have been major construction projects along the South Thompson River at Hoffman's Bluff and Pritchard (BC Ministry of Transportation and Infrastructure). These projects may cause direct impacts to fish and fish habitat in the river, or at creek crossings. The BC MOTI and its contractors adhere to standard specifications and site-specific special provisions for construction to minimize environmental impacts (BC Ministry of Transportation and Infrastructure; B. Persello, pers. comm.).

The City of Kamloops completed a Source Water Protection Plan (SWPP) in 2014; this document presents strategies specific to protecting source water for drinking but may also benefit fish and fish habitat (T. Thomas, pers. comm.). The process for developing a SWPP is laid out in the Ministry of Health's Source-to-Tap Assessment Guideline, and includes steps such as conducting a hazard source inventory, risk assessment, and recommending actions to improve drinking water protection (Government of British Columbia). The Kamloops SWPP is limited to city limits.

The South Thompson River has had at least two significant restoration projects done. Streambank stabilization work was completed in Dallas and at Chase, the latter of which was prone to repeated streambank failures from a high streambank, depositing significant amounts of sediment to nearby chinook spawning habitat.

Management Priorities

The management priorities for the South Thompson River are protecting and restoring riparian zones and salmon spawning grounds, maintaining good water quality, and minimizing impacts to valuable fish stocks by improperly screened or installed irrigation intakes. Understanding the impacts of boat wake erosion in the South Thompson system is also a priority.

Table 8 summarizes progress made against the 1997 strategies, and presents new strategies.

6.1.2 Campbell Creek, Monte Creek, Dry Creek, Neds Creek, Martin Creek, Niskonlith Creek and Harper Creek

The lower reaches and delta areas of small South Thompson tributary streams including Campbell, Monte, Dry, Neds, Martin, Niskonlith, and Harper Creeks provide seasonal rearing habitats during high water periods for chinook and other salmonids. They are also an important source of spawning gravels to the South Thompson River as evidenced by the concentration of chinook spawning in the adjacent downstream areas (R. Bailey, pers. comm).

In the late 1990s sediment sumps were installed in Neds Creek, upstream of the railway crossing, to keep priority sites clear of sediment during low-flow conditions thereby eliminating the need for clearing culverts during high water periods.

Pink salmon have been recently observed spawning in Campbell Creek and local residents and student in the nearby neighbourhood area have cleaned the stream of debris and taken on a stewardship role (Youds, 2013).

Fish passage improvements were made to the Campbell Creek highway culvert in 1999 (i.e., installation of baffles); additionally, riparian planting and fencing was completed adjacent to the creek at the Kamloops Wildlife Park in 2000 (D. Hussey, pers. comm.).

Management Priorities

Management priorities for South Thompson tributaries are maintaining or improving water quality, maintaining flows for rearing salmonids (especially coho and chinook), restoring riparian zones, maintaining gravel recruitment (an especially important consideration in flood mitigation and emergency works), and ensuring that fine sediment loading from these creeks doesn't negatively impact chinook spawning grounds in the South Thompson mainstem.

Table 9 lists management strategies.

6.1.3 Chase Creek

Chase Creek enters the South Thompson River near the municipality of Chase. Pink salmon have been observed spawning in the creek in years of high returns. There is significant chinook spawning in the South Thompson River below the confluence with Chase Creek. Consequently, fish and fish habitat concerns are associated mainly with downstream impacts from Chase Creek, particularly sedimentation of spawning areas due to streambank erosion and channel degradation. There are also concerns for resident fish species and juvenile salmon in the lower portion of the creek. An impassable falls on Chase Creek located at 2 km upstream from the mouth is a barrier to upstream fish migration.

The Chase Creek basin has had a history of landslide incidents, sedimentation, and aggradation issues – some of which have been natural due to steep stream escarpments and slope instability, and others related to timber harvesting. The middle reaches of Chase Creek in particular have aggraded and widened because of sediment deposits from upstream, leading to flooding, erosions, and channel migration issues (Bates, 2010).

Timber harvesting in the upper watershed has resulted in the loss riparian cover, while the construction and operation of roads has contributed to de-stabilization of banks, erosion and siltation (as cited in DFO, 1997). In recent years, extensive harvesting has occurred in the Chase Creek watershed, in part due to the Mountain Pine Beetle epidemic. The current ECA is not known and since 1995, 30.03% of the gross watershed area has been harvested; this is the highest proportion of harvest for that time frame of all the basins in the HMA and is a significant concern for its impact to fish habitat. The combination of natural instability with extensive forest harvesting increases flood frequencies and magnitude, subsequently causing debris slides, bank erosion, and channel widening (Bates, 2010).

The middle and lower reaches of Chase Creek are impacted by agriculture. These include non-point source water quality degradation, livestock encroachment to riparian areas and loss of vegetation, trampling and increased erosion and sedimentation, and water withdrawal for irrigation.

Trans-Canada highway improvement projects pose a risk to Chase Creek. The replacement of the Chase Creek Bridge may cause some disturbance to fisheries habitat; however, the small span enables a bridge design that can minimize local impacts (B. Persello, pers. comm.).

Management Priorities

Management priorities for Chase Creek are maintaining or improving water quality, restoring riparian zones, maintaining gravel recruitment (an especially important consideration for flood mitigation and emergency works), and ensuring that sediment loading from Chase Creek doesn't negatively impact chinook spawning grounds downstream of the creek confluence. An update of the current and projected harvest plans and road building would be useful to determine the current risk to fisheries values and for planning restoration works.

Table 10 summarizes progress made against the 1997 strategies, and presents new strategies.

6.1.4 Little Shuswap Lake and Little River

Within the HMA, Little Shuswap Lake is a relatively small and shallow body of water. The Village of Chase and Adams Lake Indian Band Sahhaltkum Reserve 4 are located at the southwest end of the lake (where it discharges into the South Thompson River); Little Shuswap Lake Indian Band Quaaout Reserve 1 and a resort and golf course are located at the northeast end of the lake.

Developments associated with settlement on the lake's shorelines have resulted in loss of valuable foreshore habitat. These activities include construction of docks, groynes, retaining walls, break-waters and boat launches; and foreshore modifications including beach-combing (i.e., clearing the natural substrate), importation of sand for beaches, and clearing of riparian vegetation. One site at the southeast corner of the lake was significantly impacted by the installation and subsequent break-down of a large breakwater comprised of hundreds of tires and fill.

Foreshore Inventory and Mapping (FIM) and Aquatic Habitat Index (AHI) were completed were completed for Shuswap, Little Shuswap and Mara Lakes in 2009, and Shoreline Management Guidelines were completed in 2011. A key outcome of the FIM project was the creation of a map of the lakes' shorelines in which individual shoreline segments are colour-themed based on their AHI, a relative ranking of habitat value. The map is housed on the Community Mapping Network (Shuswap Lake Watershed Atlas). The results of that project indicated that the largest proportion of shoreline habitat value is ranked as *High*, followed by *Moderate* and *Low*. Furthermore, it indicated that slightly more than half of the shoreline of Little Shuswap Lake is disturbed; the remaining portion is in a natural state (Ecoscape Environmental Consultants Ltd., 2009).

Little River runs 3.6 km downstream from the outlet of Shuswap Lake into Little Shuswap Lake. The AHI ranks its entire length as having *Very High* habitat values. The river is among the most important habitats in the HMA because it is a bottleneck and a migration corridor to upstream spawning habitats and for out-migration of smolts. Approximately half of the riverbank habitat is disturbed; the remaining proportion is in a natural state (Ecoscape Environmental Consultants Ltd., 2009).

Trans-Canada highway improvements (i.e., highway four-laning) pose a risk to the lake and the river because of the possibility of infilling, spills, and sediment flushes during construction. The BC MOTI and its contractors adhere to standard specifications and site-specific special provisions for construction to minimize environmental impacts (BC Ministry of Transportation and Infrastructure; B. Persello, pers. comm.).

Management Priorities

The management priority for Little Shuswap Lake and Little River is protection of migration, spawning and rearing habitat.

Table 11 summarizes progress made against the 1997 strategies, and presents new strategies.

Table 8. South Thompson River management strategies

Strategies from *1997 Review*	Status	Notes
Map riparian areas upstream of Monte Creek/Pritchard, including the foreshore and riparian zones of Little Shuswap Lake and Little River. Classify habitat and develop guidelines for use by the Municipality and Regional Districts for incorporation to OCPs and zoning. Protect undisturbed riparian habitat and restore riparian zones where vegetation has been lost or reduced.	✔ Complete	Foreshore Inventory and Mapping (FIM) and Aquatic Habitat Index (AHI) of the Shuswap Lake system including Little River and Little Shuswap Lake was completed in June 2009; Shoreline Management Guidelines were completed in 2012 (see Section 6.3 for more information). Sensitive Habitat Inventory and Mapping (SHIM) and AHI are underway for the entire South Thompson River (completion anticipated mid-2016).
Promote stream stewardship and public awareness on the importance of riparian zones to facilitate a program of re-vegetation on private lands. Efforts should also be directed at protection and restoration of small tributary streams of the South Thompson, including those flowing through the City of Kamloops.	✔ Ongoing	Various awareness campaigns and events have achieved this, including annual BC Interior Stewardship Workshops, the Shuswap Lake Integrated Planning Process, BC Rivers Day, Stream-to-Sea Program, and the Farmland Riparian Interface Stewardship Program.
Apply DFO/MELP Land Development guidelines for future developments to protect fish habitat and ensure proper stormwater management. Future municipal and industrial works should be planned in advance with DFO personnel to explore the ability to reclaim riparian vegetation lost through previous land use.	🚫 Not applicable	Land Development Guidelines are no longer applicable; have been replaced by Riparian Area Regulations for riparian protection
Monitor water quality in the South Thompson River and continue current initiatives by the South Thompson/Chase Creek Turbidity Committee to develop a watershed management plan and reduce sediment inputs to the system. Follow recommendations for erosion control by re-establishment of riparian trees along the South Thompson mainstem, Chase Creek and other tributaries.	✔ Ongoing	Water quality monitoring in the river is ongoing. It's not known if the turbidity committee is still assembled.
Ensure spill contingency plans are in place to deal with potential toxic spills along the transportation corridor.	✔ Partially complete	The City of Kamloops completed a Source Water Protection Plan in 2014; the Village of Chase has one underway but not complete at the time of this update
New Strategies		

Educate irrigators about the importance of properly screened and installed intakes to prevent fish mortality
Assess impacts of historical log drives and dredging, and look for ways to mitigate impacts to chinook spawning grounds
Ensure debris removal at Pritchard Bridge doesn't negatively impact spawning
Implement Source Water Protection Plans

Table 9. Campbell Creek, Monte Creek, Dry Creek, Neds Creek, Martin Creek, Niskonlith Creek and Harper Creek management strategies

Assess restoration opportunities on Campbell and Monte Creeks and restore riparian zones to improve fish habitat and reduce sediment loading
Consider Environmental Flow Needs before issuing further water licences
Inspect fish passage works to ensure proper function

Table 10. Chase Creek management strategies

Strategies from *1997 Review*	Status	Notes
Monitor water quality in the South Thompson River and continue current initiatives by the South Thompson/Chase Creek Turbidity Committee to develop a watershed management plan and reduce sediment inputs to the system. Follow recommendations for erosion control by re-establishment of riparian trees along the South Thompson mainstem, Chase Creek and other tributaries.	✔ Ongoing	Water quality monitoring in the river is ongoing. It's not known if the turbidity committee is still assembled.
Promote stream stewardship to develop a riparian restoration plan for Chase Creek, aiming to re-establish a riparian corridor by fencing livestock, re-vegetating streambanks and stabilizing banks	✔ Partially complete	Educational signage is in place at the community park at the confluence of Chase Creek.
Identify areas of terrain instability, conduct inventory of logging roads and identify areas where logging activity has reduced riparian vegetation in Chase Creek (through IWAP and Level 2 Channel Assessment). Implement activities identified from this process including decommissioning of inactive roads and maintenance of existing ones.	? Unknown	IWAPs are not a current management tool
New Strategies		
Restore priority sites on Chase Creek with bio-engineering streambank stabilization techniques and livestock exclusion fencing		
Assess Chase Creek channel stability		
Consider Environmental Flow Needs before issuing further water licences on Chase Creek		

Table 11. Little Shuswap Lake and Little River management strategies

Strategies from *1997 Review*	Status	Notes
Map riparian areas upstream of Monte Creek/Pritchard, including the foreshore and riparian zones of Little Shuswap Lake and Little River. Classify habitat and develop guidelines for use by the Municipality and Regional Districts for incorporation to OCPs and zoning. Protect undisturbed riparian habitat and restore riparian zones where vegetation has been lost or reduced.	✔ Complete	Foreshore Inventory and Mapping (FIM) and Aquatic Habitat Index (AHI) of the Shuswap Lake system including Little River and Little Shuswap Lake was completed in June 2009; Shoreline Management Guidelines were completed in 2012 (see Section 6.3 for more information). Sensitive Habitat Inventory and Mapping (SHIM) and AHI are underway for the entire South Thompson River (completion anticipated mid-2016).
New Strategies		
Utilize the results of the FIM to guide restoration works		
Ensure streambank restoration works don’t negatively impact gravel recruitment in Little River		
Identify off-channel habitat access opportunities		

6.2 Adams River System

The Adams River system includes upper Adams River, which flows southward into Adams Lake from its headwaters, then continues as the lower Adams River into Shuswap Lake. The river and lake are fed by its' tributaries Cayenne Creek, Momich River, Sinmax Creek, Hiuihill Creek and Nikwikwaia Creek.

The sub-basin is within some of the most rugged landscapes in the Shuswap watershed: it is typified by high mountain peaks, deeply cut valleys, alpine meadows and rainforest. The sub-basin is within the Interior Douglas Fir, Interior Cedar Hemlock and Engelmann Spruce – Subalpine Fir biogeoclimatic zones. The region's primary land uses are forestry, recreation, and park/conservation. There are a few small, localized areas of settlement in the lower corridor and along the lake (e.g., Adams Lake community and Squaam Bay); otherwise, the region is largely uninhabited. Adams Lake Sawmill is located near the bottom end of the lake.

The Adams River system – the lake and lower Adams especially – have a long and significant history with timber harvesting activities. In 1907-08 the Adams River Lumber Company built a splash dam on the outlet of the lake to raise the water level in the lake; stored water was released in summer to flush logs down the river to Shuswap Lake to a mill in Chase (Allen, 1979; Cal-Eco Consultants Ltd. and Mariposa Trails, 2006). For decades, the flows in the river were interrupted and sometimes ceased, causing the river to dry up – the effects of which were noticed downstream to Kamloops. During that time, spawning habitat in the lower Adams was greatly reduced; furthermore, what eggs were laid in the gravel were subsequently scoured by the passage of logs and debris en route to the mill. Worse yet, the splash dam blocked passage into the lake and upper river, thereby decimating the summer upper Adams salmon run; an impact from which it never recovered although the splash dam was removed in 1945 (Allen, 1979). Additional dams and water diversions were developed in the Hiuihill Creek basin in the early 1900s; see Section 6.2.2 for more information.

6.2.1 Lower Adams River

The lower Adams River flows from Adams Lake to Shuswap Lake; it enters the lake near the outlet to Little River. The lower Adams supports the largest sockeye run in the HMA and the second largest in the Fraser system, as well as significant chinook populations. Coho and pink salmon also use the lower Adams, as do resident rainbow trout and bull trout (Department of Fisheries and Oceans Canada, 1997). The lower Adams River is without a doubt one of the most productive rivers in the Fraser watershed.

The lower Adams is within the Roderick Haig-Brown Provincial Park, which provides protection to the river and its riparian corridor. Outside this area, the lower Adams has been impacted by activities associated with settlement and tourism. Although there are no urban centres in the sub-basin, low-density settlements exist throughout the lower corridor.

Resource development along the lower Adams is low (in part due to the provincial park). Use of motorized watercraft is restricted on the Adams River, however the river is commonly used in the summer months for non-motorized recreation including kayaking and commercial raft tours. Roderick Haig-Brown Provincial Park is the site of an interpretive cabin and walking trails which further facilitates recreational use and enjoyment of the area. A quadrennial festival[3] takes place in October to commemorate the return of the Sockeye Salmon; this event attracts up to 200,000 visitors over a three-week period on dominant return years (2014). The lower Adams is known internationally for the sockeye salmon run and has been recognized by the International Union for the Conservation of Nature as one of the "World's Greatest Natural Areas" (Cal-Eco Consultants Ltd. and Mariposa Trails, 2006). Care has been taken and must continue to ensure the impacts of the visitors to migrating and spawning salmon is negligible. As part of this, trails and bridges on the interpretive site were improved in 2002 and a new salmon viewing platform was constructed in 2014.

The Adams River Bridge was replaced in 2009; the decades-old single-lane truss bridge was replaced by a two-lane clear-span structure. As part of the construction project, the BC MOTI did some on-site streambank restoration (B. Persello, pers. comm.).

The water quality in lower Adams River is generally very good. This may in part be due to a buffering effect by Adams Lake, which is a large deep lake and serves as a sediment trap. The water draining from the lake flows out over and through coarse gravels, meaning little sediment is added to the river from the lake. The two main tributaries to the Lower Adams River – Hiuihill and Nikwikwaia Creeks – have experienced erosion and can increase sedimentation to the river (as cited in Cal-Eco Consultants Ltd. and Mariposa Trails, 2006).

The Adams River is at risk of 'Didymo'[4] blooms, a fresh-water diatom that thrives in very cold-water lotic environments such as the Adams River. An abundance of Didymo can compromise spawning and rearing habitat and alter the riverine food web as thick mats smother the river bottom (as cited in Max L. Bothwell, 2009). An alarming bloom occurred in the lower Adams in 2012 (Brouwer, 2012). It's thought the method of introduction of the algae is via waders and foot traffic associated with angling; indeed, the river is a popular angling location.

---

[3] The festival is hosted by the Adams River Salmon Society, with support provided by BC Parks and DFO and many other community partners.

[4] *Didymosphenia geminata*, commonly known as 'rock snot'

6.2.2 Hiuihill Creek and Nikwikwaia Creek

Hiuihill (also known as Bear) and Nikwikwaia (also known as Gold) Creeks flow into the lower Adams River. Sockeye and coho salmon utilize the lower portion of each creek (approximately 1 km); chinook also utilize Hiuihill Creek.

In the Hiuihill watershed, timber harvesting, agriculture and low-density settlement have resulted in the reduction of riparian vegetation and contributed to channel destabilization, flooding and bank erosion (as cited in DFO, 1997). In the past, the watershed has been logged extensively, including up to the edge of fish-bearing streams. In the early 1900s, Hiuihill Creek was the site of a 17 km flume used to transport logs from the upper watershed to lower Adams River and onward to Adams River Lumber Company mill. Water was diverted from the creek into Skmana Lake, which was dammed to provide consistent flow in the flume (Golder Associates Ltd., 1996).

The current ECA is not known and since 1995, 9.74% of the gross watershed area has been harvested. An Interior Watershed Assessment Procedure was completed for the Hiuihill Creek basin in 1996 (Golder Associates Ltd., 1996) the results of which created great concern over the amount of timber harvesting and led to a subsequent slow-down of forestry operations (B. Harding, pers. comm.) As a follow-up to the IWAP, creek bank stabilization was done in 1998-1999 through the former Watershed Restoration Program of Forest Renewal BC (BC Ministry of Environment, Lands and Parks).

Some private landowners have carried out activities harmful to fish habitat, including channelizing stream sections, armouring sections of the streambank, and forest harvesting that has resulted in a loss of riparian vegetation and habitat complexity (B. Harding, pers. comm.).

The creek's water quality has been degraded through non-point source inputs of nutrients and summer flows have been reduced through water withdrawal for agriculture (as cited in DFO, 1997).

In the Nikwikwaia watershed, forestry has been the primary land use. The current ECA is not known and since 1995, 10.19% of the gross watershed area has been harvested. The terrain is unstable and subject to debris flows and slide activity (as cited in DFO, 1997); timber harvesting therefore places risks on the downstream fisheries production. Some stabilization work on de-activated roads was done through the former Watershed Restoration Program of Forest Renewal BC (BC Ministry of Environment, Lands and Parks).

Management Priorities

Management priorities for the Lower Adams River, Hiuihill and Nikwikwaia Creeks focus on the protection of the spawning grounds through maintenance of good spawning substrate, water quality and water flows. Reducing sediment input from tributary creeks is a priority.

Table 12 summarizes progress made against the 1997 strategies, and presents new strategies.

6.2.3 Adams Lake

Adams Lake has considerable fisheries resources that include lake spawning sockeye, rearing sockeye and chinook juveniles, shore-spawning kokanee, and resident salmonid species including rainbow trout, bull trout and lake char. Numerous non-salmonid species also utilize the lake including burbot, whitefish, sculpins, and others (Department of Fisheries and Oceans Canada, 1997).

