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

Department of Fisheries and Oceans
Fraser River Action Plan
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STRATEGIC REVIEW OF FISHERIES RESOURCES

FOR THE SOUTH THOMPSON - SHUSWAP

HABITAT MANAGEMENT AREA

Prepared for:

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TABLE OF CONTENTS

LIST OF FIGURES ... iv

LIST OF TABLES ... v

LIST OF PHOTOS ... vi

LIST OF APPENDICES ... vii

ACKNOWLEDGEMENTS ... viii

SUMMARY AND RECOMMENDATIONS ... ix

1. INTRODUCTION ... 1

2. FISHERIES RESOURCES ... 4
- 2.1 SOCKEYE SALMON ... 4
  - 2.1.1 Life History ... 4
  - 2.1.2 Spawning and Rearing Habitat ... 7
  - 2.1.3 Catches, Escapements and Escapement Trends ... 10
  - 2.1.4 Habitat Productive Capacity ... 10
  - 2.1.5 Production Objectives ... 13
  - 2.1.6 Enhancement Activities ... 13
- 2.2 CHINOOK SALMON ... 14
  - 2.2.1 Life History ... 14
  - 2.2.2 Spawning and Rearing Habitats ... 14
  - 2.2.3 Catches, Escapements and Escapement Trends ... 18
  - 2.2.4 Habitat Productive Capacity ... 22
  - 2.2.5 Production Objectives ... 22
  - 2.2.6 Enhancement Activities ... 23
- 2.3 COHO SALMON ... 23
  - 2.3.1 Life History ... 23
  - 2.3.2 Spawning and Rearing Habitat ... 24
  - 2.3.3 Catches, Escapements and Escapement Trends ... 26
  - 2.3.4 Habitat Productive Capacity ... 30
  - 2.3.5 Production Objectives ... 31
  - 2.3.6 Enhancement Opportunities ... 31
- 2.4 PINK SALMON ... 32

3. BIOPHYSICAL FEATURES ... 34
- 3.1 PHYSIOGRAPHIC DESCRIPTIONS ... 34
- 3.2 REGIONAL HYDROLOGIC REGIME ... 37
  - 3.2.1 Hydrologic Analysis ... 38

4. RESOURCE USES ... 39
- 4.1 FORESTRY ... 39

4.1.1 Watershed Inventory . . . 41
4.1.2 Current Trends in Forestry . . . 44
4.2 AGRICULTURE . . . 46
4.2.1 Existing Resource Use . . . 46
4.2.3 Current Trends in Agriculture . . . 51
4.3 WATER USE . . . 52
4.3.1 Existing Resource Use . . . 52
4.3.2 Current Trends in Water Use . . . 54
4.4 WATER QUALITY . . . 54
4.4.1 Existing Conditions . . . 54
4.4.2 Current Trends in Water Quality . . . 55
4.5 POPULATION / SETTLEMENT, RECREATION AND TRANSPORTATION . . . 56
4.5.1 Existing Resource Use . . . 56
4.5.2 Impacts on Fishery Resource . . . 56
4.5.3 Current Trends in Settlement, Recreation and Transportation . . . 58
4.6 MINERAL RESOURCES AND PLACER MINING . . . 59

5. WATERSHED MANAGEMENT ISSUES AND RECOMMENDATIONS . . . 60
5.1 SOUTH THOMPSON SUB-BASIN . . . 63
South Thompson River and Little River . . . 63
Chase Creek . . . 64
5.2 ADAMS RIVER SYSTEM . . . 66
Lower Adams River . . . 66
Hiuihill Creek and Nikwikwaia Creek . . . 67
Adams Lake . . . 68
Upper Adams River . . . 69
Sinmax Creek . . . 69
Momich River and Cayenne Creek . . . 71
5.3 SHUSWAP LAKE SYSTEM . . . 73
Shuswap Lake . . . 73
Shuswap Lake System Streams . . . 76
Scotch Creek . . . 76
Onyx Creek and Ross Creek . . . 77
Seymour River . . . 79
Hunakwa Creek . . . 80
Anstey River . . . 82
Eagle River . . . 82
Owlhead Creek . . . 83
Perry River . . . 83
South Pass Creek . . . 84
Reienecker Creek . . . 85
Tappen Creek . . . 85
5.4 SALMON RIVER SYSTEM . . . 86
Salmon River and Bolean Creek . . . 86
Canoe Creek . . . 90
5.5 LOWER SHUSWAP RIVER SYSTEM . . . 90
Lower Shuswap River . . . 91
Johnson Creek and Blurton Creek . . . 92

Fortune Creek and Trinity Creek 92
Kingfisher and Danforth Creeks 93
5.6 MIDDLE SHUSWAP RIVER SYSTEM 94
Noisy Creek, Wap Creek and Tsuius Creek 94
Middle Shuswap River and Tributaries 95
Middle Shuswap River 95
Ireland Creek 98
Bessette Creek and Tributaries 99