Developments on Adams Lake include a large sawmill at the south end of the lake with a log dump and handling / storage area. There are an additional four log handling tenures on Adams Lake (K. Weir, pers. comm.). The adverse effects of log handling on the aquatic environment have been reasonably well documented. The primary effects include physical changes from shading, grounding, and scouring by logs, debris accumulations on the lake bottom, and reduced current and wave action (D.A. Toews, 1981).

There is a debris boom at the outlet of the lake that captures loose logs and other large woody debris that would otherwise flow to the lower Adams River, the latter of which is important to fish habitat in the river. The debris boom requires monitoring and periodic clean-up to prevent a possible collapse and resultant debris flow into the river below (B. Harding, pers. comm.).

Settlement at Adams Lake is minimal, compared to Shuswap Lake. Residential and seasonal recreation properties are scattered around the lake, mostly centered near the south end of the lake. A small community on the south-east side of the lake is accessed by a cable ferry. There is recreational and residential development at Squaam Bay. The lake is used by recreationists for fishing, and motorized and non-motorized boating; however, recreation is much less than at Shuswap Lake. Recreation use and development at Adams Lake may increase in future as more people are seeking a quieter experience than can be found at nearby Shuswap Lake.

Invasive and non-native species pose a significant threat to Adams Lake and downstream waters. Sport fish species such as bass, perch, and pumpkinseed have been observed in many lakes in BC where they have been introduced either accidentally or unlawfully by individuals with intentions of creating a new sport fishery. There have been occasional unconfirmed reports of spiny ray fish (i.e., perch) being caught in Adams Lake (A. Klassen, pers. comm.). There are no treatment options for large lakes such as Adams; prevention is the only suitable mechanism. Adams Lake is also at risk of water milfoil and zebra and quagga mussels, all of which can be introduced to lakes via boat traffic. Again, prevention is the only effective management option because once these species are present in a lake they are impossible to eradicate. Zebra and quagga mussels in particular would have a devastating effect on the lake ecosystem and downstream waters.

Management Priorities

The management priorities for Adams Lake are to protect foreshore spawning and rearing habitat and prevent the introduction of invasive species.

Table 13 summarizes progress made against the 1997 strategies, and presents new strategies.

6.2.4 Upper Adams River

The upper Adams River flows into Adams Lake at its north end; the river drains a wild, remote, and mountainous part of the Shuswap watershed. The upper Adams habitat includes a variety of riparian-types such as wetlands and marshes that are excellent for salmon production (Cal-Eco Consultants Ltd. and Mariposa Trails, 2006).

Fisheries resources in the upper Adams include sockeye, chinook and coho salmon (Department of Fisheries and Oceans Canada, 1997). Fish populations in the river have been greatly reduced from historic levels following the construction of a splash dam in 1908 at the outlet of Adams Lake that blocked passage by migrating salmon for almost 40 years, effectively decimating the historically dominant upper Adams summer sockeye run (Allen, 1979).

The upper Adams sockeye has been identified as one of the best stock enhancement opportunities in the province (D. Lofthouse, pers. comm.). A number of enhancement activities have taken place, mostly coinciding with the dominant cycle (2014). In 1992, upper Adams River brood were reared at the Clearwater River Hatchery and 315,000 fry were released into the river the following spring; in 1996, over 30,000 sockeye spawners returned. That year, production increased and 1.3M fry were released into the river in 1997. An enrichment project took place on Adams Lake that year that involved application of fertilizer to the lake from May to September to improve juvenile rearing conditions. In 2000, a record 75,000 sockeye spawners returned to the upper Adams watershed. Fish culture activities were re-located to Shuswap Falls Hatchery, production increased again and the following spring a record 1.94M fry were released in the river. Additionally, an "off-cycle" enhancement project took place and 340,000 fry were released in 2002. The sockeye return in 2004 was disappointingly low: an estimated 13,500 spawners returned, thought to be due to unfavourable river conditions across the Fraser basin causing high mortality. Enhancement activities were attempted again in 2005, 2006 and 2008 but limited brood stock was available due to poor escapements. The most recent significant return was in 2014, an estimated 5,500 sockeye spawners returned to the river; 2018 may present an opportunity to re-commence enhancement (D. Lofthouse, pers. comm.).

Timber harvesting is the major resource use in the upper Adams area. There is an extensive logging road network, and combined with timber harvest on steep terrain these activities have contributed sedimentation to the river and Tum Tum Lake (located in the uppermost region of the sub-basin). The current ECA is not known and since 1995 7.9% of the gross watershed area has been harvested; road density is 1.19 km/km^2.

6,100 hectares of valley bottom, floodplain and riparian areas were designated as a Protection Resource Management Zone under the Kamloops Land Resource Management Plan, and established in 1996 as a provincial park (Kamloops Interagency Management Committee, 1995; Upper Adams River Provincial Park). These designations protect the valley floor from future development.

6.2.5 Sinmax Creek

Sinmax Creek flows into Adams Lake at Squaam Bay on the west side of the lake. Fisheries resources in the creek include sockeye and coho stocks, with fish utilizing mainly the lower creek reaches and the fan at Adams Lake. Sockeye follow the same cycle and similar timing as the lower Adams River run, suggesting that they may be of that origin (Department of Fisheries and Oceans Canada, 1997).

Forestry is the primary resource use in the Sinmax watershed; timber harvesting has been extensive throughout. This has contributed to bank instability and sediment input. The current ECA is not known and since 1995 18.33% of the gross watershed area has been harvested, and road density is 1.88 km/km^2.

Agriculture is also prevalent in the watershed. The valley bottom has been cleared of timber for conversion to pasture and hay lands. Clearing of riparian vegetation, bank instability and increased erosion, water withdrawals for irrigation, and non-point source pollution are some of the effects of agriculture on Sinmax Creek (Department of Fisheries and Oceans Canada, 1997).

The sediments carried downstream have resulted in an accelerated development of the fan at the creek confluence. During years of low flows, returning spawners may experience difficulty entering Sinmax Creek. To increase the flow and improve fish passage, local landowners have occasionally deepened the mainstem and blocked smaller channels (as cited in DFO, 1997). The BC Cattlemen's Association FRISP staff have facilitated stewardship and restoration projects with landowners there in recent years (Hesketh, pers. comm.).

Recreational use and settlement activity is highest at the lower end of the creek. Several cabins are situated along the bottom of the creek, and there is a network of trails including bridge crossings over the creek.

6.2.6 Momich River and Cayenne Creek

Momich River and its tributary, Cayenne Creek, enter Adams Lake near the north end on the east side. Sockeye and coho salmon utilize the river and creek, along with resident salmonid and non-salmonid species. Sockeye from Cayenne Creek have been used as broodstock to re-establish a sockeye run in the Upper Adams River on the dominant (2014) cycle (Department of Fisheries and Oceans Canada, 1997).

Timber harvest is the primary resource activity in this sub-basin. Logging and road construction began there in the 1960s and grew steadily for three decades. An IWAP completed in 1996 indicated an ECA of 15% and 'moderate' road and trail densities. It was also noted that several landslides were initiated on or adjacent to logging roads (Silvatech Consulting Ltd.) The current ECA is not known and since 1995 9.15% of the gross watershed area has been harvested.

A 1,650 hectare portion of land encompassing the Momich Lakes valley bottom and wetlands was designated as a Protection Resource Management Zone under the Kamloops Land and Resource Management Plan (Kamloops Interagency Management Committee, 1995). This designation protects the area from future resource development including timber harvesting, mining and energy development.

Management Priorities

Re-building salmon populations, particularly the historically dominant sockeye run, is the management priority for the upper Adams River.

Management priorities for the Sinmax and Momich systems include protecting habitat and water quality, rehabilitating and preventing impacts from timber harvesting, and ensuring fish passage.

Table 14 summarizes progress made against the 1997 strategies, and presents new strategies.

Table 12. Lower Adams River, Hiuihill Creek and Nikwikwaia Creek management strategies

Strategies from *1997 Review*	Status	Notes
Assess the potential to create additional coho spawning and rearing habitat through the development of side channels in the lower Adams River. Add in-stream complexing to side channels in the Adams River fan.	✔ Complete	An assessment was done and determined that new side channels in the lower Adams mainstem and complexing in the fan area should not be developed.
Continue to monitor activities on the Hiuihill and Nikwikwaia Creeks for potential risks to gravel and water quality in the lower Adams River	✗ Incomplete	
Continue to defer logging plans in Hiuihill Creek until an IWAP is completed in 1997, and the Hiuihill Watershed Committee can review the strategy for the watershed	✔ Partially complete	IWAP was completed in 1996. It's not known if the Hiuihill Watershed Committee is still in tact.
Defer further logging in the Nikwikwaia basin pending a roundtable review of a completed IWAP, stream channel assessment and restoration programs	? Unknown	It's not known if an IWAP was completed for Nikwikwaia Creek before the sunset of the WRP; however, slope stabilization at de-activated roads was completed through WRP in 1998-1999.
Apply DFO/MELP Land Development Guidelines to future developments in the area to protect in-stream and riparian habitats	🛇 Not applicable	Land Development Guidelines are no longer applicable; have been replaced by Riparian Area Regulations for riparian protection
Through a partnership with the timber licensee, FRBC, MELP and landowners, promote protection, restoration and stream stewardship projects in the Hiuihill Creek basin, both on private and Crown lands	✔ Partially complete	Creek bank stabilization was completed through WRP in 1998-1999. It's not known if further work has been done.
Promote riparian restoration on private lands along the lower reaches of Hiuihill Creek. Where required, stabilize eroding banks focusing on bio-engineering techniques, and re-establish habitat diversity in the system	✔ Partially complete	
Complete and evaluate IWAP conducted on Hiuihill and Nikwikwaia Creeks to identify restoration opportunities	✔ Ongoing	IWAP was completed for Hiuihill Creek in 1996; it's not known if an IWAP was completed for Nikwikwaia Creek before the sunset of the WRP
Restore upslope areas through road deactivation, replanting riparian zones and channel downstream areas. Upgrade culverts to restore previous drainage patterns.	✔ Partially complete	Slope stabilization was completed at de-activated roads in the Nikwikwaia basin in 1998-1999. It's not known if further work has been done.

Continue DFO activities at the Roderick Haig-Brown Park to educate the public on the importance of salmon stocks	✔ Ongoing	The Adams River Salmon Society is the main steward at Roderick Haig-Brown Park, and receives support from DFO, MOE, and local community partners. The Society has an interpretive cabin on-site and hosts a quadrennial festival during peak return season.
New Strategies		
Continue education and interpretive services at Roderick Haig-Brown Provincial Park, including support for the quadrennial "Salute to the Sockeye" event and visitor infrastructure. Ensure tourism is low-impact.		
Conduct education and prevention campaigns for *Didymo* at popular angling locations on the lower Adams River		
Continue to foster land stewardship ethic in private land owners		
Assess restoration opportunities on Hiuihill Creek		

Table 13. Adams Lake management strategies

Strategies from *1997 Review*	Status	Notes
Inventory and classify foreshore habitat, and minimize impacts of foreshore development on the lake	✗ Incomplete	FIM and Shoreline Management Guidelines have not been completed. Impacts to the foreshore by development are regulated by Riparian Area Regulations.
Ensure log handling operations are consolidated at existing sites	✔ Partially complete	
New Strategies		
Conduct a FIM for Adams Lake and develop an AHI and Shoreline Management Guidelines		
Re-visit the draft Recreation Management Plan for Shuswap, Little Shuswap Mara and Adams Lakes and implement strategies as they pertain to recreation and the environment		
Support programs and infrastructure to prevent spread and introduction of non-native and invasive species such as spiny ray fish and zebra/quagga mussels		
Conduct water quality monitoring		
Assess the impacts and possible mitigation to decreased large woody debris input to the lower Adams River as a result of the debris boom located at the outlet		

Table 14. Upper Adams River, Sinmax Creek, Momich River and Cayenne Creek management strategies

Strategies from *1997 Review*	Status	Notes
Review IWAPs to guide future logging activities and identify restoration opportunities	? Unknown	The recent utility of IWAPs is not known; they are not a current management tool

Defer logging in the Momich watershed pending review of completed IWAP and stability assessments, and the development of recommendations to prevent further slope failure	? Unknown	The recent utility of IWAPs is not known, they are not a current management tool
Review and develop programs to remedy site-specific impacts on the upper Adams and tributaries and prioritize the sites	? Unknown	
Develop a road access plan for the upper Adams watershed. Deactivate or upgrade/maintain logging roads, restore riparian zones and where possible restore areas of terrain instability impacted by past logging activity	? Unknown	
Continue sockeye re-building efforts through transplants to the upper Adams River. Also continue to monitor the transplanted chinook population.	✔ Partially complete	Sockeye enhancement took place in 1992, 1996, 2000, and 2001.
Develop stewardship arrangements with landowners along Sinmax Creek to reclaim lost riparian areas. Increase landowner awareness of the importance of functioning riparian systems.	✔ Complete and ongoing	BC Cattlemen's Association FRISP and Secwepemc Fisheries Commission have done restoration projects and increased awareness of healthy riparian areas and fish habitat
Determine instream flows for Sinmax Creek and assess storage opportunities prior to considering further water withdrawals	? Unknown	
Apply DFO/MELP Land Development Guidelines to recreational developments at the mouth of Sinmax Creek	🚫 Not applicable	Land Development Guidelines are no longer applicable; have been replaced by Riparian Area Regulations for riparian protection
Ensure fish access to Sinmax Creek during low flow periods. Assess fish barriers that may be restricting upstream access.	✔ Partially complete	Coho, sockeye and kokanee periodically have difficulty accessing Sinmax Creek. Local residents assist passage into the creek with the use of sandbags to channelize the mouth.
New Strategies		
Re-initiate sockeye re-building efforts through transplants to the upper Adams River. 2018 may be the next immediate opportunity due to 2014 escapement and spawning success rate.		
Assess perch populations in Adams Lake; results of this must be considered in future sockeye enhancement work or lake fertilizations		
Conduct a SHIM and restoration analysis for Sinmax Creek, and assess restoration opportunities for the mouth of Sinmax Creek		
Consider Environmental Flow Needs before issuing further water licences on Sinmax Creek		

6.3 Shuswap Lake System

The Shuswap Lake System consists of Shuswap Lake, Mara Lake, and many tributaries that flow into the lakes from the uplands. The small tributaries are described in this section. The three largest tributaries to the lakes – Shuswap River, Salmon River and Eagle River – are described separately in sections 6.4, 6.5 and 6.6.

6.3.1 Shuswap and Mara Lakes

Shuswap Lake consists of five arms (Main, Anstey, Seymour, Sicamous, and Salmon); Mara Lake drains into the Sicamous Arm through Sicamous Narrows. The lakes support a significant population of lake-spawning sockeye and lake char, in addition to diverse and important fish populations including chinook, coho, rainbow trout, kokanee, mountain whitefish, burbot, and bull trout. There are also numerous non-sportfish including sculpins, dace, pike-minnow, and peamouth chub (as cited in DFO, 1997).

There is abundant spawning throughout the system. Salmon spawn in the fall (trout in the spring) in tributaries to the lakes. Lakeshore spawning of sockeye takes place in many areas of Shuswap Lake, with concentrations in the main arm. Lake char spawn in the fall in shallow waters along the shoreline, mostly in the main arm of Shuswap Lake (Rosenau, 2014). Fry descend the rivers in the spring and start feeding along the lake shoreline, which provides an important rearing area for many fish species, particularly juvenile salmon. The juveniles subsequently migrate along the shoreline and become distributed throughout the basin. As temperatures increase throughout summer, rearing coho and chinook juveniles move further offshore into deeper cooler waters, while maintaining contact with lake margins. Sockeye fry migrate in the spring from the littoral zones into deeper waters to take up pelagic rearing (as cited in DFO, 1997).

The primary resource uses on Shuswap and Mara Lakes are settlement, tourism and recreation. This includes medium- and high-density residential developments around the lakes with urban centres at Sicamous, Salmon Arm, Sorrento, Scotch Creek and Celista. Shoreline development (i.e., settlement and roads) is dense in some areas on the lake, notably at Salmon Arm Bay, the north shore of the main arm, Eagle Bay, Blind Bay, Tappen and Sunnybrae.

Numerous and abundant activities and developments associated with settlement on the lakes' shorelines have resulted in loss of valuable foreshore habitat. These activities include dredging and filling; construction of docks, groynes, retaining walls, break-waters and boat launches; and foreshore modifications including beach-combing (i.e., clearing the natural substrate), importing sand for beaches, and clearing riparian vegetation.

Foreshore Inventory and Mapping (FIM), Aquatic Habitat Index (AHI) and Shoreline Management Guidelines were completed for Shuswap, Little Shuswap and Mara

Lakes in 2011 (Ecoscape Environmental Consultants Ltd., 2011). A key outcome of the FIM project was the creation of a map of the lakes' shorelines in which individual shoreline segments are colour-themed based on their AHI, a relative ranking of habitat value. The map is housed on the Community Mapping Network (Shuswap Lake Watershed Atlas). The FIM recorded > 1,100 groynes and windrows and > 1,500 retaining walls, more than half of which were located below the Mean Annual High Water Mark. There were also a small number of upland drainage modifications (i.e., culverts) detected by the FIM. Shoreline modifications such as these can negatively impact shore-spawning habitat. The former Shuswap Lake Integrated Planning Process (SLIPP) facilitated an education campaign about shoreline management best practices, and did demonstration shoreline restoration projects. SLIPP also facilitated the removal of several derelict, abandoned docks from the shorelines of the lakes on a short-term basis. A permanent program for reporting and removing derelict, abandoned docks does not exist for the Shuswap (M. Simpson, pers. comm.).

The houseboat industry in particular expanded greatly through the 1990s and early 2000s; it's centered in Sicamous Narrows and has a smaller presence in Salmon Arm Bay. The Sicamous Narrows Management Plan (1979) prescribes restrictions to six zones of the Narrows; this is to alleviate crowding, maintain a navigable channel, and protect important fish habitat along the east shore while still allowing for development offshore (BC Ministry of Lands, Parks and Housing, 1985). Despite the management plan in place, mooring and shoreline structures are affecting habitat (as cited in DFO, 1997; B. Harding, pers. comm.). Furthermore, low water levels and siltation in the channel have been a concern for residents and tourism businesses in Sicamous for over two decades (due to the restrictions low water and siltation place on moorage capacity). The District of Sicamous has looked into the possibility of dredging the channel but to date no actions have been taken due to a ruling by the Environmental Appeal Board (B. Harding, pers. comm.).

In 2009, a developer was penalized under the Federal Fisheries Act for causing harm to sensitive fisheries habitat; this was for work done in 2007 on the shore of Shuswap Lake near the mouth of the Eagle River at Sicamous. The 'Old Town Bay' development garnered a $375,000 fine. Since that time, restoration at the site has been completed.

Canoe Forest Products Ltd. sawmill and plywood plant are located on Shuswap Lake, just a few kilometres east of Salmon Arm at Canoe. It operates two log dumps on the lake: one at the mill site in Canoe, and one at Lee Creek (Canoe Forest Products Ltd., 2012). There are an additional 7 log handling tenures on Shuswap Lake; they range in size from 1 hectare to 38 hectares (K. Weir, pers. comm.); in the past there have been up to 25 log dumps operating on the lake at one time (B. Harding, pers. comm.). The adverse effects of log handling on the aquatic environment have been reasonably well documented. The primary effects include physical changes from shading, grounding, and scouring by logs, debris accumulations on the lake bottom, and reduced current and wave action (D.A. Toews, 1981).

Trans-Canada highway improvements (i.e., highway four-laning and structure replacements) pose a risk to the lake. Some segments in particular, such as at Cruickshank Point where the highway is immediately adjacent to the lake and built on fill, have significant potential for impacts to the lake. The Bruhn Bridge at Sicamous Narrows is a pending priority upgrade; construction will create impacts to fish habitat, partly because of the need to place piers in the Narrows (B. Persello, pers. comm.). The BC MOTI and its contractors adhere to standard specifications and site-specific special provisions for construction to minimize environmental impacts (BC Ministry of Transportation and Infrastructure).

Water quality in the lakes is impacted from a number of sources. Nutrient loading via resource use in the Shuswap and Salmon River basins, wastewater treatment plant discharges, seepage and leakage from septic tanks, storm water, and grey water from pleasure crafts all degrade the lakes water quality. The water quality of the lakes is considered generally good (Shuswap Lake Integrated Planning Process, 2014) however there is mounting concern over areas of the lake that have shown signs of eutrophication for a number of years (D. Einarson, pers. comm.). An analysis of nutrient sources suggested that management should focus on reducing loadings from agricultural activities in the Shuswap, Salmon and Eagle Rivers, and the Enderby wastewater treatment plant (Tri-Star Environmental Consultants, 2014).

The potential effects on salmon of the widespread use of motorized watercraft on the lakes during the spring and summer months have not been assessed. There has been some interest in managing boating activity for purposes such as conflict mitigation, noise reduction, and preservation of sensitive ecosystems (Peak Planning Associates, 2014; Peak Planning Associates, 2012).

Boating activity on the lake has increased the spread of water milfoil. The largest infestation is located in Salmon Arm Bay. Milfoil can have a negative impact on salmon spawning habitat and may provide cover for salmon predators (as cited in Okanagan Basin Water Board, 2009). The Columbia Shuswap Regional District has a milfoil removal program for the primary purpose of ensuring safe and aesthetically pleasing swimming beaches, however they have also collaborated with DFO to remove milfoil in key shore-spawning locations or migration corridors (H. Kassa, pers. comm.).

Perch, bass, pumpkinseed and other non-native sportfish species pose a significant threat to salmon. They have been observed in many lakes in BC where they have been introduced either accidentally or unlawfully by individuals who have intentions of creating a new sport fishery. In 2007, the BC Ministry of Environment implemented a lake rehabilitation program to eradicate non-native spiny ray fishes from several small lakes in the Shuswap watershed. From 2007 - 2013, 13 small lakes were treated with Rotenone, then stocked in subsequent years with hatchery trout. Monitoring by the BC Ministry of Environment indicates that the eradication program was successful, and to date spiny rays have not been observed in any of the treated lakes (A. Klassen, pers. comm.). There have been occasional unconfirmed reports of spiny ray fish being caught in Adams Lake and Shuswap Lake; however, even if a catch is confirmed, there are no treatment options for large lakes such as these. Prevention is the only suitable mechanism.

Zebra and quagga mussels also pose a significant threat to the Shuswap lakes. While they have not been detected in BC waters, the accidental introduction of these invasive species would have extremely detrimental consequences. Monitoring and prevention work is underway (Columbia Shuswap Invasive Species Society, 2013).

There is a strong stewardship community in the Shuswap. The Shuswap Environmental Action Society has advocated for the protection of important habitats and done education and outreach; the Adams River Salmon Society is a key player in the quadrennial Sockeye festival at Roderick Haig-Brown Provincial Park, and the Shuswap Water Action Team had advocated for the protection of water quality and flows in the basin.

Management Priorities

Protection of water quality, foreshore and riparian habitats; prevention of the introduction or spread of non-native species; and protection of upland hydrologic integrity are the management priorities for these lakes.

Table 15 summarizes progress made against the 1997 strategies, and presents new strategies.

6.3.2 Shuswap Lake Streams

The tributaries to Shuswap Lake are typified by productive low-gradient lower reaches adjacent to the lake, and steeper upland portions. The lower reaches of many streams are subjected to high land use through urbanization, intensive agriculture, and linear development whereas the upper reaches are subjected primarily to forestry activities. Salmon River, Eagle River and Shuswap River are the largest tributaries to the lakes and are described separately in Sections 6.4, 6.5 and 6.6.

Scotch Creek – Main Arm

Scotch Creek enters Shuswap Lake at the lower (i.e., west) end of the Main Arm. Scotch Creek is an important sockeye producer with the dominant return being an early summer run. Both sockeye and coho utilize the lower creek reaches. At one time, upstream migration was impeded by a difficult passage 16 km from the outlet, since that time however fish have been observed above that point (as cited in DFO, 1997). The most important spawning habitat, especially for sockeye, is on the fan;

scattered spawning and rearing habitat exists through the middle reaches of the lower mainstem (Dobson Engineering Ltd., 1999).

Forestry in the upland areas constitutes the major land use in this watershed. Since 1995, 7.65% of the gross watershed has been harvested. Interior Watershed Assessment Procedures were completed in 1995 and 1997, and updated in 1999 to incorporate interim results of watershed restoration (Dobson Engineering Ltd., 1999). Harvesting in the Scotch Creek basin is a significant concern to fisheries habitat. Canoe Forest Products Ltd. is the primary license holder in the area, and they work with a hydrologist in forest planning and development; recommendations for rate of cut account for factors such as plantation recovery and the movement of material on the fan (G. Hislop, pers. comm.).

Recreational developments and rural settlements are located along the lower reaches of Scotch Creek and on the fan. The lower reaches and the fan are unstable with braiding, woody debris and logjams; flood events could impact developments on the fan. Attempts have been made to re-route the creek to protect urbanized areas (as cited in DFO, 1997) and to stabilize the channel through placement of large organic debris, rip-rap, berms and plantings (B. Harding, pers. comm.).

Salmon viewing is a popular activity on Scotch Creek, as the run coincides with peak summer tourism. Little Shuswap Lake Indian Band has led education efforts to minimize the impacts of visitors to the creek, and installed signs at the roadside pull-out.

Any future highway improvement projects in the North Shuswap area would likely focus on the Scotch Creek Bridge. Although there are no plans for the Scotch Creek Bridge, it will eventually need to be replaced as it nears its life-span (B. Persello, pers. comm.).

Habitat restoration works on Scotch Creek include bank stabilization and riparian plantings at a large cut bank, stabilizing the Squilax-Anglemont Road with armouring and plantings, and bio-engineered streambank and bar stabilization all in the lower reaches of the stream. The most significant improvement to fish habitat in recent years is believed to be the natural stabilization of the stream channels from reduced peak flows and sediment supply from reductions in forest harvesting and road deactivation (B. Harding, pers. comm.)

Management Priorities for Scotch Creek

Protection of water quality, protection of sockeye and coho spawning habitat, and restoration of impacted habitat are the management priorities for Scotch Creek.

Table 16 summarizes progress made against the 1997 strategies, and presents new strategies.

Onyx Creek and Ross Creek – Main Arm

Onyx and Ross Creeks enter Shuswap Lake approximately halfway along the Main Arm, at Celista and Magna Bay respectively. Both sockeye and coho utilize the streams. Sockeye are documented on the dominant Adams cycle (2014) and shore-spawn at the creek mouths (as cited in DFO, 1997). At Onyx Creek, an impassable culvert restricts salmon to the lower few hundred metres. Ross Creek is mostly dry in the summer but may be utilized by coho and trout during their various life stages.

Onyx Creek is impacted by forestry activities and agriculture. The uplands of the Onyx Creek basin have been extensively logged in the past, and there are concerns for peak flows affecting channel integrity and debris slides. In 1997 the ECA was 22% (as cited in DFO, 1997); the current ECA is not known and since 1995, 10.8% of the gross watershed area has been harvested.

A significant amount of land has been cleared in the Onyx Creek drainage for agriculture; the primary uses are for growing feed crops (i.e. hay) and grazing cattle. Livestock access to streams and water withdrawal for irrigation has resulted in impacts to riparian areas, degradation of water quality, and low in-stream flows. The BC Cattlemen's Association FRISP program has done some restoration work and education about beneficial management practices with landowners in the area.

Ross Creek has been extensively logged in the past and suffered impacts from forest fires (as cited in DFO, 1997), however since 1995 only 0.82% of the gross watershed area has been harvested.

Agricultural activity is minimal in the Ross Creek drainage. However, the lower reaches are affected by residential development. Although residential development is sparse, channelization by landowners has reduced riparian vegetation and decreased channel complexity. The lower channel has been stabilized to protect development on the fan from flood events. The CSRD maintains a community park adjacent to the creek, and there is potential to develop some walking paths there (S. Abbott, pers. comm.).

<u>Management Priorities for Onyx Creek and Ross Creek</u>

Restoration of riparian habitat in upslope areas, improving agricultural practices, and protecting lakeshore spawning and rearing habitat are the management priorities for Onyx and Ross Creeks.

Table 17 summarizes progress made against the 1997 strategies, and presents new strategies.

Wright Creek – Seymour Arm

Wright Creek enters Shuswap Lake near the head of Seymour Arm. Coho utilize the lower reaches for spawning and rearing. Wright Creek flows out of Wright Lake, and both are within Anstey Hunakwa Provincial Park, which affords the creek protection from development (BC Parks, 2013). There is a logging road and stream crossing in the Wright Creek basin that access timber development areas in the upland.

Seymour River – Seymour Arm

Seymour River enters Shuswap Lake at the head of Seymour Arm. The river is an important producer of early summer sockeye; chinook and coho salmon have also been observed utilizing the river. A waterfall restricts anadromous salmon and resident trout to the lower 14.6 km of the river. McNomee Creek is a tributary to the lower portion of Seymour River, and is also utilized by sockeye and coho spawners. An impassable barrier restricts fish passage to the lower 8.7 km of the creek (Department of Fisheries and Oceans Canada, 1997).

Timber harvesting is the main resource development in the Seymour River watershed. The Seymour River valley and the McNomee and Ratchford sub-basins (both are tributaries to Seymour) have been extensively logged in the past, but since 1995 only 4.66% of the gross watershed area has been harvested. Impacts associated with timber harvesting and road-building pose a risk to fisheries resources because of increased sedimentation and loss of riparian cover. In the past, resource development and large landslides in the Ratchford Creek basin have resulted in downstream sedimentation, scouring, and channelization (as cited in DFO, 1997; B. Harding, pers. comm.). Currently, there is concern that the Seymour River could have a channel avulsion and cut off the lower reaches of the present channel where a significant portion of the salmon spawning occurs (B. Harding, pers. comm.).

Other resource activities in the Seymour watershed are limited. There is some settlement along the lower reaches of Seymour River and the confluence of McNomee Creek where salmon habitat values are highest. The small community of Seymour Arm, once a gold rush town known as Ogden City, consists of vacation properties and some agricultural development. The lowest reaches of the river and the estuary are within Silver Beach Provincial Park, which enables recreational enjoyment of the area and protects it from further development (BC Parks).

<u>Management Priorities</u>

The management priorities for the Seymour River watershed are assessing the stream channel, protecting water quality, and minimizing impacts from upland timber harvesting.

Table 18 summarizes progress made against the 1997 strategies, and presents new strategies.

Hunakwa Creek – Anstey Arm

Hunakwa Creek flows into Shuswap Lake at the head of Anstey Arm. The flows in the lower reach of the creek are buffered by Hunakwa Lake. The creek is utilized by sockeye (both early and late season stocks) and coho (as cited in DFO, 1997). It is also used by resident rainbow trout and kokanee (BC Parks).

Timber harvesting was historically the major use in the Hunakwa basin. The creek, Hunakwa Lake, and surrounding upland areas were established as a protected area in 2001 through a recommendation from the Okanagan Shuswap Land and Resource Management Plan and later established in 2004 as Anstey Hunakwa Provincial Park. This classification restricts timber harvesting within the park, but there are forest development plans adjacent to the park (BC Parks, 2013). Since 1995, 1.43% of the gross watershed area has been harvested.

Low flows in Hunakwa Creek have been noted in the past. Beaver activity in the area has resulted in ponding and restricting upstream fish access (as cited in DFO, 1997).

Management Priorities

Protecting fish habitat and rebuilding salmon stocks are the management priorities for Hunakwa Creek.

Table 19 summarizes progress made against the 1997 strategies, and presents new strategies.

Anstey River – Anstey Arm

Anstey River enters Shuswap Lake at the head of Anstey Arm. The creek is used predominantly by sockeye as well as chinook, coho and pink salmon. It is also used by resident rainbow trout, bull trout and kokanee. Anadromous fish are restricted to the lower 5.7 km, at which point there is an impassable barrier (Department of Fisheries and Oceans Canada, 1997).

Timber harvesting is a primary resource use in the Anstey watershed. In the past, logging has created instability problems in the lower watershed where fisheries values are the highest. Logging in headwater areas could impact water quality in tributaries, and subsequently in Anstey River (as cited DFO, 1997). An IWAP completed in 1998 indicated the ECA for the Anstey River sub-basin was 7% (Thiem, 1998). The current ECA is not known and since 1995 12.4% of the gross watershed area has been harvested.

Observations of Anstey River in the last few years indicate increasing turbidity and increased flows after fall rainfall events. Some of these events have impacted sockeye redds and have caused substrate deposition in the fan, causing it to become braided. This has caused concern for fish passage into Anstey River (B. Harding, pers. comm.).

The lower reaches of Anstey River and surrounding upland areas were established as a protected area in 2001 through a recommendation from the Okanagan Shuswap Land and Resource Management Plan and later established in 2004 as a Anstey

Hunakwa Provincial Park. This classification restricts timber harvesting within the park, but there are forest development plans adjacent to the park (BC Parks, 2013).

Management Priorities

Rebuilding salmon stocks and mitigating risks of terrain and channel instability and erosion are the management priorities for Anstey River.
Table 20 summarizes progress made against the 1997 strategies, and presents new strategies.

Reinecker Creek – Salmon Arm

Reinecker Creek enters Shuswap Lake on the north side of the Salmon Arm. Sockeye are the only anadromous species in the area, and spawn at the creek mouth on the dominant Adams cycle (2014). Lake-spawning sockeye concentrate along the shoreline near the mouth of the creek; kokanee and rainbow trout also spawn there.

The concern to fisheries resources in this drainage is sedimentation, which degrades water quality and can smother incubating eggs. Forestry in the upper watershed has degraded riparian zones and contributed sediment to the system in the past (as cited in DFO, 1997).

Herald Park Provincial Park and campgrounds are located along the lakeshore and the mouth of Reinecker Creek. There are trails adjacent to the Creek. There may be impacts to the creek and disturbances to spawning salmon from park visitors; however, the lower creek through the campground is fenced and educational signage is in place (BC Parks, 2015).

Management Priorities for Reinecker Creek

Protecting habitat and water quality at Reinecker Creek and along the shoreline at the creek outlet are the management objectives for this creek.

Table 21 summarizes progress made against the 1997 strategies, and presents new strategies.

White Creek – Salmon Arm

White Creek flows from White Lake into Shuswap Lake at Tappen Bay in the northwest end of the Salmon Arm. Broderick Creek is a small tributary to White Creek. It's suspected the creek is utilized by rearing juvenile salmon; the use by adult salmon is not known (B. Harding, pers. comm.).
White Creek has been severely impacted by agriculture. Non-point source pollution from farming activities, clearing of riparian vegetation, and diversion of water for irrigation and stock watering have degraded water quality, quantity, and habitat.

The Trans-Canada Highway crosses White Creek twice: once at Carlin, and again at Sunnybrae-Canoe Point Road. Future highway improvement projects may pose a risk to White Creek during construction; there may also be long-term benefits to fish habitat as crossings will be improved (B. Persello, pers. comm.).

Management Priorities

Restoration of riparian vegetation and improvement of water quality and quantity are the management priorities for White Creek.

Table 22 lists management strategies.

Tappen Creek – Salmon Arm

Tappen Creek flows into Shuswap Lake at Tappen Bay in the northwest end of the Salmon Arm. Sockeye and coho utilize this creek, along with resident rainbow trout. At one time, fish use was restricted to the lower several kilometres of the creek due to impassable structures, but those have been remediated. There is an ongoing maintenance issue with beaver dams at a culvert under the CPR near the creek confluence.

Fish habitat has been impacted by timber harvesting in the upper watershed, and agricultural and residential development in the lower reaches. The upslope logging has resulted in the loss of riparian vegetation, and in sediment input from construction of logging roads. Since 1995, 21.2% of the gross watershed area has been harvested.

The residential and agricultural activity in the lower reaches have led to degraded riparian conditions and reduced channel complexity. Livestock activity has caused streambank degradation and water quality concerns over non-point source inputs. Water withdrawals for irrigation pose further risk to the creek (as cited in DFO, 1997).

The Trans-Canada Highway crosses Tappen Creek near the bottom end of the creek. Future highway improvement projects may pose a risk to Tappen Creek during construction; there may also be long-term benefits to fish habitat as the crossing is improved (B. Persello, pers. comm.).

Management Priorities

Restoration of riparian vegetation, improvement of water quality and quantity, and provision for upstream passage of fish are the management priorities for Tappen Creek.
Table 23 summarizes progress made against the 1997 strategies, and presents new strategies.

Canoe Creek – Salmon Arm

Canoe Creek enters the Salmon Arm of Shuswap Lake near the eastern boundary of the City of Salmon Arm. The creek is utilized by sockeye, coho and rainbow trout. In the past, fish access was restricted to the lower reaches of the stream by culvert barriers, but those have been remediated by the installation of tail-water controls at the CPR crossing and Canoe Beach Drive; installation of an open-bottom culvert at 20 Avenue NE in Salmon Arm; and a fish-way at the second Trans-Canada Highway crossing (B. Harding, pers. comm.).

Canoe Creek is prone to low flows. This can impede passage for anadromous fish from the lake into the creek. This problem is exacerbated by the lack of riparian cover and channel instability at the mouth of the creek (B. Harding, pers. comm.).

Timber harvesting is a primary resource use in the Canoe Creek basin. In the past, it has impacted downstream areas through increased sediment input from construction and use of logging roads, and from streambanks that have lost riparian vegetation (as cited in DFO, 1997). The current ECA is not known and since 1995 7.4% of the gross watershed area has been harvested.

Agriculture activities, including livestock grazing and crop production, are predominant through the lower reaches of Canoe Creek. These have resulted in a loss of riparian cover, water quality deterioration due to non-point sources of pollution, and reduced flows due to withdrawals for irrigation (as cited in DFO, 1997).

The impacts of urbanization and recreation are apparent in the lower reaches of the creek. The creek passes through two golf courses. Settlement, mostly low-density rural properties, is developed throughout the lower reaches. The Canoe Forest Products sawmill and plywood plant is located adjacent to the creek mouth on the shore of Shuswap Lake.

Canoe Creek provides part of the domestic water supply for the City of Salmon Arm (City of Salmon Arm).

<u>Management Priorities</u>

Restoration of riparian vegetation, improvement of water quality, and maintenance of adequate stream flows are the management priorities for Canoe Creek.

Table 24 summarizes progress made against the 1997 strategies, and presents new strategies.

Sicamous Creek and Hummingbird Creek – Mara Lake

Sicamous Creek (also known as Two-Mile Creek) enters Mara Lake at the north end, just south of Sicamous; Hummingbird Creek enters the lake at Swansea Point. Sockeye salmon spawn at the confluence of Sicamous Creek; it’s the only known place in Mara Lake where this occurs. It’s not known if salmon use the creeks; if they do, it would be limited to the lowest reaches.

Development at Hummingbird Creek is a concern; the small but densely populated community of Swansea Point is built on the fan of the creek and along the shoreline of the lake.

Management Priorities

Protecting shore-spawning habitat at the confluence is the management priority for Sicamous Creek.

Table 25 lists management strategies.