6. REFERENCES 104

LIST OF FIGURES

Figure		
1.1	South Thompson-Shuswap Habitat Management Area	2
2.1	Average escapements of sockeye, chinook and coho salmon to the South Thompson-Shuswap HMA, 1951-1995	5
2.2a	Sockeye spawning streams in the South Thompson-Shuswap HMA	8
2.2b	Foreshore spawning of sockeye salmon in Shuswap Lake, 1962 to 1994	9
2.3	Sockeye escapements to the South Thompson-Shuswap HMA, 1951-1995	11
2.4	Chinook spawning streams in the South Thompson-Shuswap HMA	16
2.5	Chinook escapements to the South Thompson-Shuswap HMA, 1951-1995	20
2.6	Coho spawning streams in the South Thompson-Shuswap HMA	25
2.7	Coho escapements to the South Thompson-Shuswap HMA, 1951-1995	29
2.8	Coho escapements to the Eagle and Salmon rivers, 1981-1995	29
2.9	Pink spawning streams in the South Thompson-Shuswap HMA	33
3.1	Physiographic land units in the Thompson River Basin	35
3.2.	Generalized biogeoclimatic zones of the South Thompson-Shuswap HMA	36
4.1	Forest districts (Kamloops Forest Region) in the South Thompson-Shuswap HMA	40
4.2	Watersheds with greater than 20% of their watershed logged, South Thompson-Shuswap HMA	42
4.3	Watersheds with high level of concern related to agricultural activities, South Thompson-Shuswap HMA	47
4.4	Watersheds with high level of concern related to water demand and/or low instream flows, South Thompson-Shuswap HMA	49
4.5	Roads and railways in the South Thompson-Shuswap HMA	57

LIST OF TABLES

Table

2.1 Total sockeye escapements by cycle line to the South Thompson-Shuswap HMA, 1951-1995 . . . 6

2.2 Sockeye spawning and rearing capacity estimates, recent mean escapements and interim escapement targets for selected streams in the South Thompson-Shuswap HMA . . . 12

2.3 Major characteristics of the stream type and ocean type life histories exhibited by the chinook salmon . . . 15

2.4 Commercial and sport catch distribution of ocean type and stream type chinook from the South Thompson-Shuswap HMA . . . 19

2.5 Comparison of average chinook escapements to interim escapement goals by stream, South Thompson-Shuswap HMA . . . 21

2.6 Commercial and sport catch distribution of coho from the South Thompson-Shuswap HMA . . . 27

2.7 Average annual escapements for consistently reported coho stocks in the South Thompson-Shuswap HMA, 1971-1995 . . . 28

4.1 Watersheds showing percentage of the area logged, South Thompson-Shuswap HMA . . . 43

4.2 Status of assessments and projects in the South Thompson-Shuswap HMA, 1996 . . . 45

4.3 Watersheds showing percentage of the area consisting of improved farmland (1990 estimates), South Thompson-Shuswap HMA . . . 48

4.4 Most sensitive streams regarding high summer water demand and low summer/winter flows, South Thompson-Shuswap HMA . . . 50

4.5 Measurable and achievable goals for sustainable fisheries development . . . 61

4.6 Streams with concerns over impacts due to forestry, agriculture, water demand, low flows, water quality, settlement / recreation / transportation, and mining activities in the South Thompson-Shuswap HMA . . . 62

LIST OF PHOTOS

Photo		
5.1	Logging in Upper Adams drainage, 1992	70
5.2	High density development on Mara Lake	74
5.3	Houseboats on Shuswap Lake	74
5.4	Foreshore fill on Shuswap Lake	75
5.5	Foreshore disturbance on Mara Lake	75
5.6	Logging in Scotch Creek watershed	78
5.7	Foreshore and submerged vegetation near the mouth of Scotch Creek, August 1994	78
5.8	Extensive logging in the Seymour River Valley, 1994	81
5.9	Slope erosion below a clearcut on a tributary to the Anstey River, 1994	81
5.10	Riparian loss and erosion along Salmon River	87
5.11	Landowner cutting riparian vegetation to improve view of Salmon River	87
5.12	School volunteers planting at a restoration site on Salmon River	89
5.13	Shuswap Falls on Middle Shuswap River	97
5.14	Loss of riparian vegetation and impacts of cattle grazing on Duteau Creek	100
5.15	Channelization of Harris Creek	100
5.16	Loss of riparian vegetation and instream habitat on Bessette Creek through rip-rap placement	101
5.17	Revegetated riparian zone on Duteau Creek 7 years after fencing	101

LIST OF APPENDICES

Appendix

A-1a. Early summer run sockeye escapements to the South Thompson-Shuswap HMA, 1951-1995 . . . 113

A-1b. Early summer run sockeye escapements to the other streams in the South Thompson-Shuswap HMA, 1974-1995 . . . 114

A-2a. Late run sockeye escapements to the South Thompson-Shuswap HMA, 1951-1995 . . . 115

A-2b. Late run sockeye escapements to the other streams in the South Thompson-Shuswap HMA, 1962-1995 . . . 116

A-3. Total sockeye escapements to the South Thompson-Shuswap HMA, 1951-1995 . . . 117