Table 15. Shuswap and Mara Lakes management strategies

Strategies from *1997 Review*	Status	Notes
Map existing habitat values along lakeshores, classify habitat, and provide development guidelines that can be incorporated into zoning and OCPs of local governments	✔ Complete	The Foreshore Inventory and Mapping; Aquatic Habitat Index; and Shoreline Management Guidelines for Shuswap, Mara and Little Shuswap Lakes were completed in June 2011; the same were completed for Mabel lake in September 2011
Work with local governments to implement zoning and foreshore management plans that recognize and protect fish habitat (Fisheries Sensitive Zones)	✔ Complete	The CSRD adopted Bylaw 900 in August 2012 which sets out foreshore zoning, and docks and moorage buoys regulations (Columbia Shuswap Regional District, 2015)
Work with local governments to develop and incorporate guidelines into bylaws	✔ Ongoing	
Work with local governments to restrict/regulate the expansion of the houseboat industry in areas with high fish values, e.g. Sicamous Narrows	✔ Ongoing	The Sicamous Narrows Management Plan is in place, although there are concerns about compliance
Encourage better enforcement of existing legislation, such as the Soil Deposition Bylaw in the Municipal Act to enable removal of unauthorized fills	? Unknown	
Protect the integrity and water quality of tributary streams	✔ Partially complete	There have been many restoration works done and beneficial practices implemented; however agriculture, forestry, and point-sources have the greatest impact on water quality and still must be improved
Work with DOE (Environment Canada), MELP (BC Ministry of Environment) and landowners to monitor and control non-point sources of water pollution (e.g., agricultural and domestic wastes)	✔ Ongoing	
Ensure milfoil control does not impact sockeye spawning areas	✔ Ongoing	The CSRD follows best practices (i.e., timing windows) for harvesting and roto-tilling milfoil; they also work on occasion with DFO to remove milfoil from critical shoreline locations

Ensure that log handling sites are consolidated at existing locations	✗ Incomplete	Sites come in and out of action depending on where forest harvesting is taking place. There are a greater number of log handling sites on the lake than there were in 1997; however, the number is less than historical.
Review recommendations in the Shuswap Lake Environmental Management Plan to improve water quality in the lake and assess risks of development on alluvial fans. Review and refine shoreline habitat zones.	? Unknown	The recent utility of the Shuswap Lake Environmental Management Plan is not known. A FIM, AHI and Shoreline Management Guidelines were completed for Shuswap Lake in 2011.
New Strategies		
Utilize FIM restoration analysis for future restoration works		
Protect fish habitat in the Sicamous channel		
Support watershed-wide (lakes and streams) water quality monitoring		
Re-visit the draft Recreation Management Plan for Shuswap, Little Shuswap Mara and Adams Lakes and implement strategies as they pertain to recreation and the environment		
Support programs and infrastructure to prevent spread and introduction of non-native and invasive species such as spiny ray fish and zebra/quagga mussels		
Support development of facilities for receiving and treating black and grey water from pleasure crafts		
Encourage implementation and enforcement of Riparian Area Regulations		

Table 16. Scotch Creek management strategies

Strategies from *1997 Review*	Status	Notes
Defer logging in Scotch Creek pending a roundtable review of a completed IWAP to FPC standards	? Unknown	The recent utility of IWAPs is not known
Conduct Level 2 Channel Assessment Procedure to further assess stability of Scotch Creek and identify restoration opportunities	✔ Complete	A channel assessment was completed in 1997 for Adams Lake Indian Band
Restore riparian zones in logged upslope areas, deactivate old logging roads, and improve and maintain active roads (through WRP)	? Unknown	It's not known what was completed before the sunset of the WRP
Monitor the potential obstruction at km 16 of Scotch Creek to ensure adequate fish passage. Conduct inventory above the barrier to assess salmon use.	✔ Ongoing	

Explore the opportunity to open up old side channels on the Scotch Creek fan. (A side channel inventory to assess potential off-channel habitat development is being conducted through FRBC.)	✔ Complete	An assessment recommended that side channel work not be undertaken
New Strategies		
Assess large cut-bank at apex of Scotch Creek fan		

Table 17. Onyx Creek and Ross Creek management strategies

Strategies from *1997 Review*	Status	Notes
Re-vegetate streambank sections in previously logged upslope areas, deactivate old logging roads and upgrade/maintain active roads, and ensure that future road development does not increased risk of landslides (through WRP process)	? Unknown	
Promote stream stewardship arrangements with local landowners to re-vegetate streambanks along the lower reaches.	✗ Incomplete	
Restrict further developments on the fans of Onyx and Ross Creeks	🚫 Not applicable	Development permitting is the decision and responsibility of the CSRD
Ensure that future water withdrawals do not create critical summer low flows and do not affect beach spawning on the fans	? Unknown	
New Strategies		
Consider Environmental Flow Needs before issuing further water licences		

Table 18. Seymour River management strategies

Strategies from *1997 Review*	Status	Notes
Complete and review an IWAP on Seymour River and McNomee Creek, and conduct additional assessments as required to guide future logging activities to prevent watershed impacts	? Unknown	It's not known if an IWAP was completed. A Fisheries Sensitive Watershed (FSW) Risk Analysis was completed in 2010 for Seymour River and others to prioritize restoration planning and treatment (Timberline Natural Resource Group & M.J. Milne and Associates Ltd., 2010)

Restore upslope areas through re-vegetation of streambanks and deactivate or upgrade and maintain logging roads (through WRP). Ratchford Creek should be the focus of restoration efforts. A watershed assessment initiated on McNomee Creek will help define areas where restoration efforts should be directed.	? Unknown	
Apply DFO/MELP Land Development Guidelines to recreational and urban developments along the lower Seymour River	🛇 Not applicable	Land Development Guidelines are no longer applicable; they have been replaced by Riparian Area Regulations for riparian protection
New Strategies		
Assess stream channel stability for lower Seymour River		

Table 19. Hunakwa Creek management strategies

Strategies from *1997 Review*	Status	Notes
Assess impacts of logging and conduct restoration activities in upslope areas impacted by logging (through IWAP)	? Unknown	It's not known if this has been carried out. It may no longer be an applicable strategy as part of the basin is within a protected area.
Monitor beaver activity to ensure access to upstream areas	✔ Ongoing	
New Strategies		
Continue with beaver activity monitoring to ensure passage		

Table 20. Anstey River management strategies

Strategies from *1997 Review*	Status	Notes
Initiate an IWAP to assess logging impacts and to guide future logging activities to prevent watershed impacts	? Unknown	An IWAP for Anstey and Eagle River watersheds was completed in 1998. The recent utility of IWAPs is not known. A Fisheries Sensitive Watershed (FSW) Risk Analysis was completed in 2010 for Anstey River and others to prioritize restoration planning and treatment (Timberline Natural Resource Group & M.J. Milne and Associates Ltd., 2010)
Re-vegetate riparian vegetation lost as a result of past logging practices. Deactivate old logging roads, and upgrade/maintain active roads.	? Unknown	

Determine terrain instability problems and avoid construction of new logging roads in erodible areas.	? Unknown	
New Strategies		
Assess channel stability		

Table 21. Reinecker Creek management strategies

Strategies from *1997 Review*	Status	Notes
Restore riparian vegetation affected by past logging practices; deactivate old logging roads and maintain active roads (through WRP)	? Unknown	
Develop an interpretive stream program in association with Herald Park staff, to educate the public on the importance of streams and lake foreshore areas to fisheries resources	✔ Complete	BC Parks has installed educational signage in Herald Park
Ensure that milfoil control activities do not impact on sockeye beach spawning	✔ Ongoing	The CSRD follows best practices (i.e., timing windows) and works with DFO to remove milfoil from critical shoreline locations
New Strategies		
None at this time		

Table 22. White Creek management strategies

New Strategies
Promote stream stewardship programs and Environmental Farm Planning to re-vegetate streambanks and improve water quality
Consider Environmental Flow Needs before issuing further water licences

Table 23. Tappen Creek management strategies

Strategies from *1997 Review*	Status	Notes
Restore upslope areas impacted by logging through road de-activation and/or maintenance, riparian planting and stabilization of terrain	? Unknown	
Control siltation from streambanks and explore the use of bio-engineering techniques	✔ Partially complete	The lower reaches of the creek have been planted and a culvert under the Trans-Canada highway was tail-water controlled
Promote stream stewardship programs to re-vegetate and fence livestock away from streambanks	✔ Ongoing	

Determine instream flow requirements, and monitor water withdrawals to ensure compliance with water licenses particularly during periods of low summer flows. Restrict further water licensing.	? Unknown	
Upgrade the culvert at 1.7 km to allow fish passage at all water levels	✔ Complete	
New Strategies		
Periodic monitoring of beaver dam at CPR culvert near creek confluence		
Assess Bolton Road culvert		
Consider Environmental Flow Needs before issuing further water licences on Tappen Creek		

Table 24. Canoe Creek management strategies

Strategies from *1997 Review*	Status	Notes
Initiate IWAP (to FPC standards) to assess logging related impacts in upslope areas and develop restoration initiatives	? Unknown	It's not known if an IWAP was completed for Canoe Creek before the sunset of the WRP
Promote stream stewardship to restore riparian vegetation by replanting streamside vegetation and fencing livestock from streambanks	✔ Ongoing	
Protect eroding banks through bio-engineering techniques, to maintain habitat complexity, where appropriate	✔ Ongoing	Some projects have been completed, including at the Salmon Arm Golf Course and adjacent to Highway 97
Develop instream flow requirements and monitor summer water withdrawals. The goal is to ensure compliance and improve summer flows. Investigate storage opportunities and reject further water licensing in Canoe Creek.	✔ Partially complete	Some flow monitoring has occurred. Additional storage on Canoe Creek is not feasible.
Upgrade culverts that restrict fish passage, and assess other fish passage problems (e.g., beaver dams)	✔ Complete	
New Strategies		
Consider Environmental Flow Needs before issuing further water licences		
Continue to promote stream stewardship with private landowners and the agriculture community		

Table 25. Sicamous Creek and Hummingbird Creek management strategies

New Strategies
Protect shore-spawning habitat values at the Sicamous Creek confluence
Consider forest activities and development planning in the upland watersheds before undertaking fish habitat restoration and channel stability works on the fans

6.4 Salmon River System

The Salmon River watershed drains the area south of Salmon Arm from its headwaters on the Thompson Plateau bordering the Nicola watershed. The Salmon River system includes the Salmon River – a major tributary to Shuswap Lake – as well as several small streams such as Spa Creek, Silver Creek, and Bolean Creek.

The watershed is within the Interior Douglas-fir, Montane Spruce and Engelmann Spruce – Subalpine Fir biogeoclimatic zones. The valley bottom, from Salmon Arm upstream to Westwold, has a history of settlement associated with agriculture. The valley bottoms have been cleared and converted to pastures and fields for agriculture.

6.4.1 Salmon River

The Salmon River flows into Shuswap Lake at the head of the Salmon Arm, near the City of Salmon Arm. It flows through a diverse topography of mountains, hills, rocky gullies and fertile valleys. A portion of the middle reach of the river flows underground for nearly 13 kilometres most of the year, presenting a barrier to migrating salmon, before it re-surfaces at the community of Westwold (S. Gwanikar, 1998).

The river supports the second largest coho population in the HMA (second only to Eagle River) and is an important chinook producer. In addition, late run sockeye return to the river on the dominant (2014) Adams River cycle. Historically there were summer runs of sockeye, but the stock was decimated following the Hell's Gate landslide of 1913 and did not recover (Department of Fisheries and Oceans Canada, 1997). The best spawning habitat is in the reach between Silver Creek and Falkland, although the quality of the habitat is at risk of being diminished by fine-silt sedimentation, and lack of riparian cover and pool habitat (Summit Environmental Consultants Ltd., 2015).

Eagle River Hatchery and Spius Creek Hatchery have both been involved in enhancing coho and chinook stocks for the Salmon River. Eagle River Hatchery, once located at Taft east of Malakwa, operated from 1983 to 1994 and could produce 17,000 adult coho and 5,400 adult chinook to catch and escapement (for Salmon and Eagle Rivers, combined). The Eagle River Hatchery ceased its operations in 1994 and since that time chinook and coho enhancement has been conducted out of the Spius Creek Hatchery located near Merritt. Significant re-building of coho has been observed throughout 2000 – 2015 (D. Lofthouse, pers. comm.). Local resident Gene Puetz has operated a fish-fence on the Salmon River at Silver Creek for over 30 years to facilitate accurate annual counts of migrating salmon.

The Salmon River watershed has been severely impacted by timber harvesting, extensive agricultural activity, residential development and linear development, and natural disturbances. Habitat degradation has resulted from removal of riparian vegetation, channelization of the riverbed, water withdrawal, and water quality deterioration from nutrient and sediment input (as cited in DFO, 1997; Michael McPhee, 1996).

The Mountain Pine Beetle epidemic had a big impact on the Salmon River watershed, more than any other major sub-basin of the South Thompson – Shuswap HMA. Over 35,000 hectares within the mainstem basin were impacted by the MPB, or 22.4% of the mainstem watershed area. In 1998, the ECAs for some sub-basins were as high as 43.6% (Forsite Consultants Ltd., 1998). The current ECA is not known, but since 1995 22.79% of the gross watershed area has been harvested. The road density is 2.54 km/km^2.

A substantial wildfire occurred on Mt. Ida and the Fly Hills in 1998; the hillsides on both sides of the lower reaches of the river were burned extensively. Over 6400 hectares of land near Salmon Arm were burned in the Silver Creek Fire (Grace, 2003); it is perhaps the largest fire to have occurred in the HMA in the last few decades. Another large fire occurred in 2003; the Cedar Hill fire burned 1620 hectares just east of Falkland (BC Ministry of Forests, Lands and Natural Resource Operations, 2004). Post-wildfire water quality monitoring in the small creeks draining the affected area had high levels of turbidity, sediment, and nutrients; sedimentation measures were high enough in some creek to have detrimental impacts to aquatic life (Grace, 2003). Other impacts of wildfire to fish and fish habitat include the loss of riparian cover, resulting in increased temperature variation, decreased leaf and insect drop, streambank instability and increased erosion, and less recruitment of large woody debris (Panko, 2003).

The valley bottom is used extensively for agriculture. A range of agricultural activities occurs including grazing livestock, dairy farming, egg and poultry farming, and growing feed crops (i.e., hay and corn), vegetables, and turf. The effects of historic land-clearing for conversion to pastures and crops is exacerbated by ongoing livestock grazing and farming, resulting in the loss of riparian cover, bank erosion, and non-point sources of pollution (as cited in DFO, 1997). Field research in the Salmon River watershed has suggested that livestock exclusion fencing is an effective tool to reduce sedimentation and allow riparian vegetation to recover (Agriculture and Agri-Food Canada, 2012).

The Salmon River is prone to low flows and high temperatures. At certain times of year, the flows cannot sustain fish populations and meet agricultural irrigation needs (Michael McPhee, 1996). During drought, flows at the mouth of the river are too low to facilitate the passage of migrating salmon. Lack of high quality habitat for spawning and migration may result in departure of some adults. In the past there have been efforts to move salmon upstream of the fan and wetland areas to a location where the channel is narrower and deeper. DFO is working in partnership with first nations to address the historic fish passage problems on the delta (B. Harding, pers. comm.; S. Bennett, pers. comm.). Additionally, low flows result in less physical space for rearing, and high temperatures decrease survivorship and fecundity (Summit Environmental Consultants Ltd., 2015). Migration and spawning in the Salmon River coincide with the irrigation season; in 2015 – a particularly bad drought year for many streams in the BC Interior – irrigation caused significant flow reductions in the river; flows approached the critical flow threshold for juvenile rearing, and were below the critical flow threshold for chinook migration and spawning (Summit Environmental Consultants Ltd., 2015). In 2015, the Minister of Forests, Lands and Natural Resource Operations made a request to licensed water users in the watershed to voluntarily reduce their consumption in an effort to protect fish and fish habitat.

In addition to the impacts that diversion of water for irrigation has on the Salmon River, there is also at least one barrier to fish passage in the form of an irrigation weir, located west of Falkland near the Highway 97 crossing (B. Harding, pers. comm.).

The Salmon River contributes a substantial nutrient load to the lake. This has affected water quality in the Salmon Arm Bay area of the lake, which exhibits a higher trophic status than other parts of Shuswap Lake (as cited in DFO, 1997). An analysis of water quality and land uses in the watershed suggests that nutrients in the river are mostly derived from agricultural activity (Tri-Star Environmental Consultants, 2014).

Settlement along the Salmon River is mainly rural and associated with agricultural activity, except for small communities at Silver Creek, Falkland and Westwold. In addition to impacts associated with agriculture, impacts from residential settlement are associated with clearing of riparian vegetation and seepage from septic tanks.

Concerns for the Salmon River watershed resulted in the formation of the Salmon River Restoration Committee in 1991, which morphed into the Salmon River Watershed Roundtable (SRWR) in 1993 (Salmon River Watershed Roundtable, 2003). The group – a partnership of local residents and representatives from federal, provincial, and first nations governments and non-government organizations – has been active for over 20 years. The SRWR completed a watershed plan in 1995 that prioritized restoring the riparian corridor. By 2015, the SRWR had been involved in over 470 restoration projects with over 100 landowners. These include streambank revetments, exclusion fencing and off-stream watering developments for livestock, re-vegetation and bank stabilization (J. Felhauer, pers. comm.).

Improvements to the Trans-Canada Highway are planned for the Salmon Arm area, and it’s likely that priority will be given to replacing the Salmon River Bridge in early phases of construction. There is an opportunity to replace the bridge with a new structure that has a wider span, thereby eliminating the bottle-neck that the existing bridge sometimes creates during spring freshet (B. Persello, pers. comm.). During construction, there will be impacts to the riparian area and a chance of spills or sediment plumes to the river. The BC MOTI and its contractors adhere to standard specifications and site-specific special provisions for construction to minimize environmental impacts (BC Ministry of Transportation and Infrastructure).

Management Priorities

Building coho stocks, continued restoration, and protecting in-stream flows are the management priorities for the Salmon River.

Table 26 summarizes progress made against the 1997 strategies, and presents new strategies.

6.4.2 Palmer Creek, Rumball Creek, Silver Creek, Spa Creek and other small tributaries

Several small tributaries feed into the Salmon River, particularly into the lower reaches. Palmer Creek is one such small tributary, near the confluence of the river; coho have been observed spawning in it. Rumball, Silver and Spa Creeks enter the Salmon River further upstream; they are not known to be spawning grounds for salmon, in part because flows are not adequate during spawning season, however they provide rearing habitat for juveniles (B. Harding, pers. comm.).

A perched culvert at Foothills Road is a barrier to fish migration on Rumball Creek. Juvenile coho and chinook salmon were found to be rearing in Rumball Creek between the Salmon River and Foothills Road in 1998 (B. Harding, pers. comm.).

Juvenile salmon have been found to frequent several small drainages flowing into the Salmon River and have been impacted in the past by ditch cleaning activities. Ditch cleaning management plans have been recommended to local governments by DFO to prevent mortality of juvenile salmonids (B. Harding, pers. comm.).

6.4.3 Bolean Creek and Six-Mile Creek

Bolean Creek flows into the Salmon River at Falkland. It is utilized by coho salmon for spawning in the lower 6.5 km of the creek and at the mouth. Juvenile coho rear throughout the system, although beaver dams can limit their distribution. The creek is also a major producer of rainbow trout (as cited in DFO, 1997).

Timber harvesting is the predominant resource use in the Bolean Creek basin; the concerns for the Bolean are the same as for the Salmon River watershed (as cited in DFO, 1997). Since 1995, 23.7% of the gross watershed area has been harvested and the road density in the basin is 2.72 km/km^2.

Six Mile Creek is a tributary to Bolean Creek and is utilized by coho salmon for spawning and rearing; large rainbow trout have also been observed in the creek.

Barriers to fish migration (perched culverts) were remediated at two sites, including a farm access road and at the confluence of St. Laurent Creek (a tributary to Six Mile). Juvenile Salmon River coho were out-planted in the area above and below these former barriers in the hopes of re-establishing the coho distribution in Six Mile Creek. Although the creek basin has extensive agricultural use in the lower reaches, flows are not as significantly impacted by irrigation withdrawals as other parts of the Salmon River watershed (B. Harding, pers. comm.).

Management Priorities

Maintaining habitat, water quality and flows, and preventing juvenile mortality are the management priorities for the tributaries to Salmon River.

Table 27 summarizes progress made against the 1997 strategies, and presents new strategies.

Table 26. Salmon River management strategies

Strategies from *1997 Review*	Status	Notes
Initiate IWAP (to FPC standards) and conduct additional assessments as required to assess past logging impacts and guide future logging activities to prevent watershed impacts	✔ Complete	An IWAP was completed in 1998 however its recent utility is not known; IWAPs are not current management tools
Continue to develop a riparian corridor along the Salmon River by protecting existing vegetation, stabilizing and re-vegetating streambanks, and fencing livestock away from streambanks	✔ Completed and ongoing	The Salmon River Watershed Roundtable has been involved in hundreds of restoration projects of various types, completing most of what they identified in the Watershed Restoration Plan. Additional projects will be completed when funding is secured.
Stabilize upslope areas affected by past logging practices, through road deactivation and/or maintenance, riparian re-vegetation of streambanks and slope stabilization (through WRP process)	? Unknown	It's not known what was completed before the sunset of the WRP
Increase habitat complexity by creating additional pool and off-channel habitat and identify opportunities to re-develop lost wetland	✔ Completed and ongoing	Extensive restoration work has been done to achieve this: four off-channels have been built, efforts are ongoing for mainstem and off-channel restoration
Work with Water Management Branch and water license holders to develop a water management plan that includes fisheries flow needs, surface and groundwater uses, identification of storage opportunities and monitoring requirements to improve instream flows. Continue to reject further water licensing.	✗ Incomplete	A water management plan has not been completed for the Salmon River, however the MOE, Ministry of Agriculture and clients have worked together on an as-needed basis to manage water quantity
Apply DFO/MELP watershed stewardship guidelines for agriculture and other relevant guidelines to control runoff and non-point sources of nutrients from cattle and feedcrop production	✔ Completed and ongoing	Several stewardship initiatives and tools are in use in the Salmon Valley including provincial government guidelines, Environmental Farm Planning, BC Cattlemen's Farmland Riparian Interface Stewardship Program, the Salmon River Watershed Roundtable, and industry self-governance. Additionally, the Agriculture Waste Control Regulation is currently being updated.
Apply DFO/MELP land develop guidelines for urban developments	🚫 Not applicable	Land Development Guidelines are no longer applicable; have been replaced by Riparian Area Regulations for riparian protection

Continue to work with the SRWR to promote public awareness and educate user groups on the importance of riparian restoration in the Salmon River watershed	✔ Ongoing	
Monitor the effectiveness of restoration programs	✔ Complete	The SRWR has monitored restoration sites
New Strategies		
Consider Environmental Flow Needs before issuing further water licences on Salmon River		
Continue to support and encourage the work of stewardship organizations		
Continue working with the agricultural community, particularly the new influx of the dairy industry, to foster stewardship ethic		

Table 27 Palmer Creek, Rumball Creek, Silver Creek, Spa Creek, Bolean Creek, and Six Mile Creek management strategies

Strategies from *1997 Review*	Status	Notes
Stabilize upslope areas affected by past logging practices, through road deactivation and/or maintenance, riparian re-vegetation of streambanks and slope stabilization (through WRP process)	? Unknown	It's not known what was completed before the sunset of the WRP
Increase habitat complexity by creating additional pool and off-channel habitat and identify opportunities to re-develop lost wetland	✔ Completed and ongoing	Extensive restoration work has been done to achieve this: four off-channels have been built, efforts are ongoing for mainstem and off-channel restoration
New Strategies		
Consider Environmental Flow Needs before issuing further water licences on creeks		
Continue to support and encourage the work of stewardship organizations		
Restore priority sites on Chase Creek with bio-engineering streambank stabilization techniques and livestock exclusion fencing		
Encourage authorities to develop ditch cleaning management plans, and conduct routine ditch maintenance in a manner that doesn't cause juvenile salmonid mortality		

6.5 Eagle River System

The Eagle River watershed drains the area east and north of Sicamous, from its headwaters high in the Monashee Mountains at the eastern boundary of the HMA, through Three Valley Lake, and lastly through a wide fertile valley before entering Shuswap Lake at Sicamous. The Eagle River system includes its major tributary, the Perry River, as well as several other small high-gradient streams.

The watershed is within the Interior Cedar Hemlock and Engelmann Spruce – Subalpine Fir biogeoclimatic zones. Timber harvesting is the predominant land use throughout the watershed; the lower reaches of the valley bottom are used for agriculture. There are substantial linear developments in the watershed; notably, the Trans-Canada Highway and the Canadian Pacific Railway both of which are adjacent to the Eagle River.

6.5.1 Eagle River

The river supports the largest coho population in the HMA, as well as a significant chinook population. Sockeye and pink salmon are also observed. The bottom half of the river has a significant meander and there is excellent habitat for juvenile coho in oxbows and wetlands.

The Eagle River Hatchery operated at Taft from 1983 to 1994 with the goal of increasing coho and chinook production. It had the capacity to produce 17,000 coho adults and up to 5,400 chinook adults to catch and escapement (for Eagle and Salmon Rivers, combined). Enhancement activities at the hatchery ceased in 1994 due to financial constraints and poor adult chinook survival. Coho production was re-initiated for stock assessment purposes in the Eagle River system in 2009 with fish culture being conducted at Spius Creek Hatchery (D. Lofthouse, pers. comm.).

The lower reaches of the Eagle River show degradation of riparian habitat from a variety of activities. Agriculture is most predominant in the lower reaches of the river and includes cattle ranching and growing feed crops. The effects of historic land-clearing for conversion to pastures and crops is exacerbated by ongoing livestock grazing and farming resulting in the loss of riparian cover, bank erosion, and non-point sources of pollution (as cited in DFO, 1997).

Urban, linear and industrial development occurs throughout the valley bottom, with the densest settlement occurring in the District of Sicamous. The Trans-Canada Highway and the Canadian Pacific Railway are adjacent to the Eagle River, except for the uppermost reaches. Linear developments have resulted in channelization of some river sections, degradation of riparian zones, and loss of off-channel habitat. To offset the loss of habitat, the BC Ministry of Transportation and Highways (former) built rearing ponds for coho between Malakwa and Cambie (Department of Fisheries and Oceans Canada, 1997). Sawmilling has also impacted riparian areas;

although the number of sawmills along the Eagle River corridor is reduced from historical, the impacts to riparian areas can still be seen. Additionally, a large hotel/resort is located on the outlet of Eagle River into Three Valley Lake; the impact of this development on the habitat and potential disturbance to salmon is not known.

A concrete box culvert at mile 16 on the CPR is a barrier to fish migration during years of low flows. It's thought that the barrier has been occurring for decades but went undetected due to its remote location. DFO advised the CPR of the barrier in 2002 and since that time, several studies have been conducted and mitigation options developed but due to the complexity of the situation and the costs of mitigation, an agreement has not yet been reached. An additional impact is present at mile 15.5 where a sub-surface diversion of the river base flow through the rail way grade has resulted in de-watering the main stem and causing fish kills (B. Harding, pers. comm.).

In the early 2000s, DFO observed numerous treated railway ties deposited in and adjacent to the Eagle River. This was cause for concern, as treated wood ties contain Polycyclic Aromatic Hydrocarbons that cause detrimental effects to aquatic organisms at certain concentrations. In 2003, DFO advised the CPR of the locations of the ties, and the CPR conducted an extensive survey and removed them (B. Harding, pers. comm.).

These developments have resulted in an overall loss of channel complexity, especially off-channel habitat which is particular important to coho salmon. A SHIM was done for the Eagle River in 2014, but was not publically available at the time this document was prepared (A. Neil, pers. comm.).

Improvements to the Trans-Canada Highway east of Sicamous may have a substantial impact on the Eagle River. Some reaches of the valley are narrow, and there is a possibility that four-laning the highway may require infilling of the river or riparian areas. All design scenarios are considered during planning phases, and the BC MOTI and its contractors adhere to standard specifications and site-specific special provisions for construction to minimize environmental impacts (BC Ministry of Transportation and Infrastructure).

Forestry has impacted the upper Eagle watershed. Timber harvesting and road development, particularly in the tributary watersheds, have contributed sediment to the lower reaches of the Eagle River (as cited in DFO, 1997). The terrain in the upper watershed is steep and can be unstable, a problem which can be exacerbated by road building and harvesting. Since 1995, 6.61% of the gross watershed area has been harvested and road density is 1.22 km/km^2.

At one time, there was an Eagle River Watershed Roundtable stewardship organization but at the time of this update it is no longer an active group.

Management Priorities

Protecting river habitat, especially off-channel juvenile rearing habitat, in relation to future development is the management priority for the Eagle River.

Table 28 summarizes progress made against the 1997 strategies, and presents new strategies

6.5.2 Owlhead Creek

Owlhead Creek enters the Eagle River approximately 5 km from the river mouth. Spawning and rearing by coho, and limited rearing by chinook, are observed in the lower creek reaches (as cited in DFO, 1997). Kokanee and brook trout have also been observed (Summit Environmental Consultants Ltd., 1997).

Forestry is a predominant land use in the Owlhead basin. In the past, forestry activities in the upper Owlhead watershed have resulted in flooding, sedimentation and landslides (as cited in DFO, 1997). Aerial photography indicates that forest harvest is extensive throughout the upper watershed (Summit Environmental Consultants Ltd., 1997). Since 1995, 9.22% of the gross watershed area has been harvested.

Residential development and agricultural activity in the lower watershed have impacts on water quality, particularly due to non-point source pollution from livestock (Department of Fisheries and Oceans Canada, 1997; Summit Environmental Consultants Ltd., 1997). Recreation use (e.g., off-roading) has also impacted riparian vegetation and streambank integrity.

The Trans-Canada Highway crosses Owlhead Creek east of Sicamous. The pending expansion of the highway may aggravate fish passage problems and impact the riparian zone. The culvert under the highway imposed problems to migrating salmon in the past until it was tail-water controlled.

6.5.3 Yard Creek and Senn Creek

Yard Creek and Senn Creek flow into the Eagle River near the community of Malakwa. Yard Creek is primarily a sockeye-producing creek, and also provides habitat for rearing juvenile coho. Senn Creek is a very important coho producer and provides excellent spawning habitat. Habitat on both creeks is limited to the lower reaches.

Senn Creek flows adjacent to an agricultural field and then into an oxbow of the Eagle River; the stream channel was modified many years ago but with the oxbow it remains very important habitat for juveniles. This is in part due to the landowner’s stewardship activity that has included fencing and bridging the creek (B. Harding, pers. comm.).

The Yard Creek drainage has been extensively logged. In 1998, the ECA was 20% (Thiem, 1998). The current ECA is not known and since 1995 6.78% of the gross watershed area has been harvested. Roads and related sources are identified as the main source of sedimentation in the basin (Thiem, 1998).

The lower reaches of the creek are within Yard Creek Provincial Park; this classification protects the area from further development while enabling recreational enjoyment of the area (BC Parks).

6.5.4 Perry River and South Pass Creek

Perry River enters the Eagle River near Craigellachie, approximately 30 km east of Sicamous. This tributary is used by sockeye and chinook spawners, with some coho rearing observed in the lower reaches. A partial obstruction approximately 6 km upstream of the mouth may restrict fish passage at some water levels. Fisheries production in the Perry River may be low due to glacial melt and cold water temperatures (as cited in DFO, 1997).

Forestry activities in the upper watershed have contributed to loss of riparian habitat and channel degradation. Channel instability is high due to steep terrain, and channel movement has taken place as a result of harvesting and the input of large woody debris to the system (as cited in DFO, 1997). The current ECA for the Perry River basin is not known and since 1995 6.96% of the gross watershed area has been harvested.

Recreation is becoming increasingly popular in the Perry River area. A network of forestry roads helps to facilitate this. Heli-skiing, cat-skiing, snowmobiling, and off-roading are common activities, the last of which can cause sedimentation and erosion and damage riparian vegetation.

South Pass Creek flows into the Eagle River at Three Valley Lake, upstream of the Perry River, approximately 50 km east of Sicamous. Coho and sockeye utilize the creek as well as resident bull trout. Anadromous fish are restricted by an impassable falls 1.2 km upstream of the creek mouth (Department of Fisheries and Oceans Canada, 1997).

Forestry activities in the upper watershed constitute the major land use. The terrain is steep and unstable, with avalanche chutes present; forest harvesting and road development can further destabilize the slopes. The ECA for the South Pass Creek basin is not known and since 1995 5.1% of the gross watershed area has been harvested.

The pending expansion of the Trans-Canada Highway east from Sicamous presents additional concerns for the creek and Three Valley Lake. There may be impacts to fish passage, creek and shoreline spawning habitat, and lake rearing habitat. The Malakwa Bridge over Perry River was replaced and a 2.7 km segment of the highway was expanded to four lanes in 2015; bank restoration upstream of the new bridge was done as compensation for impacts created during construction. The North Fork Bridge at Perry River is scheduled to be replaced within five years (B. Persello, pers. comm).

6.5.5 Crazy Creek

Crazy Creek flows into the Eagle River east of the historic site of Craigellachie. Spawning sockeye and coho, and rearing juvenile coho utilize the; their use is restricted to the lowest reaches of the creek due to an impassable falls. Western slope cutthroat trout have also been observed in the stream.

Management Priorities

Protecting river habitat, especially off-channel juvenile rearing habitat, in relation to future development is the management priority for Owlhead Creek, Yard Creek, Senn Creek, Perry River, South Pass Creek and Crazy Creek.

Table 29 summarizes progress made against the 1997 strategies, and presents new strategies.

Table 28. Eagle River management strategies

Strategies from *1997 Review*	Status	Notes
Complete and review IWAPs on Perry and Eagle Rivers, and conduct additional assessments as required to guide future logging activities to prevent watershed impacts	✔ Complete	An IWAP for Anstey and Eagle River watersheds was completed in 1998 (Thiem, 1998). The recent utility of IWAPs is not known. A FSW Risk Analysis was completed in 2010 for Eagle and Perry Rivers, Yard Creek and others to prioritize restoration planning and treatment (Timberline Natural Resource Group & M.J. Milne and Associates Ltd., 2010)
Inventory and classify riparian vegetation and juvenile rearing habitat along the Eagle River (off-channel habitat, small tributaries, wetlands groundwater-fed channels), and develop guidelines for habitat protection and restoration	✔ Complete	A SHIM has been completed for Eagle River
Re-vegetate riparian zones lost as a result of past logging practices, deactivate old logging roads, upgrade and maintain active roads, determine terrain instability problems, and avoid construction of new logging roads in erodible areas (through WRP)	? Unknown	It's not known what was completed before the sunset of the WRP
Assess potential impacts of future highway expansion, and ensure there is no encroachment and loss of rearing habitat	✔ Partially complete	Impacts are considered as projects are completed; since 1997, some bridges have been replaced and segments of highway expanded. Environmental, social and economic factors are weighed in highway design and planning.
Ensure that contingency plans for toxic spills are in place	✔ Partially complete	Planning for toxic spills are partially addressed by Source Water Protection Plans, which are underway by some local governments in the HMA. Spill response is also the responsibility of the BC Ministry of Environment, Environmental Protection division.
New Strategies		
Support and encourage landowner stewardship of riparian areas; encourage completion of Environmental Farm Plans		
Utilize the results of the SHIM to guide restoration works		
Re-establish the Eagle River Roundtable, or similar group, to do stewardship activities and advocate for the river		

Table 29. Owlhead Creek, Yard Creek, Senn Creek, Perry River, South Pass Creek, and Crazy Creek management strategies

Strategies from *1997 Review*	Status	Notes
Complete and review IWAPs on Perry and Eagle Rivers, and conduct additional assessments as required to guide future logging activities to prevent watershed impacts	✔ Complete	An IWAP for Anstey and Eagle River watersheds (incuding Perry River sub-basin) was completed in 1998 (Thiem, 1998). The recent utility of IWAPs is not known. A FSW Risk Analysis was completed in 2010 for Eagle and Perry Rivers, Yard Creek and others to prioritize restoration planning and treatment.
Initiate an IWAP on Owlhead Creek to assess past hydrological impacts, implement restoration initiatives, and guide future logging activities to prevent watershed impacts	? Unknown	It's not known if an IWAP was completed for Owlhead Creek
Promote stream stewardship to re-vegetate streambanks and increase awareness of the importance of streamside vegetation and critical rearing habitats. Re-establish riparian corridor in Owlhead Creek, including replanting and fencing livestock away from the creek.	✔ Ongoing	Restoration and stewardship activities are ongoing, and led by Splatsin, FRISP, fish and game clubs, and others.
Assess fish habitat and utilization of Perry River	? Unknown	
Re-vegetate riparian zones lost as a result of past logging practices, deactivate old logging roads, upgrade and maintain active roads, determine terrain instability problems, and avoid construction of new logging roads in erodible areas	? Unknown	It's not known what was completed before the sunset of the WRP
Monitor fish passage at the Owlhead Creek culvert previously modified to restore fish passage under highway	✔ Ongoing	
Assess potential impacts of future highway expansion, and ensure there is no encroachment and loss of rearing habitat	✔ Partially complete	Impacts are considered as projects are completed; since 1997, some bridges have been replaced and segments of highway expanded. Environmental, social and economic factors are weighed in highway design and planning.
New Strategies		
Support and encourage landowner stewardship of riparian areas; encourage completion of Environmental Farm Plans		
Utilize the results of the FIM to guide restoration works		
Re-establish the Eagle River Roundtable, or similar group, to do stewardship activities and advocate for the river		

6.6 Lower Shuswap River System

The Lower Shuswap River System includes the lower reach of Shuswap River and several salmon-bearing tributaries including Cooke and Trinity Creeks. The lower Shuswap flows out of Mabel Lake, west to Enderby, then turns north and flows through a wide fertile valley into Mara Lake. The tributaries drain mountainous forested terrain, primarily within the Interior Cedar Hemlock and Interior Douglas Fir biogeoclimatic zones and to a lesser degree the Engelmann Spruce – Subalpine Fir zone.

The system is a major producer of sockeye and chinook. The system is also utilized by coho and resident species such as rainbow trout, bull trout, and kokanee. The lower Shuswap is used for spawning and for migration to spawning beds upstream.

The primary developments in the sub-basin include forestry in the uplands and extensive agriculture in the valley bottom. The area has a long history of settlement associated with agriculture; the valley bottoms have been cleared and converted to pastures and fields for crop production.

6.6.1 Lower Shuswap River

The lower Shuswap River flows from Mabel Lake to Mara Lake. Mabel Lake buffers the flow in the river, and therefore the river has relatively minimal seasonal variation. The lake also serves as a 'biological filter', which means the quality of the water flowing out of the lake can be better than its source (D. Einarson, pers. comm.; J. Curtis, pers. comm.).

The river is the largest producer of chinook in the HMA and a major producer of late-run sockeye; nearly one million sockeye spawners were recorded in 1990. Chinook spawn in the river; fry emerge and rear in streamside habitat and then migrate downstream to Mara Lake. Sockeye also spawn in the system; fry migrate downstream to Mara Lake upon emergence. Coho salmon also utilize the river for spawning and rearing but to a much lesser extent as they are more commonly found in the small tributaries. Pink salmon have been observed in the lower Shuswap; this is the edge of their range (Department of Fisheries and Oceans Canada, 1997).

The Shuswap Falls Hatchery (located east of Lumby) and Kingfisher Hatchery (located east of Enderby) are involved in chinook enhancement. Shuswap Falls has been in operation since 1984 and produces 650,000 – 700,000 smolts annually which yields up to 14,000 adults to catch and escapement for the lower and middle Shuswap, weighted in favour of lower Shuswap. Kingfisher Hatchery has been in operation for approximately the same period of time; it is primarily a stewardship facility but produces and releases 38,000 – 225,000 juvenile lower Shuswap chinook since 2000 (D. Lofthouse, pers. comm.).

The valley bottom is used extensively for agriculture, more so than any other sub-basin in the HMA. The effects of historic land-clearing for conversion to pastures and crops is exacerbated by ongoing cattle grazing and farming, resulting in the loss of riparian cover, bank erosion, and non-point sources of pollution (as cited in DFO, 1997).

The Shuswap River contributes a substantial nutrient load to Mara Lake downstream, more than any other tributary to the lakes system; this is attributed to the large volume of water it carries in addition to the concentrations of nutrients (G. Matscha, pers. comm.). An analysis of water quality and land uses in the watershed suggests that nutrients in the river are derived mostly from agricultural activity (Tri-Star Environmental Consultants, 2014).

Timber harvesting is predominant in the Lower Shuswap watershed, but the direct impacts are more noticeable in the small tributaries than they are to the mainstem. However, the downstream effects mean that timber harvesting still poses a risk to fish habitat.

There is considerable settlement along the lower Shuswap River. The City of Enderby and adjacent Splatsin Indian Band Enderby Reserve 2 are the largest settlements; there are also the small communities Grindrod and Mara (downstream of Enderby), and Ashton Creek and Kingfisher (upstream of Enderby). Enderby discharges its secondary-treated wastewater into the river.

Recreational activity has become increasingly popular on the river in the last 10 – 15 years. In the lowest reaches of the river, high power motorboats and personal watercrafts have become more common and their wake has created concern for exacerbating the streambank erosion that the river is naturally prone to. A study done on the Shuswap River suggests that when certain boat speeds are combined with low water (i.e., lower than spring freshet), boat wake action will undercut banks and cause erosion (Fraser Basin Council, 2014; Bauer, 2013). The river is popular with non-motorized recreationists (i.e., paddling and floating); the effects of potential disturbance to migrating and spawning salmon by recreationists is not known.

A Sensitive Habitat Inventory Mapping (SHIM) and Aquatic Habitat Index (AHI) project was completed for the lower Shuswap River in 2011. The results of that work indicate that only 14% and 41% of the right and left banks (facing downstream), respectively, are natural (i.e., no evidence of recent anthropogenic disturbance). Furthermore, only 18% of the river channel was identified as suitable spawning habitat. The inventory identified a lack of deep holding pools, particularly in the river segments downstream of Enderby to Mara Lake. The AHI ranked 53% of the river as having *Low* habitat value; the *High* and *Very High* rankings occurred mostly upstream of Enderby and around the Cooke Creek confluence. Further breakdown of the AHI rankings indicates that 43% of the left bank is ranked as *Very High* habitat value, whereas 45% is ranked as *Low* or *Very Low*; these results corroborate to the findings on natural vs. disturbed stream banks (Ecoscape Environmental Consultants Ltd., 2011).

In response to concerns about the riverine ecosystem, water quality, and boat traffic on the river, the Regional District of North Okanagan developed the Shuswap River Watershed Sustainability Plan. The process began in 2010 and was completed in 2014. The plan contains strategies to achieve goals related to water quality, ecosystems, and recreation (Regional District of North Okanagan, 2014).

There is a strong stewardship ethic in the Shuswap River system. In the lower reaches, the Lower Shuswap Stewardship Society has been involved in advocacy, public education and awareness, and water quality monitoring (J. Clark, pers. comm.). The Kingfisher Interpretive Centre Society has played a critical role in education in addition to being the site of the Shuswap River Hatchery; it is the primary education and outreach facility in the BC Interior, and sees thousands of visitors annually (N. Brookes, pers. comm.). The Shuswap River Ambassadors program is also involved in education and fostering stewardship, primarily among recreationists.