A-4. Chinook escapements to the South Thompson-Shuswap HMA, 1951-1995 . . . 118

A-5. Coho escapements to the South Thompson-Shuswap HMA, 1951-1995 . . . 119

A-6. Pink escapements to the South Thompson-Shuswap HMA, 1957-1991 . . . 122

B. Hydrology of the salmon streams in the South Thompson-Shuswap HMA . . . 123

C. Sensitivity indices -- South Thompson-Shuswap HMA . . . 125

D. Forest inventory of South Thompson-Shuswap HMA salmon streams . . . 127

E. Agricultural inventory of the South Thompson-Shuswap HMA streams . . . 131

F. List of acronyms used in this report . . . 133

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SUMMARY AND RECOMMENDATIONS

FISHERY RESOURCE

The South Thompson-Shuswap Habitat Management Area (HMA) contributes significantly to the overall production of salmon in the Fraser River Basin and to the genetic diversity of the Fraser salmon populations. This HMA encompasses the Shuswap Lake system and its tributaries, including the Adams, Eagle and Shuswap River systems. The area supports sockeye (*Oncorhynchus nerka)*, chinook (O. tshawytscha), coho (*O. kisutch)* and small populations of pink salmon (*O. gorbuscha)*. Salmon stocks contribute substantially to the First Nations', commercial and sport fisheries. Numerous resident fish species are also present. These contribute to local recreational fisheries and include rainbow trout (*O. mykiss)*, kokanee (*O. nerka)*, bull trout (*Salvelinus confluentus*) and lake char (*S. namaycush*).

In the last decade, up to four million sockeye, 34,000 chinook and 20,000 coho spawners have utilized annually the Shuswap Lake system, with spawning occurring in approximately 40 major streams and numerous small tributaries. The Shuswap Lake system also provides vital rearing area for hundreds of millions salmon fry and is one of the most important salmon producing areas in British Columbia.

The Lower Adams River is the major sockeye producer in the area and the second largest in B.C. The largest chinook producers in the HMA are the Lower Shuswap River and the South Thompson mainstem; the Middle Shuswap, Lower Adams, Eagle and Salmon rivers are also important chinook producers. Coho are produced in many tributaries of the Shuswap system, with the Eagle and Salmon rivers being the major producers. Coho stocks in the HMA contribute to the Thompson coho stock group which represents about one third of the total Fraser River coho population.

Escapement Trends

In general, total sockeye and chinook escapements to the HMA have increased in the last decade. The rebuilding trend for these species is attributed largely to an overall reduction in harvest rates and good ocean conditions during that period. It should be noted, however, that the increase in chinook escapements to the HMA reflects largely the status of the Shuswap River chinook stocks, with the trend less clear for other chinook populations in the HMA. In contrast to sockeye and chinook returns, coho escapements to the HMA have declined dramatically since 1989. Many coho stocks are threatened and the decline is attributed mainly to excessive exploitation rates, low marine survival and degradation of freshwater habitat.

Salmon Enhancement

Hatchery production in the HMA includes the Eagle River facility (closed in 1994) and the Shuswap River facility. The Eagle River Hatchery has focused on enhancement of coho stocks in the Eagle and Salmon rivers, but survival rates have been low. Currently, only the Salmon River coho continue to be enhanced (at the Spius Creek Hatchery). The Shuswap River facility continues to enhance the Middle and Lower Shuswap chinook. A small hatchery on Kingfisher Creek contributes to coho production in the Shuswap area.

For sockeye salmon, the estimated rearing capacity of Adams Lake remains greatly underutilized since the decimation in 1908 of the historically dominant Upper Adams stock. Currently, this population is being rebuilt using local broodstocks. Sockeye returns to the Upper Adams in 1996 indicated that some success is being achieved. Chinook salmon are being transplanted above Wilsey Dam in the Shuswap River. Chinook historically accessed this area, and many kilometres of potential chinook stream habitat could be gained if upstream access were reestablished.

Restoration projects for chinook and coho salmon have focused on the development of groundwater spawning and rearing side channels, fencing of cattle away from stream banks, revegetation of riparian zones, and bank stabilization using techniques such as tree revetments. Many of the restoration projects have been conducted on the Salmon River and Duteau Creek.

FISHERY MANAGEMENT ISSUES AND PRIORITIES

The primary goal is to conserve and continue to rebuild salmon stocks in order to increase their abundance and maintain genetic diversity. As well, an urgent conservation concern must be addressed regarding coho stocks. A recent review of endangered salmon stocks in B.C. identified extinct and threatened stocks. While generally stock aggregates (other than coho) were doing relatively well, the study concluded that a serious concern exists at the individual stock level, and that habitat preservation is a critical link in preserving native salmon stocks (Slaney et al. 1996).

For coho salmon in the HMA, information on current stock status (i.e., catch and escapement), habitat carrying capacity and life history is limited. Also for chinook salmon, the total productive capacity of the habitat is unknown. This information is essential for developing a comprehensive management plan for salmon stocks in the HMA. Research is also required to improve understanding of the factors regulating the production of chinook and coho salmon in the interior streams.

The hatchery program in the HMA has shown limited success due to poor survival rates. For the declining coho stocks, enhancement alone is clearly insufficient to rebuild wild stocks. Conservation measures for these populations must include a reduction in the exploitation rates, and protection and restoration of fish habitat.

HABITAT IMPACTS

Key habitat issues in the South Thompson-Shuswap HMA are related to past and present land and water uses, and increasing development pressures that result in cumulative impacts on fish habitat. The Salmon River, Chase Creek, Hiuihill Creek and Bessette/Harris watersheds are prime examples of salmon bearing watersheds that are at high risk due to cumulative impacts of logging in the headwaters and agriculture/settlement activities downstream.

Logging is the major resource activity in the HMA, with virtually all the watersheds logged. The estimated logged areas range from 20% to 40% of the watershed in the majority of cases. Harvest rates of around 20% of a watershed can result in changes in peak flows, thereby increasing erosion and sedimentation. High rate of cut, road building and high road densities have resulted in impacts that include changes to the hydrologic regime, landslide activity, destabilization of the channel, and sedimentation affecting downstream fish habitat. Scotch Creek is an example

where high rate of cut and road building have severely degraded the stream and resulted in downstream risks to fish habitat.