Management Priorities

Maintaining good spawning substrate and water quality, preventing impacts and disturbance from recreation, and riparian restoration are the management priorities for lower Shuswap River.

Table 30 summarizes progress made against the 1997 strategies, and presents new strategies.

6.6.2 Johnson Creek and Blurton Creek

Johnson and Blurton Creeks enter the lower Shuswap River approximately 2 and 3 km upstream of Mara Lake, respectively. Coho and sockeye (the latter on dominant return years) utilize the lower reaches of both creeks: the lower 1 km in Johnson Creek, and 1.5 km in Blurton Creek, due to cascade (Department of Fisheries and Oceans Canada, 1997).

Timber harvesting is the predominant land use in the uplands of these creek basins. Since 1995, 11.52% and 5.25% of the gross watershed areas have been harvested for Johnson and Blurton, respectively. Impacts to Johnson Creek have occurred from the slumping of Skyline Forest Service Road and private land logging in the riparian area (B. Harding, pers. comm.).

Agriculture is extensive throughout the lower reaches of the creek basins. Summer and winter low flows have been documented on the creeks, the former of which is a problem that has been exacerbated by irrigation (as cited in DFO, 1997). Impacts to Johnson Creek have occurred from lack of livestock exclusion fencing, lack of riparian cover adjacent to crop land areas, barriers to off-channel rearing habitat, and improperly screened irrigation intakes (B. Harding, pers. comm.).

Blurton Creek has had restoration works completed to address issues of fish habitat, passage, low flows, and fish kill events. Through the work of many partners, two farms completed restoration projects included modifying irrigation weirs; installing tail-water controls in culverts; replacement of culverts with a free-span bridge; relocating irrigation intakes from the creek to the lower Shuswap River, installation of livestock exclusion fencing, and riparian planting to stabilize the channel and streambanks (B. Harding, pers. comm.).

The creek fans have had significant deposition events in past years, causing channel braiding and localized flooding. Channel dredging has resulted in the removal of large woody debris and stream substrate, and damaged instream habitats and streambank stability (B. Harding, pers. comm.).

Johnson Creek has a large beaver pond complex, and some off-channel areas with high potential for providing excellent coho rearing habitat but that have very limited access.

Management Priorities

The protection and restoration of riparian and instream habitat are the management objectives for Johnson and Blurton Creeks.

Table 31 summarizes progress made against the 1997 strategies, and presents new strategies.

6.6.3 Fortune Creek

Fortune Creek flows into the lower Shuswap River at the City of Enderby. It is utilized rearing juvenile coho, chinook, and rainbow trout (as cited in DFO, 1997; Elinor McGrath, 2008). Coho and chinook spawning occurs in low densities where suitable flows and substrates allow, primarily downstream of the Highway 97 crossing near Armstrong (B. Harding, pers. comm.).

Fortune Creek has been heavily impacted throughout its length. The upper watershed has been harvested; the lower reaches have been dredged and channelized. Agricultural activity is extensive through the lower reaches of the creek, and the riparian zones have been degraded by removal of streamside vegetation (as cited in DFO, 1997). Run-off from farm fields carries sediment into the low gradient channel impacting fish habitat and decreasing channel capacity.

The City of Armstrong withdraws water from Silver Star Lakes reservoirs that drain into the south fork of Fortune Creek (W. Wallin, pers. comm.). The damming of the lakes regulates the flow out of them, thereby dampening the effects of the withdrawals on flow. Further withdrawals downstream for agriculture put Fortune Creek at risk of low-flows and high water temperatures. McGrath et al. found that water temperatures appear to be the primary limiting factor to the extent of juvenile coho, chinook and rainbow trout rearing in the creek: large numbers of salmonids utilize the lower reaches of the creek during freshet, whereas for the remainder of the year salmonids were found in the upper part of the creek where it is shaded and cool (Elinor McGrath, 2008).

In the late 1990s and early 2000s, over seven kilometres of livestock exclusion fencing was completed along the creek, in addition to riparian planting, designated livestock watering areas, and sediment sumps. Passage was improved at the Highway 97 culvert by constructing a tail-water control weir and the placement of rocks for holding areas (B. Harding, pers. comm.).

Management Priorities

The re-establishment and protection of riparian vegetation, and protection of instream flows and sufficiently cool water temperatures are the management priorities for Fortune Creek.

Table 32 summarizes progress made against the 1997 strategies, and presents new strategies.

6.6.4 Ricardo Creek, Brash Creek and Ashton Creek

Upstream of Fortune Creek there are three small tributaries: Ricardo Creek enters the river approximately 2 km upstream of the Enderby townsite; Brash Creek and Ashton Creek flow into the river just downstream of and at the rural community of Ashton Creek, respectively. These creeks are utilized for rearing by juvenile coho. Little else is known about their fisheries values.

Agricultural activity is extensive in the lowest reaches of the creeks; the upper watershed is forested and mostly in tact. In Brash Creek, timber harvesting has resulted in changes to channel morphology in downstream reaches and significantly increased the size of the delta of Brash Creek. This has resulted in difficult migration conditions into Brash Creek and channel changes to the lower Shuswap River (Ecoscape Environmental Consultants Ltd., 2011). The current ECA for these creeks are not known, but since 1995, 0.2%, 6.1%, and 8.3% of the gross watershed areas for Ricardo, Brash and Ashton have been harvested, respectively.

Ashton Creek is subject to flooding, and the channel at the bottom of the creek is unstable. In the past, emergency works during flood events have resulted in the removal of large woody debris and channel complexity from Ashton Creek. The creek has not yet returned to a stable functioning condition. The creek is also subject to de-watering during summer months, and fish stranding and fish kills have been observed; community members have helped with fry salvages to prevent mortality (B. Harding, pers. comm.).

Management Priorities

The protection of riparian vegetation and bank stabilization are the management priorities for Ricardo, Brash and Ashton Creeks.

Table 33 lists management strategies.

6.6.5 Trinity Creek

Trinity Creek flows into the lower Shuswap River near the community of Ashton Creek, upstream of Enderby. Coho and chinook spawn in the creek, as do kokanee. Bull trout, rainbow trout and mountain whitefish have also been observed in Trinity Creek. Anadromous fish are restricted to the lower 1.8 km due to an impassable falls (as cited in DFO, 1997). Beaver dams just upstream of the creek confluence can impede migration if fall rains are insufficient to provide an increase in flows.

Forest harvesting in the upper watershed has resulted in changes to channel morphology in downstream reaches (as cited in DFO, 1997). The current ECA for Trinity Creek is not known and since 1995 17.27% of the gross watershed area has been harvested. Road density is 2.21 km/km^2.

Agricultural activity is extensive in the valley bottom. Dairy farms in the area have improved manure storage and handling in recent years, which has benefited the water quality of Trinity Creek and the lower Shuswap River. Both summer and winter low flows have been noted for Trinity Creek (as cited in DFO, 1997) however at least one licensed irrigator has moved their intake to the lower Shuswap River to maintain flows in Trinity Creek (B. Harding, pers. comm.).

Management Priorities

The re-establishment and protection of riparian vegetation, and protection of water quality and instream flows are the management priorities for Trinity Creek.

Table 34 summarizes progress made against the 1997 strategies, and presents new strategies.

6.6.6 Cooke Creek, Kingfisher Creek and Danforth Creek

Cooke Creek enters the lower Shuswap River approximately 9 km downstream of Mabel Lake, or 26 km upstream of Enderby. The creek is utilized by coho and sockeye, as well as resident bull trout and rainbow trout. Kingfisher Creek enters the lower Shuswap River 1.5 km downstream of Mabel Lake; Danforth Creek is a tributary to Kingfisher Creek and enters approximately 10 km from the mouth.

Kingfisher and Danforth provide important spawning and rearing habitat for coho; spawning occurs in the middle reaches of Kingfisher Creek and the lower 2 km of Danforth Creek (Department of Fisheries and Oceans Canada, 1997; Silvatech Consulting Ltd., 1998).

Forestry is the major resource use in these watersheds, with extensive timber harvesting in the upland areas in the past. This has altered hydrology and degraded riparian cover, both of which may potentially affect downstream fisheries. Valley walls in these drainages are classified as unstable, although Danforth Creek is more stable than Kingfisher. Hunter Creek, a tributary to Kingfisher Creek, contributes a high amount of bedload to Kingfisher Creek during freshets, thereby affecting downstream fisheries production (as cited in DFO, 1997). In 1998, the ECA for Cooke Creek and Kingfisher Creek basins were 19.7% and 16.4%, respectively (Silvatech Consulting Ltd., 1998). The current ECAs are not known and since 1995 3.64% and 4.76% of the gross watershed areas have been harvested.

In the past, emergency works during flood events have resulted in the removal of large woody debris and channel complexity from Kingfisher Creek. The creek has not yet returned to a stable functioning condition, and bedload has been moved to maintain channel capacity.

A large debris torrent occurred on Cooke Creek in May 2014. Tons of logs and debris came down the creek, washed out the Cooke Creek bridge, and flowed into the Shuswap River altering the course of the creek and the riverbanks. The nearby Kingfisher Interpretive Centre was flooded, severely damaging the infrastructure including the water intake for the hatchery. The debris flow was the result of a plugged culvert and subsequent road failure in the upper watershed. In the year that followed, Cooke Creek was cleared of debris, the creek banks were restored and planted, the water intake for the hatchery was replaced and the interpretive centre mostly restored (B. Harding, pers. comm., L. Hesketh, pers. comm.).

Management Priorities

The protection of water quality, spawning, and rearing habitat are the management priorities for Cooke, Kingfisher and Danforth Creeks.

Table 35 summarizes progress made against the 1997 strategies, and presents new strategies.

Table 30. Lower Shuswap River management strategies

Strategies from *1997 Review*	Status	Notes
Inventory riparian zones along the river and develop a riparian restoration plan (in cooperation with land users) that includes re-vegetation of streambanks and fencing cattle away from streams	✔ Complete	A SHIM was completed for the river in 2011
Protect Shuswap River habitat by restoring tributary systems affected by past logging activities (through WRP)	? Unknown	Restorations have taken place, but it's not known what was completed before the sunset of the WRP
Continue operation of the Shuswap River Hatchery	✔ Ongoing	
Develop stewardship initiatives with organizations, such as the Kingfisher Creek Community Group, who are currently involved in a small enhancement project on the lower Shuswap River	✔ Complete and ongoing	
New Strategies		
Utilize the results of the SHIM to guide restoration works		
Continue to support and encourage the work of stewardship organizations such as the Lower Shuswap Stewardship Society, Kingfisher Interpretive Centre Society, Splatsin, Environmental Farm Plan, and FRISP		
Investigate opportunities for enhanced protection in critical spawning and rearing habitats		

Table 31. Johnson Creek and Blurton Creek management strategies

Strategies from *1997 Review*	Status	Notes
Promote stewardship programs to inventory fish populations and habitat utilization, assess and restore riparian habitat, and improve instream flows and fish migration access	✔ Complete	Stream channel and fish habitat assessments have been completed (Summit Environmental Consultants Ltd., 1997). Restoration works to habitat and passage have been completed.
Initiate IWAP (to FPC standards) to assess logging impacts in upslope areas and implement restoration activities (through WRP)	? Unknown	It's not known if an IWAP was completed for Johnson and Blurton Creeks
New Strategies		
Consider Environmental Flow Needs before issuing further water licences		
Assess opportunities for further restoration works on the creeks		
Investigate potential restoration of access to groundwater-fed off-channel habitat		

Table 32. Fortune Creek management strategies

Strategies from *1997 Review*	Status	Notes
Promote stewardship initiatives with landowners to inventory riparian vegetation and develop and riparian restoration plan; include re-vegetation of streambanks and fencing cattle away from banks	✔ Complete and ongoing	Livestock exclusion fencing and riparian planting has taken place
Increase awareness of stakeholders on the importance of streamside vegetation for aquatic ecosystems. Control bank erosion by using bio-engineering methods. Continue to work with local groups on stream restoration initiatives and fry releases.	✔ Partially complete	Sediment sumps were put on Fortune Creek for sediment control. Fry releases have not taken place.
Conduct IWAP (to FPC standards) on the creeks to assess logging impacts in upland areas and implement restoration measures (through WRP)	? Unknown	It's not known if an IWAP was completed for Fortune Creek
Assess feasibility of using flow control for storage and release opportunities to improve instream flows for fish	? Unknown	
New Strategies		
Continue stewardship efforts to re-vegetate riparian areas and streambanks; focus on the lower reaches (below Highway 97)		
Monitor water temperature in the creek		
Consider Environmental Flow Needs before issuing further water licences		

Table 33. Ricardo Creek, Brash Creek and Ashton Creek management strategies

New Strategies
Work with authorities (e.g., MOTI and local governments) to ensure flood preparedness and emergency works during flood events aren't harmful to fish and fish habitat
Consider forest activities and development planning in the upland watersheds before undertaking fish habitat restoration and channel stability works on the fans
Consider Environmental Flow Needs before issuing further water licences

Table 34. Trinity Creek management strategies

Strategies from *1997 Review*	Status	Notes
Promote stewardship initiatives with landowners to inventory riparian vegetation and develop and riparian restoration plan; include re-vegetation of streambanks and fencing cattle away from banks	✔ Complete and ongoing	Livestock exclusion fencing and riparian planting has taken place

Increase awareness of stakeholders on the importance of streamside vegetation for aquatic ecosystems. Control bank erosion by using bio-engineering methods. Continue to work on stream restoration initiatives and fry releases.	✔ Partially complete	Fish passage restoration works were completed at Hidden Lake road. Fry releases have not taken place.
Conduct IWAP (to FPC standards) on the creeks to assess logging impacts in upland areas and implement restoration measures (through WRP)	? Unknown	It's not known if an IWAP was completed for Trinity Creek
Assess upstream habitat and migration blockages in Trinity Creek and develop by-pass facilities around barriers if feasible	✔ Complete	The migration barrier (culvert) was tail-water controlled
Assess feasibility of using flow control for storage and release opportunities to improve instream flows for fish	✔ Partially complete	Storage opportunities have not been assessed. Flows have been improved since irrigators voluntarily moved their point of diversion to the mainstem lower Shuswap River.
New Strategies		
Consider Environmental Flow Needs before issuing further water licences		
Look for additional opportunities to reduce water demand on Trinity Creek		

Table 35. Cooke Creek, Kingfisher Creek, and Danforth Creek management strategies

Strategies from *1997 Review*	Status	Notes
Conduct IWAPs (to FPC standards) on Kingfisher and Danforth Creeks to assess past logging impacts and prevent further logging impacts	✔ Complete	IWAP was completed in 1998
Focus on restoration of upper watershed; de-activate or maintain logging roads, re-vegetate streambank areas impacted by past logging practices, and stabilize eroding slopes, where practical (through WRP)	? Unknown	It's not known what was completed before the sunset of the WRP
Remove or by-pass obstructions to upstream fish passage, including beaver dams in the lower Danforth Creek	✗ Incomplete	
Enhance coho through hatchery supplementation by the Kingfisher Community Club	✗ Incomplete	Coho enhancement at Kingfisher Hatchery ceased in 1995 and has not been re-initiated. The hatchery is involved in chinook production.
New Strategies		
Work with authorities (e.g., MOTI and local governments) to ensure flood preparedness and emergency works during flood events aren't harmful to fish and fish habitat. Assess the application of bedload material as spawning substrate at Kingfisher Creek.		
Monitor channel stability and substrate aggradation below the Cooke Creek culvert to the lower Shuswap River		

6.7 Mabel Lake System

The Mabel Lake System includes Mabel Lake and its tributaries. The main tributary to the lake is the middle Shuswap River, which is described in detail in section 6.8. The small tributaries are typified by steep terrain, with some lower gradient sections close to the creek outlets. The lake and its tributaries are within the Interior Cedar Hemlock and Engelmann Spruce – Subalpine Fir biogeoclimatic zones.

6.7.1 Mabel Lake

Mabel Lake is fed by the middle Shuswap River at the south end of the lake, and drained by the lower Shuswap River on the west. Mabel Lake supports sockeye, chinook and coho salmon as well as several resident species including rainbow trout, kokanee, mountain whitefish and char (Ecoscape Environmental Consultants Ltd., 2010).

The primary resource uses are settlement, tourism and recreation. Relative to Shuswap Lake, it is much less developed; however, there are signs that Mabel Lake is becoming more popular and development is increasing. A new 200-slip marina opened on Mabel Lake in 2015.

Settlement is most dense at the small community of Kingfisher on the west side of the lake, adjacent to the outflow of the lake. Kingfisher has a combination of permanent residences and resort/seasonal properties. There is also a provincial park campground and boat launch on the east side of the lake at the south end, near the confluence of the middle Shuswap River (BC Parks).

A Foreshore Inventory and Mapping (FIM) project was completed for Mabel Lake in 2010. The results of that indicate that approximately 54% of the shoreline has little to no impact, while 46% of the shoreline has impacts to various degrees. Most of the impacts along the shoreline include riparian vegetation removal and construction of docks (n = 152), retaining walls (n = 107 and a cumulative total of 2.6 km), and groynes (n = 90). Furthermore, the FIM observed that some of these modifications were not in compliance with best management practices (e.g., retaining walls built below the high water mark). The FIM project also documented aquatic vegetation along 35% of the shoreline, which is an important feature for juvenile salmonids. The Aquatic Habitat Index (AHI) for Mabel Lake ranks 35% of the combined shoreline as *High* or *Very High* habitat value, most of which occur adjacent to stream flood plains and wetlands. 26% of the shoreline was ranked as having *Moderate* habitat value; this generally occurs along gravel or cobble shorelines (Ecoscape Environmental Consultants Ltd., 2010).

Management Priorities

The protection of shoreline habitat is the management priority for Mabel Lake.

Table 36 lists management strategies.

6.7.2 Wap Creek, Noisy Creek, and Tsuius Creek

Wap Creek, Noisy Creek and Tsuius Creek flow into the northern part of Mabel Lake: Wap flows in at the very north end, Noisy Creek flows in at the northwest side, and Tsuius flows in from the west, a few kilometres north of the outlet of Mabel Lake into the lower Shuswap River.

Both coho and sockeye spawn in the lower reaches of Noisy and Tsuius Creeks, with sockeye generally present only on the dominant cycle (2014). Wap Creek has a diverse fish community that includes sockeye, coho and chinook salmon as well as non-anadromous species including bull trout, rainbow trout, kokanee and mountain whitefish (as cited in DFO, 1997; Dobson Engineering Ltd., 2000). Anadromous species can access Wap Creek from Mabel Lake up to an impassable falls 29 km from the creek mouth.

Timber harvesting is the main resource activity in these three drainages. In Noisy Creek, logging in the upper watershed has resulted in increased sediment input (as cited in DFO, 1997) and has the potential to impact downstream fisheries resources. Steep terrain, slides and avalanche chutes make the upper watershed of Noisy Creek susceptible to development-related impacts. In 1998, the ECA 27.3% (Silvatech Consulting Ltd., 1998). The current ECA is not known and since 1995 4.1% of the gross watershed area has been harvested.

In Wap Creek, logging prior to the 1950s had resulted in destabilized lower reaches, creating heavy erosion and log-jams. The sediment sources in Wap Creek were not present prior to the 1950s, suggesting that subsequent logging activity has contributed to bank instability (as cited in DFO, 1997). An IWAP completed in 1998 suggested that the most significant source of sediment in the basin is due to roads and related sources. At that time, the ECA for the Wap Creek basin was 17% (Thiem, 1998). A separate IWAP estimated the ECA to be 11.6% (Dobson Engineering Ltd., 2000). The current ECA is not known and since 1995 only 3.8% of the gross watershed area has been harvested. Impacts from harvesting are aggravated by natural terrain instability (as cited in DFO, 1997).

There is an Independent Power Production facility on Wap Creek upstream of an impassable falls that services a resort hotel on Three Valley Lake. Water is diverted above the creek, and returned to the creek below the falls (Dobson Engineering Ltd., 2000; B. Harding, pers. comm.).

Restoration on Wap Creek includes the installation of a culvert to re-connect an off-channel area to the creek just upstream of Wap Lake, and the stabilization of a large failing cut-bank upstream of Mabel Lake.

Management Priorities

The protection and restoration of riparian vegetation and the maintenance of good water quality and spawning substrates are the management priorities for Wap Creek, Noisy Creek, and Tsuius Creek.

Table 37 summarizes progress made against the 1997 strategies, and presents new strategies.

Table 36. Mabel Lake management strategies

New Strategies
Implement Mabel Lake Shoreline Management Guidelines (Ecoscape Environmental Consultants Ltd., 2011)
Utilize results of the FIM to guide restoration works

Table 37. Noisy Creek, Wap Creek, and Tsuius Creek management strategies

Strategies from *1997 Review*	Status	Notes
Conduct and review IWAPs (to FPC standards) to assess past logging impacts and guide future logging activities to prevent watershed impacts	✔ Partially complete	IWAPs were conducted for Noisy Creek and Wap Creek. It's not known if one was done for Tsuius Creek. A Fisheries Sensitive Watershed (FSW) Risk Analysis was completed in 2010 for Wap Creek and others to prioritize restoration planning and treatment (Timberline Natural Resource Group & M.J. Milne and Associates Ltd., 2010)
Restore upslope areas affected by logging through road de-activation and/or maintenance, riparian re-vegetation and stabilization or eroding banks (through WRP)	? Unknown	It's not known what was completed before the sunset of the WRP
Inventory stream habitat in the lower reaches, and assess barriers to upstream fish migration in Noisy and Tsuius Creeks	✔ Partially complete	A FHAP was completed for Noisy Creek (as cited in Silvatech Consulting Ltd., 1998)
Reduce erosion in Tsuius Creek by seeding exposed slopes with hydroseeding or geotextiles, if more surface protection is required	? Unknown	
Assess opportunities to develop off-channel refuge habitat in the lower creek reaches	✔ Partially complete	Access to off-channel habitat was increased for Wap Creek
New Strategies		
Consider forest activities and development planning in the upland watersheds before undertaking fish habitat restoration works on Wap and Tsuius Creeks		

6.8 Middle Shuswap River System

The Middle Shuswap River System includes the middle Shuswap River, which flows between Sugar Lake and Mabel Lake, and its tributaries. Sugar Lake is fed by the upper Shuswap River, which the farthest-reaching and uppermost part of the entire Shuswap watershed.

The middle Shuswap sub-basin is within diverse topography, including the Monashee Mountains and wide flat valleys. It is primarily within the Interior Cedar Hemlock and Engelmann Spruce – Subalpine Fir biogeoclimatic zones.

Development in the middle Shuswap has greatly impacted the instream flows and the passage of anadromous salmon. The mainstem river flows are regulated by the presence of two dams, which block passage for fish; on the contrary, some of the other streams in the system are prone to low flows, the extent of which is exacerbated by water withdrawals for agriculture.

The Shuswap Falls Hatchery (located east of Lumby) is involved in chinook enhancement. Shuswap Falls has been in operation since 1984 and produces 650,000 – 700,000 smolts annually which yields up to 14,000 adults to catch and escapement for the lower and middle Shuswap (weighted in favour of lower Shuswap). The hatchery was also involved in coho enhancement for the middle Shuswap from 2000 – 2004 and for Bessette/Duteau from 2000 – 2013; coho enhancement ceased after significant rebuilding of those stocks occurred (D. Lofthouse, pers. comm.).

6.8.1 Middle Shuswap River

Middle Shuswap River flows southwest out of Sugar Lake to Cherryville and Lumby, and then flows north into Mabel Lake. The upper reaches of the river are contained within a narrow valley to Cherryville at which point the valley becomes wide, flat and fertile onward to Mabel Lake.

Middle Shuswap River is an important chinook and coho producer in the HMA. The river also supports a late-run sockeye population, as well as resident fish species including kokanee, rainbow trout, bull trout and mountain whitefish (as cited in DFO, 1997).

The valley bottom is used extensively for agriculture. Historically, the valley bottom was cleared for conversation to agricultural land and ongoing agricultural production has caused large sections of riparian cover to be removed. Some landowners have contained river sections, causing flow to be re-directed away from side channels thereby impacting fish habitat. The lower reaches of the middle Shuswap River have extensive sections with unstable banks. This is exacerbated by the removal of riparian vegetation, with flooding adding to erosion problems.

Furthermore, water quality is at risk of non-point source pollution from livestock (as cited in DFO, 1997).

Forestry is also prevalent in the watershed and is known to contribute sediment to the middle Shuswap River via its tributaries due to increased erosion of streambanks, road run-off and logging-related slides (as cited in DFO, 1997). Since 1995, 4.5% of the gross watershed area has been harvested.

Perhaps the biggest impediment and opportunity to the salmon fishery in the middle Shuswap River is the Wilsey Dam near Lumby. The dam was constructed in 1929 to generate hydro-electricity for the North Okanagan (BC Hydro). Concerned sportsmen at the time lobbied unsuccessfully for a ladder to be built at the facility to allow for the passage of spawning anadromous fish (Fisher; L. Hesketh, pers. comm.). The dam restricts chinook, coho and sockeye to the portion of the watershed below the dam; historically, anadromous salmon as well as kokanee, adfluvial rainbow trout and bull trout would have accessed an additional 32 km of river mainstem and tributaries above Shuswap Falls (Whitevalley Community Resource Centre).

In 2011, a Wilsey Dam Passage Committee formed with participation from DFO, WLAP, Whitevalley Community Resource Centre, Splatsin, Secwepemc Fisheries Commission, Okanagan Band, ONA, local governments and BC Hydro. The committee has facilitated a number of projects that work toward achieving passage for anadromous fish at the dam, including a feasibility report that outlines biological concerns and physical feasibility of design options, and environmental feasibility for spawning and rearing above the dam. The committee partners are currently working on assessing fish entrainment and mortality at Wilsey Dam and the feasibility of acoustic technologies to obtain proportional passage by route (i.e., by spillway or turbines) (Whitevalley Community Resource Centre; Syilx Okanagan Nation Alliance).

BC Hydro holds a Water Licence and Fisheries Act Authorization (FAA) for Wilsey Dam, the latter of which covers impacts related to fish stranding, spawning and rearing habitat, and changes to littoral vegetation. A review of Water Use Plans and associated Water Act Order is scheduled for review in 2017-18, at which time a new FAA may be issued. DFO's Fisheries Protection Program monitors and coordinates with BC Hydro on matters related to the conditions set out in the FAA (D. Watts, pers. comm.).

A chinook sport fishery has been developed on the middle Shuswap River below Wilsey Dam in response to increasing chinook returns; this increase is attributed largely to the Shuswap Hatchery production (B. Harding, pers. comm.).

Management Priorities

Enabling fish passage beyond Wilsey Dam and protecting existing habitat are the management priorities for the middle Shuswap River.

Table 38 summarizes progress made against the 1997 strategies, and presents new strategies.

6.8.2 Ireland Creek

Ireland Creek flows into middle Shuswap River downstream of Shuswap Falls. Coho and sockeye utilize the creek, with sockeye spawning on the dominant cycle (2014). Anadromous fish are restricted to the lower 3.2 km of the creek, below a weir and wooden dam near Mabel Lake Road (as cited in DFO, 1997).

The valley bottom is used extensively for agriculture, including cattle ranching, pig farming and crop production. These have resulted in the loss of riparian vegetation and streambank integrity; non-point source pollution is also a concern. The creek is prone to low flows in summer and winter (as cited in DFO, 1997).

The primary resource use in the upper watershed is forestry. The current ECA is not known and since 1995, 8.13% of the gross watershed area has been harvested.

A number of restoration and stewardship projects have taken place in the Shuswap River corridor, including at Ireland Creek. The BC Cattlemens Association's FRISP program and the Whitevalley Community Resource Centre (WCRC) have done projects to repair and restore fish habitat and increase landowner stewardship ethic (L. Hesketh, pers. comm.). The WCRC led a project to construct a side channel on Ireland Creek and fence the riparian area, including complexing the channel, planting the riparian area, and building a riffle (Whitevalley Community Resource Centre).

Management Priorities

Continued restoration of riparian and instream habitat are the management priorities for Ireland Creek.

Table 39 summarizes progress made against 1997 strategies, and presents new strategies.

6.8.3 Bessette Creek and tributaries

Bessette Creek flows into middle Shuswap River just downstream of Shuswap Falls. It is a relatively large basin (almost 80,000 ha) with several tributaries. Above Nicklen Creek, Bessette is known to some people as Harris Creek. Flows in the lower portion of Bessette Creek are partially regulated by the Greater Vernon Water

Utility[5] (GVW), at a dam located on upper Duteau Creek (Department of Fisheries and Oceans Canada, 1997).

Bessette Creek is an important coho producer; it also supports a chinook population. Sockeye salmon, rainbow trout, kokanee and mountain whitefish have also been observed in Bessette Creek (Summit Environmental Consultants Ltd., 2015). Access in Bessette/Harris Creek is restricted to the lower 18 km by a natural cascade (Department of Fisheries and Oceans Canada, 1997).

Forestry is the predominant resource use in the Bessette Creek basin. Timber harvesting in the upper watershed has contributed sediment from road construction and maintenance, as well as from bank erosion due to slope instability and removal of riparian cover (as cited in DFO, 1997). The current ECA is not known and since 1995, 14.2% of the gross watershed area has been harvested. This may be partly in response to the Mountain Pine Beetle epidemic, which affected 8.9% of the Bessette Creek basin.

Agriculture is predominant along the valley bottom; it includes cattle ranching, pig farming and crop production. Livestock grazing has resulted in trampled streambanks and removal of riparian vegetation. Loss of habitat through bank erosion and channelization has been observed. Water quality concerns arise from non-point source pollution and nutrient inputs; a problem that may be exacerbated by reduced water flows (as cited in DFO, 1997).

Bessette Creek has high water use demand and is prone to low flows; there have been streamflow- and temperature-related fish-kill events during years of drought. Because of this, Bessette Creek is one of the highest priority sub-basins within the Shuswap River watershed. Irrigation is causing flow reductions in Bessette Creek, and restricting irrigation during drought would achieve some benefits for in-stream flow needs (Summit Environmental Consultants Ltd., 2015).

The Whitevalley Community Resource Centre (WCRC) and Secwepemc Fisheries Commission (SFC) have undertaken stewardship projects on Bessette Creek to improve fish habitat, including the development of pool habitat, thermal refugia, habitat structures, gravel bar stabilization and infiltration galleries; this encourages scour, directs flow, and provides cover for juvenile salmonids (Whitevalley Community Resource Centre).

Vance Creek

Vance Creek flows into Bessette Creek approximately three kilometres north of the town of Lumby. It is utilized by spawning and rearing coho salmon; their use is limited to the lower few kilometres due to the gradient of the creek and the presence of beaver dams.

[5] Formerly the Vernon Irrigation District

Agriculture is the predominant resource use in the lower reaches of Vance Creek. The impacts to fish habitat have been associated with land clearing, channel instability, and summer low flows due to high water demand and irrigation (B. Harding, pers. comm.).

Fish passage at the Lumby – Mabel Lake Road culvert was an issue in the past but was improved in the late 1990s and early 2000s by the installation of wooden baffles and tail-water control weirs (B. Harding, pers. comm.).

Duteau Creek

Duteau Creek flows into Bessette Creek in the town of Lumby. It is an important coho producer; it also supports a chinook population, and sockeye salmon, pink salmon, mountain whitefish, rainbow trout and brook trout have been observed (Department of Fisheries and Oceans Canada, 1997; Summit Environmental Consultants Ltd., 2015). Chinook and coho distribution is affected by a natural cascade 10.8 km upstream of the creek mouth, as well as by the Greater Vernon Water[6] Utility's (GVW) Headgates Dam located 25.6 km uipstream of the mouth (Department of Fisheries and Oceans Canada, 1997).

Duteau Creek is a Community Watershed and provides water for domestic and irrigation purposes for the region, including for the City of Vernon. The water supply system includes three reservoirs in the watershed upstream of the Headgates Dam where the GVW intake is located. Additional water is diverted into the upper Duteau watershed from Harris Creek (Regional District of North Okanagan). The GVW has an agreement with DFO that outlines flow releases from the Headgates Dam for fish and in-stream needs based on time of year (Summit Environmental Consultants Ltd., 2015; R. Clark, pers. comm.). Downstream of the GVW intake, there are additional irrigation intakes.

Agriculture is predominant in the lower reaches of Duteau Creek. Livestock grazing has resulted in trampled streambanks and removal of riparian vegetation. Loss of habitat through bank erosion and channelization has been observed (as cited in DFO, 1997). In the upper reaches of the watershed, cattle-grazing poses risks to the watershed through increased sedimentation in streams and at road crossings; to help mitigate this and reduce risks to drinking water, range infrastructure has been improved including off-stream watering and fencing (Regional District of North Okanagan).

Blue Springs Creek

Blue Springs Creek flows into Bessette Creek in the town of Lumby, just upstream of the Duteau Creek confluence. It is utilized by spawning and rearing coho salmon. Additional fishery resources and the extent to which the stream is used are not known.

---

[6] Formerly the Vernon Irrigation District

The lower reaches of the creek have been severely impacted by agriculture. Sections of the creek have been channelized and/or re-aligned, and riparian vegetation is cleared throughout the valley bottom.

Fish passage at a culvert near the Creighton Valley Road was an issue in the past, but has been improved by the installation of a tail-water control weir (B. Harding, pers. comm.).

Creighton Creek

Creighton Creek flows into Bessette Creek in the town of Lumby, just upstream of the Blue Springs Creek confluence. It is utilized by spawning and rearing coho salmon, and rearing chinook salmon (Department of Fisheries and Oceans Canada, 1997). Sockeye salmon, rainbow trout, brook trout, and mountain whitefish have also been observed in Creighton Creek (Summit Environmental Consultants Ltd., 2015). Anadromous salmon distribution is restricted to the lower 4.1 km of the creek due to the presence of an irrigation weir (Department of Fisheries and Oceans Canada, 1997).

Agriculture is predominant in the lower reaches of Creighton Creek. Berms have been constructed in the lower reaches to protect fields from flooding; deposition of material within the berms increases the risk of channel avulsions (B. Harding, pers. comm.). Low summer stream flows resulting from high water demand and irrigation have frequently been documented in Creighton Creek, limiting rearing and spawning potential for salmonids (Summit Environmental Consultants Ltd., 2015).

In Spring of 1998 a major channel avulsion occurred at approximately kilometre 14 on Creighton Creek, whereby the creek left the channel for about 500 metres, eroded a pasture and deposited large amounts of materials into the creek. These sediments are still working through the system causing localized channel aggrading and flooding on the fan (B. Harding, pers. comm.).

A vast amount of work has been done in the Creighton Creek basin to minimize the gap between water supply and demand and reduce conflict. This includes water balance models, irrigation efficiencies, education and awareness-raising efforts for the importance of water conservation and stream stewardship, restoration works to improve creek morphology and riparian cover, and a storage feasibility study (Whitevalley Community Resource Centre).

Nicklen Creek

Nicklen Creek flows into Bessette Creek upstream (i.e., southwest) of the town of Lumby. Rainbow trout have been observed in the creek (C. St. Pierre, pers. comm.); the use of the creek by salmon is not known.

Nicklen Creek flows out of Nicklen Lake, upon which FLNRO has licensed conservation storage. In 2015, the flume on the outlet of Nicklen Lake was upgraded so that the conservation storage could be measured and released from the reservoir to augment flows in downstream Bessette Creek (R. McCleary, pers. comm.).

Management Priorities

Rebuilding coho stocks and restoring stream habitat by planting streamside vegetation, stabilizing banks, and providing adequate instream flows are the management priorities for Bessette Creek and its tributaries.

Table 40 summaries progress made against 1997 strategies, and presents new strategies.

6.8.4 Ferry Creek and Cherry Creek

Ferry Creek and Cherry Creek flow into the middle Shuswap River at the community of Cherryville, east of Lumby. The creeks are utilized by resident fish species; anadromous fish passage is blocked by Wilsey Dam downstream. First nations elders, long-time residents, and historical documents indicate that prior to the construction of the dam, salmon were able to migrate past Shuswap Falls and spawn in the vicinity of Ferry and Cherry Creek.

Table 38. Middle Shuswap River management strategies

Strategies from *1997 Review*	Status	Notes
Inventory and map riparian zones along the middle Shuswap River, and develop a management plan to re-establish a riparian corridor; include re-vegetation of streambanks and fencing of livestock away from the banks. Educate landowners on the importance of riparian cover to stream ecology. Promote bio-engineering techniques to stabilize eroding banks.	✔ Partially complete	Restoration works and education has been completed and is ongoing. Inventory and mapping has not been completed.
Increase stream habitat complexity by opening up side channels. Identify more opportunities to develop groundwater channels for the benefit of coho, as well as sockeye and kokanee.	✔ Complete and ongoing	Some works have been completed. Further opportunities exist.
Work with BC Hydro, MELP, and stakeholders to develop a water-use plan for the Shuswap River as part of the provincial review of hydro facilities	✗ Incomplete	
Continue to work with BC Hydro and MELP to optimize spawning and incubation flows for chinook, coho and kokanee; minimize flow fluctuations; and develop ramping rates. Review the rule curves developed by Sigma Engineering Ltd in 1993 (as cited in DFO, 1997).	? Unknown	
Monitor the recreational fishery, and restrict angling during periods of high water temperatures	✔ Ongoing	
Continue with adult chinook transplants above the Wilsey Dam, and monitor the success of this program	✔ Complete	Chinook transplants have occurred and studies are being undertaken to assess and mitigate juvenile entrainment and mortality
Continue exploring the possibility of restoring salmon access upstream of Wilsey Dam through fish bypass facilities or by decommissioning the dam	✔ Ongoing	The multi-party Wilsey Dam Fish Passage Committee is continuing to pursue this opportunity
Continue chinook production at the Shuswap River Hatchery. Assess the possibility of supplementing coho production through this hatchery.	✔ Ongoing	Chinook production is ongoing. Coho production for the middle Shuswap River occurred from 2000 – 2004.

Conduct IWAPs on tributaries to the middle Shuswap River to assess logging related impacts in upslope areas. Restore riparian vegetation, deactivate or maintain logging roads, and stabilize eroding banks caused by previous logging activities (through WRP).	? Unknown	It's not known if an IWAP was completed for middle Shuswap River, nor is it known what may have been completed before the sunset of the WRP
New Strategies		
Complete Sensitive Habitat Inventory and Mapping and Aquatic Habitat Index for the middle Shuswap River		
Work with BC Hydro to develop a Water Use Plan for the river that considers passage and in-stream flows		
Continue to support the work of the Wilsey Dam Fish Passage Committee		
Assess the functioning condition of created off-channel habitats on the river, and conduct maintenance as required		
Continue with efforts to educate landowners about the importance of riparian vegetation to stream ecology. Promote the use of bio-engineering techniques to stabilize eroding banks, re-vegetation of streambanks, installation of livestock exclusion fencing, and use of properly screened irrigation intakes.		

Table 39. Ireland Creek management strategies

Strategies from *1997 Review*	Status	Notes
Re-establish riparian corridor in co-operation with landowners, include re-vegetation of streambanks and fencing cattle away from the banks	✔ Complete and ongoing	Restoration works, including the development of off-channel habitat and livestock exclusion fencing have been completed
Assess stream habitat and ensure fish passage to upstream areas	✔ Complete	
Assess instream flow needs and monitor agricultural water withdrawals during the summer low flow period	✗ Incomplete	
New Strategies		
Continue with efforts to educate landowners about the importance of riparian vegetation to stream ecology. Promote the use of bio-engineering techniques to stabilize eroding banks, re-vegetation of streambanks, installation of livestock exclusion fencing, and use of properly screened irrigation intakes.		
Consider Environmental Flow Needs before issuing further water licences		

Table 40. Bessette Creek (and tributaries) management strategies

Strategies from *1997 Review*	Status	Notes
Conduct IWAP on Bessette Creek from its confluence with Shuswap River to assess impacts of future logging activities in Harris Creek on fish habitat in downstream areas	? Unknown	It's not known if an IWAP was completed for Bessette Creek

Review IWAP and channel and Fish Habitat Assessment to determine the amount of forest development that can be sustained without further adverse impacts on fish habitat in Bessette Creek	? Unknown	It's not known if an IWAP or FHAP were completed for Bessette Creek
De-activate roads, restore streambank vegetation and stabilize eroding banks caused by logging (through WRP)	? Unknown	It's not known what was completed before the sunset of the WRP
Inventory and map riparian zones along Bessette Creek, and develop a riparian restoration program (in cooperation with land users) that includes protection and re-vegetation of streambanks and fencing livestock. Educate landowners and other parties on the importance of riparian integrity, stream ecosystem and fisheries needs. Continue to build on the local ranchers' initiatives underway on Duteau Creek. Promote bio-engineering techniques for erosion control.	✔ Partially complete	Inventory and mapping has not been completed but restoration works and education have been completed and are ongoing
Undertake habitat complexing in previously developed groundwater channels and monitor water temperatures	? Unknown	
Develop a fish bypass system around the weir in Creighton Creek	✔ Complete	
Explore opportunities to develop off-stream groundwater channel from Harris Creek to Duteau Creek, and install Newbury weirs to re-create pool and riffle habitat in Harris Creek	? Unknown	
Explore the opportunity to augment coho production in the system through the Shuswap River Hatchery, and explore opportunities for off-channel restoration works	✔ Complete	Coho enhancement took place at the hatchery from 2000 – 2013. Restoration works have been completed.
Develop series of rule curves for Duteau Creek (release strategy) for average, dry and wet years. Complete the instream flow agreement with the Vernon Irrigation District. Monitor the summer water use downstream of the dam.	✔ Partially complete	A flow agreement with GVW is in place. It isn't known how closely summer water use downstream of the dam is monitored.
Apply DFO/MELP Land Development Guidelines and Stream Stewardship Guide for urban development to minimize impacts of urban developments	🚫 Not applicable	Land Development Guidelines are no longer applicable; have been replaced by Riparian Area Regulations for riparian protection
Apply DFO/MELP Stream Stewardship Guide for Agriculture and other relevant guidelines to protect riparian zones and control non-point source pollutants	✗ Incomplete	

Encourage DOE to resolve the issue at the chlorophenate wood-preserving plant through mediation and finalize a site remediation plan	? Unknown	
Continue monitoring the effectiveness of restoration projects	✗ Incomplete	Monitoring has not been done comprehensively on an on-going basis
<u>New Strategies</u>		
Continue with efforts to educate landowners about the importance of riparian vegetation to stream ecology. Continue to promote the use of bio-engineering techniques to stabilize eroding banks, re-vegetation of streambanks, installation of livestock exclusion fencing, and use of properly screened irrigation intakes.		
Consider Environmental Flow Needs before issuing further water licences		
Consider forest activities and development planning in the upland watershed before undertaking fish habitat restoration works		

Works Cited

Agriculture and Agri-Food Canada. (2012). WEBs Fact Sheet #9. Cattle and Water Quality in the Salmon River Watershed. Government of Canada.