Agricultural activity (mainly feedcrop production and cattle grazing) is concentrated in the southern half of the HMA. While the overall percentage of improved farmland in each watershed is relatively low, this activity is concentrated along the stream corridors resulting in considerable impacts to stream habitat. Over 50% of the salmon bearing streams in the HMA are at risk. Examples include the Salmon River (and its tributary Bolean Creek), the Bessette watershed, and the Chase, Hiuihill, Sinmax, Fortune and Trinity creeks. Loss of riparian vegetation is extensive along many streams due to land clearing for agriculture, settlements and grazing activities. The result has been wider and shallower streams, higher water temperatures and lack of cover, increased erosion and silted gravels which have impacted spawning and rearing habitat. Runoff from agricultural areas contributes nutrients, contaminants and sediments which degrade water quality.

The very high water demand in the HMA for irrigation has a major impact on instream flows affecting spawning and rearing habitat. Reduction in flows in some years significantly reduces the survival of juvenile rearing populations and impedes spawning migrations. A combination of low summer flows, high water temperatures, fines in the gravel and shortage of pools has seriously diminished the quality of rearing habitat in the Salmon River. Coho juveniles that overwinter in streams and depend on cover, pools, side channels and wetland habitat are particularly vulnerable to these impacts. Currently, over 30 streams in the HMA are considered as highly sensitive regarding high summer water demand and/or low summer/winter flows. Another concern is the operation on Shuswap River of the Peers and Wilsey dams; these have resulted in altered natural flow patterns downstream and impeded access upstream.

Riprapping and channelization of streams, encroachment from linear developments and other activities have resulted in reduced diversity of fish habitat. As well, critical rearing habitat (e.g., side channels, offchannel habitat, ponds and wetlands) particulary for coho salmon, has been often cut off (e.g., Eagle River, South Thompson and Shuswap River corridors). Potential toxic spills along the major transportation corridors represent a major hazard to fish populations in the adjacent waterways.

Urban development, particularly that centered around the Shuswap Lake system, has increased the amount of impervious surface area in the watershed. The result is altered stream hydrology with increased peak flows and degraded water quality. Development pressures along the lakeshores and related activities (e.g., filling, dredging, removal of gravel and cobble, water intakes, boat launches and houseboat industry), threaten spawning sockeye and char in Shuswap Lake. These activities also threaten the critical nursery areas along the foreshore utilized by rearing sockeye, chinook and coho of the entire Shuswap Basin.

WATERSHED MANAGEMENT PRIORITIES

Habitat management objectives are to achieve a net gain in the productive capacity of fish habitat; maintain the physical and biological diversity of fish habitat; and protect and restore watershed and stream channel integrity and stability. Management strategies must be developed at the watershed level and include the management of various regions (uplands, floodplain, riparian zones and stream channels or lakes) as an ecological unit. Watershed planning needs to address

hydrological stability or recovery, stream channel integrity, and the protection and reestablishment of a riparian corridor. Watershed plans must also address adequate instream flows for fish, protection of water quality from non-point sources, and protection of sensitive habitat areas. The major strategies for the protection, restoration and management of fish habitat in the HMA include:

- vigorous stewardship of the riparian zone and surrounding watershed to ensure health of the ecosystem,
- implementation of best management practices for land use activities to prevent impacts on fish habitat, and
- restoration of watersheds where cumulative impacts have occurred and fish habitat has been damaged.

Monitoring of the fishery resource and fish habitat is also a vital component. The key management strategies are summarized below. Stream-specific habitat management priorities are presented in the report.

Manage watersheds (forestry impacts) for hydrological stability through maintenance of water quantity and quality, and riparian protection

- Protect streamside and riparian areas by providing adequate leave strips (reserve zone) and riparian management area through application of the Forest Practices Code (FPC) (including guidebooks) on all salmon bearing streams as a minimum standard.

- Provide additional protection for sensitive salmon streams and those streams that have significant downstream effects (e.g., restrict harvesting and/or provide leave strips not specified in the Forest Practices Code (S4, S5, S6 streams)). On small fish bearing streams (S4), apply reserves and manage the riparian zone according to windthrow hazard to protect the integrity of leave strips. Non-fish bearing streams (S5, S6) may require leave strips to address temperature, LWD (large woody debris), channel stability and water quality concerns downstream.

- Conduct the appropriate level(s) of the Interior Watershed Assessment Procedure (IWAP) on all salmon bearing watersheds to assess hydrological impacts of past logging, identify restoration activities, and prevent watershed impacts from further logging (e.g. harvest and road building restrictions, road deactivation, wider leave strips, revegetation of riparian zone).

- Defer logging in high risk watersheds (e.g., Scotch, Chase and Hiuihill creeks) to promote hydrological recovery.

- Implement restoration activities (road deactivation, bank stabilization, riparian restoration) through the Watershed Restoration Program.

- Focus on rehabilitation of riparian habitat and creation of refuge habitat (offchannel, sidechannel, overwintering ponds) for fish habitat restoration.

- input into Timber Supply Review (TSR) to ensure potential watershed level constraints on harvesting to prevent fisheries impacts are reflected in the determination of Annual Allowable Cut (AAC) for the Timber Supply Area (TSA).