Allen, C. H. (1979). Lumber and Salmon: A History of the Adams River Lumber Company. *Wildlife Review* (8), 22-24.

Bates, B. G. (2010). A Semi-quantitative Risk Analysis for a Mountain Pine Beetle Infested Watershed in the Southern Interior of British Columbia. *Streamline Watershed Management Bulletin, 13* (2).

Bauer, B and Laderoute, Larissa. (2013, August). *Shuswap River Watershed Sustainability Plan.* Retrieved January 21, 2016, from Regional District of North Okanagan: http://www.rdno.ca/docs/River_Bank_Erosion_Lower_Shu_River_Final_Project_Report.pdf

BC Hydro. (n.d.). *Shuswap River*. Retrieved February 3, 2016, from BC Hydro: https://www.bchydro.com/community/recreation_areas/shuswap_river.html

BC Ministry of Energy and Mines. (2015). *Operating Mines and Selected Exploration Projects in BC, 2014.* Retrieved March 3, 2016, from BC Ministry of Energy, Mines, and Petroleum Resources : http://www.empr.gov.bc.ca/Mining/Geoscience/PublicationsCatalogue/OpenFiles/2015/Pages/2015-1.aspx

BC Ministry of Environment, Lands and Parks. (n.d.). *Annual Compendium of Aquatic Rehabilitation Projects for the Watershed Restoration Program 1998-1999.* Retrieved February 19, 2016, from BC Ministry of Forests, Lands and Natural Resource Operations: https://www.for.gov.bc.ca/hfd/library/ffip/Zaldokas_DO1999.pdf

BC Ministry of Forests, Lands and Natural Resource Operations. (2004). *Firestorm 2003: Provincial Review.* Retrieved January 27, 2016, from http://bcwildfire.ca/History/ReportsandReviews/

BC Ministry of Forests, Lands and Natural Resource Operations. (1999). *Forest Practices Code.* Retrieved February 2, 2016, from BC Ministry of Forests, Lands and Natural Resource Operations: https://www.for.gov.bc.ca/tasb/legsregs/fpc/FPCGUIDE/wap/WAPGdbk-Web.pdf

BC Ministry of Forests, Lands and Natural Resource Operations. (2010). *Research Branch.* Retrieved February 2, 2016, from BC Ministry of Forests, Lands and Natural Resource Operations: https://www.for.gov.bc.ca/hfd/pubs/docs/lmh/Lmh66.htm

BC Ministry of Lands, Parks and Housing. (1985). *Sicamous Narrows: Guidelines for Crown Foreshore Administration.* Province of BC.

BC Ministry of Transportation and Infrastructure. (n.d.). *Highway 1 Kamloops to Alberta Four-Laning Program*. Retrieved February 18, 2016, from BC Ministry of Transportation and Infrastructure: http://engage.gov.bc.ca/bchwy1/

BC Ministry of Transportation and Infrastructure. (n.d.). *Standard Specifications for Highway Construction.* Retrieved February 23, 2016, from BC Ministry of Trasnportation and Infrastructure: http://www2.gov.bc.ca/gov/content/transportation/transportation-infrastructure/engineering-standards-guidelines/standard-specifications-for-highway-construction

BC Parks. (n.d.). *Anstey Hunakwa Provincial Park*. Retrieved January 18, 2016, from BC Parks: http://www.env.gov.bc.ca/bcparks/explore/

BC Parks. (2013, May). Anstey Hunakwa Provincial Park. *Anstey Hunakwa Park Management Plan*.

BC Parks. (2015). *Herald Provincial Park*. Retrieved October 2015, from BC Parks: http://www.env.gov.bc.ca/bcparks/explore/

BC Parks. (n.d.). *Mabel Lake Provincial Park*. Retrieved February 3, 2016, from BC Parks: http://www.env.gov.bc.ca/bcparks/explore/

BC Parks. (n.d.). *Silver Beach Provincial Park*. Retrieved January 14, 2016, from BC Parks: http://www.env.gov.bc.ca/bcparks/explore/

BC Parks. (n.d.). *Upper Adams River Provincial Park*. Retrieved January 13, 2016, from BC Parks: http://www.env.gov.bc.ca/bcparks/explore/

BC Parks. (n.d.). *Yard Creek Provincial Park*. Retrieved January 27, 2016, from BC Parks: http://www.env.gov.bc.ca/bcparks/explore/

Brouwer, B. (2012, May 30). Unsightly Algae Spreads to Shuswap. *Salmon Arm Observer*. Salmon Arm, BC.

C.K. Parken, R. M. (2006). *Habitat-based methods to estimate escapement goals for data limited Chinook salmon stocks in British Columbia, 2004.* Unpublished Report.

Cal-Eco Consultants Ltd. and Mariposa Trails. (2006, March 31). *Background Study: Adams River British Columbia: Proposed National Heritage River Nomination.* Retrieved January 12, 2016, from http://www.env.gov.bc.ca/bcparks/heritage_rivers_program/reports/adams_river_chrs_background_study_march_31_06.pdf

Canoe Forest Products Ltd. (2012). *Log Purchase and Sales*. Retrieved January 20, 2016, from Canoe Forest Products: http://www.canoefp.com/Purchase.aspx
City of Kamloops. (2013). *City of Kamloops Agriculture Area Plan.* Kamloops, BC.

City of Salmon Arm. (n.d.). *Salmon Arm Water System*. Retrieved January 19, 2016, from Salmon Arm Official Website: http://www.salmonarm.ca/

Columbia Shuswap Invasive Species Society. (2013, June 13). *Zebra/Quagga Mussels*. Retrieved October 2015, from Columbia Shuswap Invasive Species Society: http://columbiashuswapinvasives.org/zebra-mussels/

Columbia Shuswap Regional District. (2015). Lakes Zoning Bylaw 900.

COSEWIC. (2002). *COSEWIC assessment and status report on the coho salmon Oncorhynchus kisutch (Interior Fraser population) in Canada.* Ottawa: Committee on the Status of Endangered Wildlife in Canada.

D.A. Toews, M. B. (1981). A handbook for fish habitat protection on forest lands in British Columbia. Fisheries and Oceans Canada.

Department of Fisheries and Oceans. (1997). *Strategic Review of Fisheries Resources for the South Thompson-Shuswap Habitat Management Area.* Government of Canada.

Dobson Engineering Ltd. (1999). *EcoCat: the Ecological Reports Catalogue.* Retrieved March 3, 2016, from Ministry of Environment: http://www.env.gov.bc.ca/ecocat/

Dobson Engineering Ltd. (2000, June). *EcoCat: the Ecological Reports Catalogue.* Retrieved March 9, 2016, from BC Ministry of Environment: http://www.env.gov.bc.ca/ecocat/

Dobson, D. (2016, January). Forest Development Planning and Water in the Okanagan. *BC Forest Professional*.

Ecoscape Environmental Consultants Ltd. (2010). *Foreshore Inventory and Mapping: Mabel Lake.* Kelowna, BC.

Ecoscape Environmental Consultants Ltd. (2009). *Foreshore Inventory and Mapping: Shuswap and Mara Lakes.* Kelowna, BC.

Ecoscape Environmental Consultants Ltd. (2011). *Lower Shuswap River Inventory, Mapping, and Aquatic Habitat Index.* Kelowna, BC.

Ecoscape Environmental Consultants Ltd. (2011). *Shoreline Management Guidelines for Fish and Fish Habitat: Mabel Lake.* Kelowna, BC.

Ecoscape Environmental Consultants Ltd. (2011). *Shoreline Management Guidelines for Fish and Fish Habitat: Shuswap, Mara and Little Shuswap Lakes.* Kelowna, BC.

Elinor McGrath, A. W. (2008). Salmonid distribution in relation to stream temperatures in Fortune Creek, British Columbia - the influence of surface water and groundwater interactions. Unpublished Extension Note.

Fisher, J. (n.d.). *Wilsey Dam: the ladder moves a step closer*. Retrieved February 3, 2016, from Kalamalka Fly Fishers: http://www.kalflyfishers.ca/projects/swuswap%20river/wilsey_dam.htm

Fisheries and Oceans Canada. (2014). *Assessment of the Interior Fraser River Coho Salmon Management Unit.* Nanaimo, BC.

Fisheries and Oceans Canada. (2005, June). Canada's Policy for Conservation of Wild Pacific Salmon. Fisheries and Oceans Canada.

Fisheries and Oceans Canada. (2015, March 20). *Changes to the Fisheries Act*. Retrieved March 22, 2016, from Fisheries and Oceans Canada: http://www.dfo-mpo.gc.ca/pnw-ppe/changes-changements/index-eng.html

Forsite Consultants Ltd. (1998). *EcoCat: the Ecological Reports Catalogue.* Retrieved March 7, 2016, from BC Ministry of Environment: http://www.env.gov.bc.ca/ecocat/

Fraser Basin Council. (2014). 10th Annual BC Interior Stewardship Workshop: Summary. Kamloops, BC: Unpublished Workshop Report.

Fraser Basin Council. (2014). *Shuswap Watershed Water Quality Program: Public Engagement Phase I.* Kamloops, BC: Unpublished Report.

Golder Associates Ltd. (1996). *EcoCat: The Ecological Reports Catalogue.* Retrieved February 19, 2016, from BC Ministry of Environment: http://www.env.gov.bc.ca/ecocat/

Government of British Columbia. (n.d.). *Resources for Water System Operators*. Retrieved February 22, 2016, from Government of British Columbia: http://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/drinking-water-quality/resources-for-water-system-operators

Government of Canada. (n.d.). *Wateroffice.* Retrieved February 17, 2016, from Monthly Discharge Data for South Thompson River at Chase (08LE031): http://wateroffice.ec.gc.ca/report/report_e.html?mode=Table&type=h2oArc&stn=08LE031&dataType=Monthly&parameterType=Flow&year=2013&y1Max=1&y1Min=1

Grace, B. (2003). Water Quality Impacts of the Silver Creek Forest Fire: 1998 to 2002. *Post Wildfire Conference.* Kamloops.
Imperial Metals. (2016). *Ruddock Creek*. Retrieved March 3, 2016, from Imperial Metals: http://www.imperialmetals.com/our-operations-and-projects/exploration/ruddock-creek/overview

Kamloops Interagency Management Committee. (1995). *Kamloops Land and Resource Management Plan.* Kamloops, BC.

Max L. Bothwell, D. R. (2009). On the Boots of Fishermen: The History of Didymo Blooms on Vancouver Island, British Columbia. *Fisheries, 34* (8), 382-388.

McDougall, R. (2014). *Agricultural Nutrient Management in the Shuswap Watershed for Maintaining and Improving Water Quality: Literature Review and Nutrient Management Strategies.* Armstrong, BC: Unpublished Report.

Michael McPhee, M. G. (1996). *The Salmon River Watershed: Overview of Conditions, Trends and Issues.* Technical Report.

Ministry of Forests. (n.d.). *Interior Watershed Assessment Procedure Guidebook*. Retrieved March 2, 2016, from Forest Practices Code: https://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/iwap/iwap-toc.htm

Northwest Hydraulic Consultants. (2014). *2013 SLIPP Water Quality report: Shuswap, Little Shuswap and Mara Lake.* North Vancouver, BC.

Okanagan Basin Water Board. (2009). *Management Plan for Eurasian Watermilfoil in the Okanagan, British Columbia.* Kelowna, BC.

Panko, J. G. (2003). Effects of Fire in Riparian Areas on Fish and Fish Habitat. *Post-Wildfire Conference.* Kamloops.

Peak Planning Associates. (2014). *Draft Recreation Management Plan for Shuswap, Little Shuswap, Mara and Adams Lakes.* Kamloops, BC.

Peak Planning Associates. (2012). *SLIPP Recreation Management Plan Report: Situation Analysis.* Kamloops, BC.

Regional District of North Okanagan. (2015). *Regional District of North Okanagan Regional Agriculture Plan.*

Regional District of North Okanagan. (n.d.). *Shuswap River Watershed Sustainability Plan*. Retrieved March 16, 2016, from Regional District of North Okanagan: http://www.rdno.ca/index.php/services/planning-building/planning-projects/shuswap-river-watershed-sustainability-plan

Regional District of North Okanagan. (2014). *Shuswap River Watershed Sustainability Plan.* Coldstream, BC.

Regional District of North Okanagan. (n.d.). *Watershed / Source Assessments and Protection.* Retrieved February 24, 2016, from Regional District of North Okanagan: http://www.rdno.ca/docs/090112_Duteau_Watershed_Assessment-Final.pdf

Regional District of North Okanagan. (n.d.). *Watershed / Source Assessments and Protection.* Retrieved February 24, 2016, from Regional Distict of North Okanagan: http://www.rdno.ca/docs/140327_-_Duteau_ARP_w_Appendices.pdf

Rolke, R. (n.d.). *Cooke Creek Slide Still Under Review*. Retrieved February 2, 2016, from The Morning Star News: http://www.vernonmorningstar.com/news/365326861.html

Rosenau, M. (2014). *Nearshore habitat utilization by spawning lake char and rearing rainbow trout in Shuswap, Little Shuswap, and Mara Lakes.* Manuscript Report.

S. Gwanikar, S. C. (1998, February). Salmon River: Water Quality Assessment and Recommended Objectives.

Salmon River Watershed Roundtable. (2003). *Final Report on the 2002-03 Salmon River Watershed Planning Project: a Pilot Watershed-Based Fish Sustainability Plan.*

Shuswap Lake Integrated Planning Process. (2014). *Summary: 2011-2013 Water Quality Monitoring Results for Shuswap and Mara Lakes.* Kamloops, BC.

Shuswap Lake Watershed Atlas. (n.d.). Retrieved September 2015, from Community Mapping Network: http://cmnmaps.ca/SHUSWAP/

Silvatech Consulting Ltd. (n.d.). *EcoCat: the Ecological Reports Catalogue.* Retrieved February 19, 2016, from BC Ministry of Forests, Lands and Natural Resource Operations: http://www.env.gov.bc.ca/ecocat/

Silvatech Consulting Ltd. (1998, January). *EcoCat: the Ecological Reports Catalogue.* Retrieved March 9, 2016, from BC Ministry of Environment: http://www.env.gov.bc.ca/ecocat/

Summit Environmental Consultants Ltd. (2015). Bessette and Duteau Creek Watersheds: Summary of water use, fisheries, and streamflow. Unpublished.

Summit Environmental Consultants Ltd. (1997, February). *EcoCat: the Ecological Reports Catalogue.* Retrieved March 8, 2016, from BC Ministry of Environment: http://www.env.gov.bc.ca/ecocat/

Summit Environmental Consultants Ltd. (2015). Salmon River Watershed: summary of water use, fisheries and streamflow. Unpublished Memo.

Sustainability Solutions Group. (2014). *Shuswap Agricultural Strategy.* Vancouver, BC.

Syilx Okanagan Nation Alliance. (n.d.). *Wilsey Dam*. Retrieved February 24, 2016, from Syilx Okanagan Nation Alliance: http://www.syilx.org/operations/fisheries-and-aquatics/habitat-restoration-initiatives/wilsey-dam/

Thiem, G. (1998). *EcoCat: The Ecological Reports Catalogue.* Retrieved March 4, 2016, from Ministry of Environment: http://www.env.gov.bc.ca/ecocat/

Timberline Natural Resource Group & M.J. Milne and Associates Ltd. (2010). *BC Ministry of Forests, Lands and Natural Resource Operations.* Retrieved February 24, 2016, from https://www.for.gov.bc.ca/hfd/library/fia/2011/LBIP_9216001a.pdf

Tri-Star Environmental Consultants. (2014). *SLIPP Water Quality Report: Sources of Nutrients 2014.* Malahat, BC.

Whitevalley Community Resource Centre. (n.d.). *Water Restoration*. Retrieved February 24, 2016, from Whitevalley Community Resource Centre: http://www.whitevalley.ca/WaterRestoration.htm

Youds, M. (2013, November 15). The Little Creek That Could. *Kamloops Daily News* . Kamloops, BC.

Personal Communications

Abbott, S. Community Parks and Recreation Planner, Columbia Shuswap Regional District, Salmon Arm, BC

Belliveau, P. Section Head, Ecosystems Branch, BC Ministry of Forests, Lands and Natural Resource Operations, Kamloops, BC

Bennett, S. Senior Restoration Biologist, Department of Fisheries and Oceans Canada, Kamloops, BC

Brookes, N. Executive Director, Kingfisher Interpretive Centre Society, Enderby, BC

Clark, J. Treasurer, Lower Shuswap Stewardship Society, Enderby, BC.

Clark, R. Water Quality Manager, Regional District of North Okanagan, Coldstream, BC

Curtis, J. Limnologist, University of British Columbia (Okanagan), Kelowna, BC

Einarson, D. Impact Biologist, BC Ministry of Environment, Kamloops, BC

Felhauer, J. Chair, Salmon River Watershed Roundtable, Salmon Arm, BC

Harding, B. Habitat and Stewardship Partnership Coordinator, Department of Fisheries and Oceans Canada, Kamloops, BC

Heinrich, J. Chief Administrative Officer, Village of Chase, Chase, BC

Hesketh, L. Farmland Riparian Interface Stewardship Program Coordinator, BC Cattlemens Association, Kamloops, BC

Hislop, G. Planning forester, Canoe Forest Products Ltd., Salmon Arm, BC

Hussey, D. Oceans and Habitat Management Biologist, Department of Fisheries and Oceans Canada, Kamloops, BC

Kassa, H. Environmental Services Coordinator, Columbia Shuswap Regional District, Salmon Arm, BC

Klassen, A. Senior Fish Biologist, BC Ministry of Environment, Kamloops, BC

Levitt, B. Conservation and Protection Field Supervisor, Department of Fisheries and Oceans Canada, Salmon Arm, BC

Martin, G. Tla-o-qui-aht First Nation member, Tofino, BC

Matscha, G. Environmental Impact Assessment Section Head, BC Ministry of Environment, Kamloops, BC

Matthew, P. Fisheries Management Coordinator, Secwepemc Fisheries Commission, Kamloops, BC

McCleary, R. Instream Flow Biologist, BC Ministry of Forests, Lands and Natural Resource Operations, Kamloops, BC

Neil, A. Operations Manager, Splatsin Indian Band, Enderby, BC

Oetter, A. Director of Authorizations, BC Ministry of Forests, Lands and Natural Resource Operations, Kamloops, BC

Parken, C. Program Head, Chinook and Coho Analytical Program, Department of Fisheries and Oceans Canada, Kamloops, BC

Persello, B. Environmental Services Manager, BC Ministry of Transportation and Infrastructure, Kamloops, BC

Simpson, M. Senior Regional Manager, Fraser Basin Council, Kamloops, BC

St. Pierre, C. Ecosystems Officer, BC Ministry of Forests, Lands and Natural Resource Operations, Kamloops, BC

Thomas, T. Assistant Regional Manager, Fraser Basin Council, Kamloops, BC

Wallin, W. Clerk, Public Works, City of Armstrong, Armstrong, BC

Watts, D. Senior Water Use Biologist, Department of Fisheries and Oceans Canada, Kamloops, BC

Weir, K. Senior Land Officer, BC Ministry of Forests, Lands and Natural Resource Operations, Kamloops, BC