- Monitor compliance and the efficacy of the FPC related to fish habitat in sensitive watersheds (e.g., monitor riparian conditions particularly for small fish bearing streams (S4) and non-fish bearing streams (S5, S6), monitor streamflows and water quality, monitor road construction and maintenance and assess logging prescriptions.

- Increase monitoring of logging practices and promote FPC standards for logging on private lands.

Manage watersheds (agriculture/settlement impacts) to maintain and restore riparian vegetation, channel stability and suitable temperatures; maintain the hydrologic regime of urban streams; and control non-point source sediments and pollutants

- Promote and implement long term solutions to channel stability problems by establishing a suitably wide riparian corridor (6-7 times the channel width) to reduce rates of channel shifting, stabilize sediment deposits, reduce channel width and lower stream temperatures.

- Develop watershed based plans to protect and restore riparian vegetation.

- Develop site specific remedial plans to rehabilitate severely disturbed sites by stabilizing banks (using bioengineering techniques) and planting vegetation, and by fencing poorly vegetated areas to exclude livestock.

- Develop optimum techniques for various types of river banks (i.e., planting techniques, species mix, bioengineering techniques) to promote rapid revegetation of actively eroding areas.

- Assign priorities for restoration activities and identify specific measures to create fish habitat.

- Monitor the long term effectiveness of stream restoration activities in improving fish habitat.

- Apply DFO/MELP Land Development Guidelines, Stream Stewardship Guides for Urban Development and Agriculture, and other relevant environmental guidelines that promote best management practices to minimize impacts of land development on fish habitat (e.g., setbacks from watercourses, waste management, stormwater management).

- Control the amount of impervious surface area in urban watersheds to maintain hydrologic stability (work with local governments).

- Monitor and control non-point sources of water pollution (sediments, nutrients, contaminants, stormwater) and ameliorate contaminated sites (work with DOE, provincial and local governments).

Manage watersheds (water use impacts) to conserve and improve instream fisheries flows for spawning and rearing salmonids

- Assess instream flow requirements for fish.

- Develop water management plans (with provincial agencies, irrigation districts and water users) to ensure adequate instream flows for fish through water conservation, licensing restrictions, flow agreements, groundwater regulation, streamflow and water use monitoring and storage opportunities.

- Optimize spawning, rearing and incubation flows from B.C. Hydro facilities at Wilsey Dam on the Shuswap River, and continue to explore the possibility of salmon access upstream of Wilsey Dam.

Manage foreshore and upland watersheds to conserve habitat diversity, riparian vegetation, substrate and water quality of spawning and nursery areas of lakes and mainstem rivers

- Develop management strategies that treat the Shuswap Lake system as an ecological unit to guide local planning and development.

- Map and classify habitat, and develop habitat management prescriptions (for protection of spawning and rearing habitat) for lake foreshore areas (Shuswap, Little Shuswap, Mara and Mabel lakes) and for the South Thompson and Shuswap mainstems to incorporate fish values into zoning bylaws and community plans.

- Protect foreshore, riparian and upland areas through control of activities (diking, dredging, filling) that impact the foreshore, through stormwater management, community intakes, sewer systems, etc.

- Protect integrity and water quantity and quality of small tributary streams that contribute to the productivity of Shuswap Lake and influence foreshore spawning and rearing areas.

Manage watersheds (multiple land use impacts) through assessment and management of cumulative impacts on Crown and non-Crown lands

- Cooperative efforts are required of agencies, public and stakeholders to manage the watershed to address cumulative impacts and direct efforts toward watershed planning, restoration and ecosystem management.

- Continue partnerships (e.g., Salmon River Roundtable) and promote new stream arrangements with various groups (provincial and local government agencies, aboriginal communities and the public) to promote stewardship of land and water, as well as riparian management on public and private lands.

- Continue education, training and support to promote public understanding of the importance of watershed management, and develop standards and guidelines for fish habitat protection.

A continuing need exists for inventory and research to identify critical fish habitat. There is also a need to increase understanding of fish life history, habitat capacity and utilization, and limiting factors affecting salmon production. Interactions between land use activities in the watershed and fish habitat also should be investigated. For example, fish-forestry interactions in the southern interior need to be studied, criteria need to be established for site specific management of riparian areas, and protection measures and restoration techniques need to be developed and evaluated.

Monitoring is an integral component of management strategies and should include monitoring of escapements of major stocks, as well as small populations (e.g., coho). In addition, monitoring of habitat conditions (quantity and quality) and of the achievement of net gain of fish habitat is required. Monitoring includes compliance monitoring (audits) and enforcement to ensure compliance to the Fisheries Act, the Forest Practices Code and other environmental standards and guidelines. Monitoring the effectiveness of management prescriptions is also essential. While the FPC provides guidelines for management of riparian areas, as well as other measures to address cumulative impacts, there is a need to evaluate the effectiveness of these measures to protect fish habitat.

There has been some improvement in understanding of fish habitat needs, stream processes, interactions between land uses and fish habitat, land management practices and restoration techniques. However, watershed specific information is limited and a conservative or risk averse approach to land use management is warranted if fish habitat is to be maintained and enhanced. Recent assessments indicate that the success of instream improvements and restoration techniques is limited. Consequently, the emphasis should be placed on the protection and restoration of stream integrity through watershed stewardship and the removal of or changes in land use activities that cause adverse impacts to riparian and aquatic ecosystems.

1. INTRODUCTION

The South Thompson-Shuswap Habitat Management Area (HMA) is located east of Kamloops B.C. within the Interior Plateau of the Canadian Cordillera, as described by Holland (1976). The South Thompson River originates in east-central B.C. in the Monashee Mountains and the Okanagan Highlands, and the total basin has a drainage area of 17,311 km², or approximately 7.5% of the total Fraser River watershed. All major watersheds within this HMA (except for the South Thompson and Little rivers) drain into the Shuswap Lake. The South Thompson River flows out of the Little Shuswap Lake, and continues about 56 km south-west before entering the Thompson River at Kamloops (Fig. 1.1).

In the last decade, up to four million sockeye, 34,000 chinook and 20,000 coho spawners have utilized the Shuswap Lake system annually, with spawning occurring in approximately 40 major streams and numerous small tributaries. Pink salmon also spawn in some tributaries, particularly in Adams River. The Shuswap Lake serves as a vital rearing area for hundreds of millions of salmon fry; this productivity makes the HMA one of the most important salmon producing areas in British Columbia. Sockeye, chinook and coho salmon originating in the HMA are an important component in the First Nations' and commercial fisheries, with chinook and coho also contributing to the sport fisheries (marine and in-river).

The HMA consists of several sub-basins that generally have similar geomorphologic characteristics and land use practices. Basins to the north and east have generally steeper relief, higher stream gradients and cooler, wetter conditions. Logging is the major resource use in these areas.

Drainages in the southern half of the HMA have long stream sections that flow through flat valley floors, and the climate is generally hot and dry. Competition for resources in this area is high, with logging conducted in the upper regions, and intensive agriculture and settlement activities primarily in the lower reaches. Residential development has accelerated in recent years, particularly along lakeshore areas and streams, and in the valleys. Recreation values are high, especially along the Shuswap, Mara and Mabel lakeshore areas, as well as along many of the smaller lakes in the HMA. Major east-west transportation corridors, including the Trans-Canada Highway and the Canadian Pacific Railway, follow the watercourses on their route through the HMA.

As the demands on the watershed continue to increase, so does the pressure on the salmon spawning and rearing habitat. To conserve and rebuild salmon stocks, the salmon spawning populations and their habitat must be protected. To achieve this, sound habitat management strategies and appropriate harvest management actions must be developed and implemented.

Habitat management is based on fish life-history information. This, combined with biophysical, land use and harvest information relating to fish production in the HMA, yields the basic information needed to develop strategies to preserve and rebuild the salmon resource. This report provides a common ground for initiating a cooperative development of long term, sustainable resource-use strategies for this area.

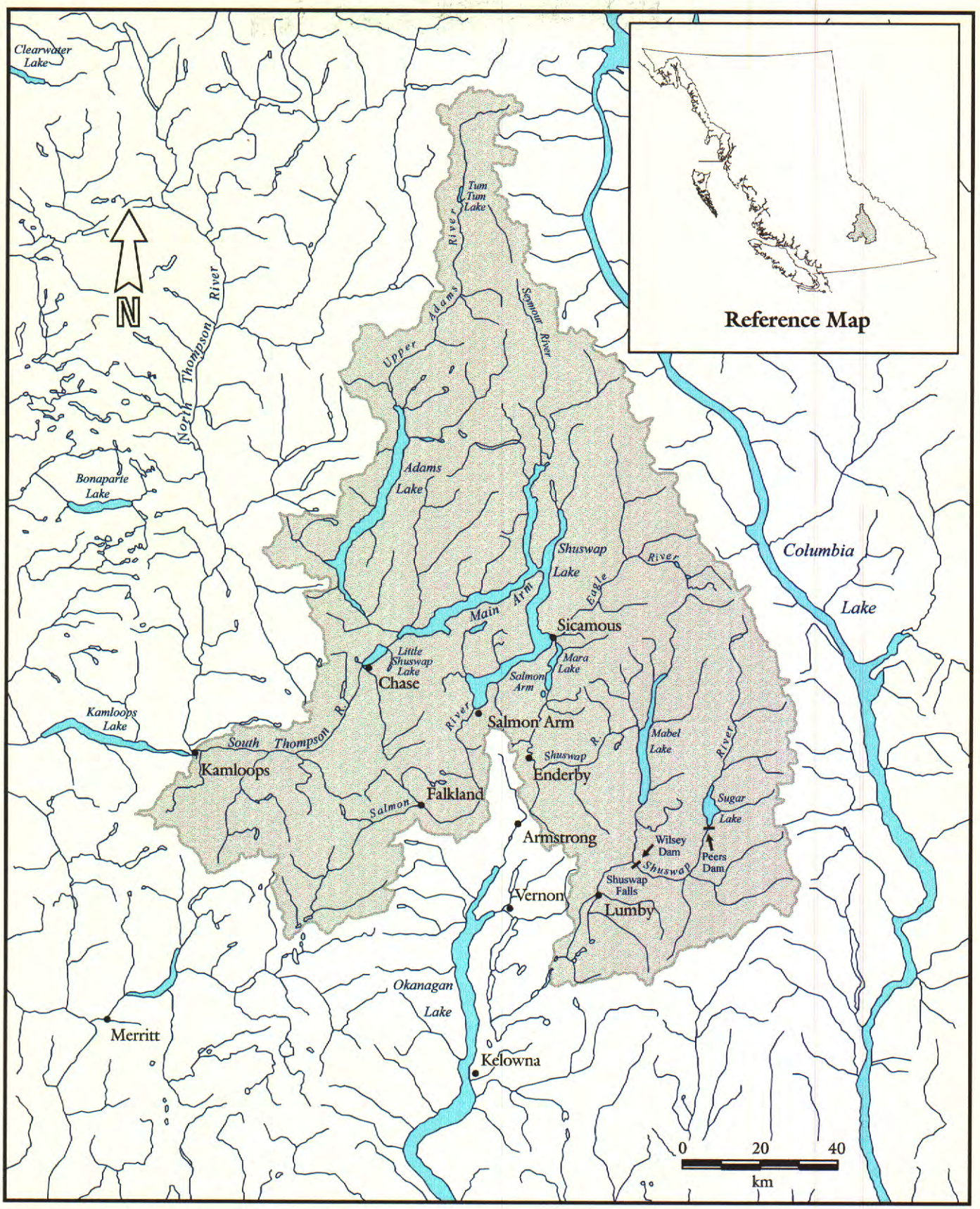


Figure 1.1 South Thompson-Shuswap Habitat Management Area.

This assessment is based on the existing information from fisheries and land use management agencies. Much of the presented information originated from interviews with personnel from regional Department of Fisheries and Oceans, Ministry of Environment, Lands and Parks and Ministry of Forests, as well as information from published reports. Key references include Sigma Engineering Ltd. (1991) for resource use information, Rood and Hamilton (1995) for hydrologic analyses, and the Department of Fisheries and Oceans database for salmon stock status. Stream profiles and the available database for each watershed in the South Thompson-Shuswap HMA are provided in a separate volume (Salmon Watershed Planning Profiles for the South Thompson-Shuswap HMA). A list of acronyms used in the report is provided in Appendix F.

2. FISHERIES RESOURCES

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 (only exceeded by the Horsefly system in recent years). The Thompson coho stocks comprise one third to almost one half of the total Fraser coho production, and chinook production in the Shuswap lake tributaries is significant.

Average escapements (1951-1995) of sockeye, chinook and coho salmon are shown for the South Thompson-Shuswap HMA in Figure 2.1. Mean annual escapements during the last decade (1986-1995) averaged approximately 1,000,000 sockeye, 26,000 chinook and 9,000 coho (Append. A-3, A-4, A-5). Sockeye and chinook escapements have increased since the 1970s, while coho escapements first increased, then declined considerably in recent years (Fig. 2.1). Pink salmon also return to this HMA on the odd year cycle, but at low numbers since the Hell's Gate landslide of 1913 (approximately 2,500 pinks during the 1980s, Append. A-6).

Recent reports summarize the life history, stock description, harvest management, enhancement activities and production potential for each salmon species in the Fraser River watershed (Dept. Fish. Oceans 1995a, b, c, 1996)

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

2.1 SOCKEYE SALMON

Sockeye are the most abundant salmon species in the HMA with total returns of up to 4 million adults on the dominant cycle (Fig. 2.3, Table 2.1). The Lower Adams River is the major sockeye producer in the area and the second largest in B.C. (Append. A-2). Historically, this population was rivalled by the Upper Adams run, but the latter was decimated in 1908 due to dam construction and has never recovered (see section 2.1.6). The Lower Shuswap River has become a major sockeye producer in the last 15 years; other important runs include the Little and Seymour rivers, Scotch Creek and Shuswap Lake spawners (Append. 1, 2).

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 (Append. A-1). The dominant stocks in the late run include Lower Adams and Little rivers, Shuswap River (Middle and Lower), Shuswap Lake and South Thompson mainstem (Append. A-2). 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.

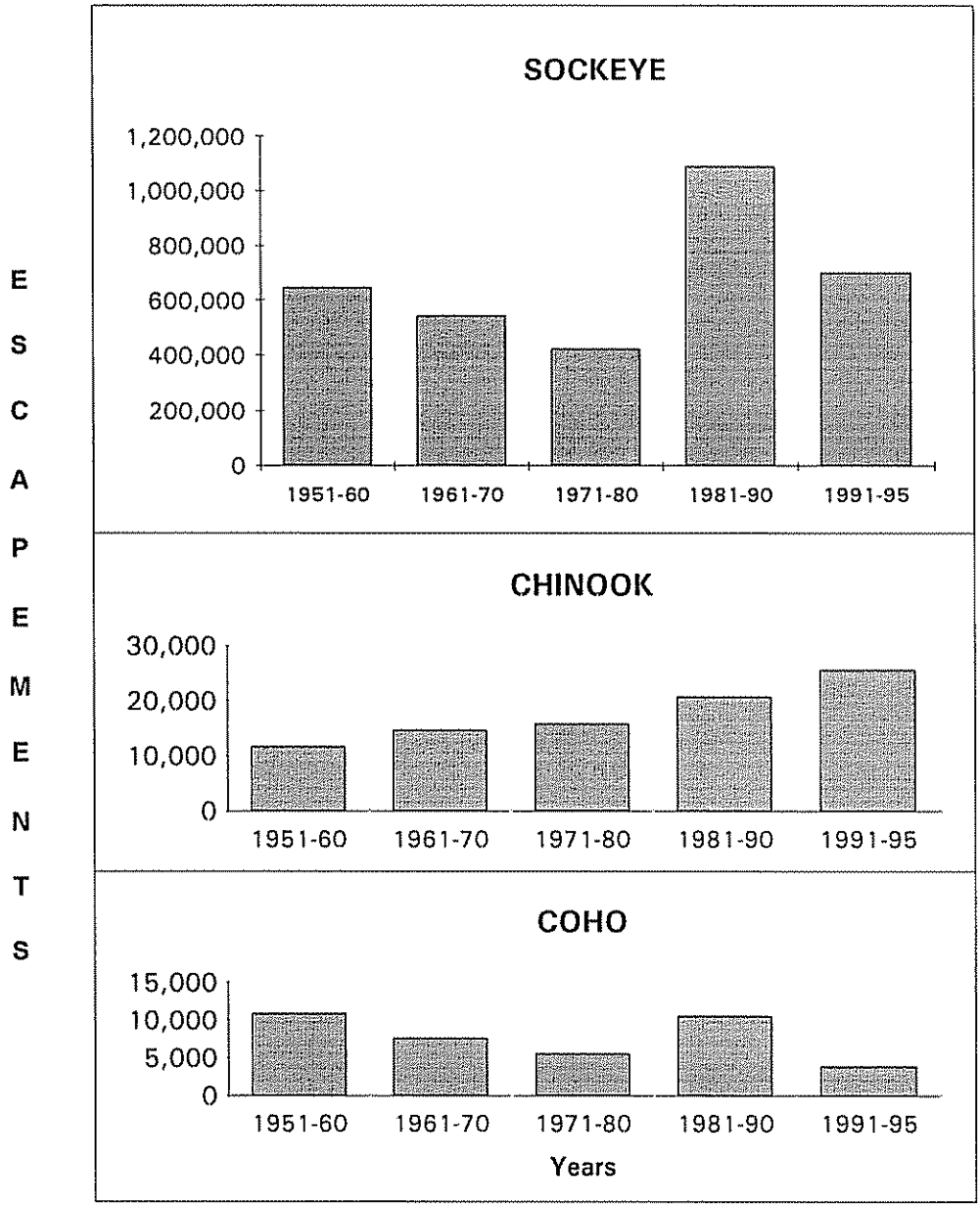


Figure 2.1 Average escapements of sockeye, chinook and coho salmon to the Thompson-Shuswap HMA, 1951-1995.

Table 2.1. Total sockeye escapements by cycle line to the South Thompson-Shuswap HMA, 1951-1995. *

1992 CYCLE LINE		1993 CYCLE LINE		1994 CYCLE LINE		1995 CYCLE LINE	
Year	Escapement	Year	Escapement	Year	Escapement	Year	Escapement
						1951	169,448
1952	17,519	1953	227,674	1954	2,056,099	1955	73,606
1956	7,231	1957	324,182	1958	3,385,163	1959	187,415
1960	5,972	1961	72,277	1962	1,209,578	1963	230,284
1964	4,485	1965	68,393	1966	1,352,044	1967	859,295
1968	8,698	1969	66,059	1970	1,569,342	1971	309,353
1972	8,672	1973	57,100	1974	1,204,195	1975	205,686
1976	16,156	1977	101,428	1978	1,966,818	1979	349,446
1980	15,175	1981	77,451	1982	3,138,734	1983	242,301
1984	31,295	1985	25,269	1986	2,526,263	1987	692,832
1988	37,323	1989	24,866	1990	4,102,034	1991	1,399,866
1992	27,456	1993	30,884	1994	1,561,454	1995	484,465
Average escapements for the last 5 cycle years							
	25,481		51,980		2,659,061		633,782

* Data from Append. A-3.

Fry typically emerge from late March to late May with peak emergence observed during the first two weeks of May (Stewart et al. 1989, Whelen et al. 1982). Fry generally migrate downstream into adjacent lakes to rear and overwinter, and subsequently migrate to sea as yearlings (Burgner 1991). Yearling sockeye begin to outmigrate 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 (Fedorenko and Pearce 1983, Whelen et al. 1982). 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 (Healey 1980). Following a brief rearing period in the Strait of Georgia (Healey 1980), the juveniles migrate predominantly northward, exiting the Strait by June or July (Groot and Cooke 1987), 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 1994 cycle line (i.e., 1994, 1998, etc.), with 1995 being the subdominant cycle, and 1996 and 1997 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 Figures 2.2a and 2.2b. The major sockeye spawning streams include the Lower Adams, Lower Shuswap, Little, Scotch and Seymour rivers, as well as a lake-spawning population in Shuswap Lake (Append. A-1, A-2). Shuswap Lake is also the major rearing area for most of the region's juvenile sockeye. Other lakes (Adams, Mabel, Mara, Little Shuswap) are utilized for rearing as well, particularly the initial rearing stages prior to the movement of juveniles into the 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 (Williams et al. 1989, Graham and Russell 1979). 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 the Little Shuswap Lake, particularly with increasing flows in the South Thompson (Williams et al 1989). 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 (Fig. 2.2b; 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. Williams et al. (1989) and Graham and Russell (1979) observed that by late May, juvenile sockeye in Shuswap Lake were distributed along both shores of the Main Arm, rearing in nearshore areas until mid- to late July, then moving into deeper offshore waters. The offshore movement coincided with nearshore water temperatures increasing above 16°C (Graham and Russell 1979).

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 (Stewart et al. 1989, Williams et al. 1989). Mara lake, on the other hand, has very high rearing densities and is a major rearing area, especially for the Lower Shuswap stock. The Little River sockeye and a portion of the

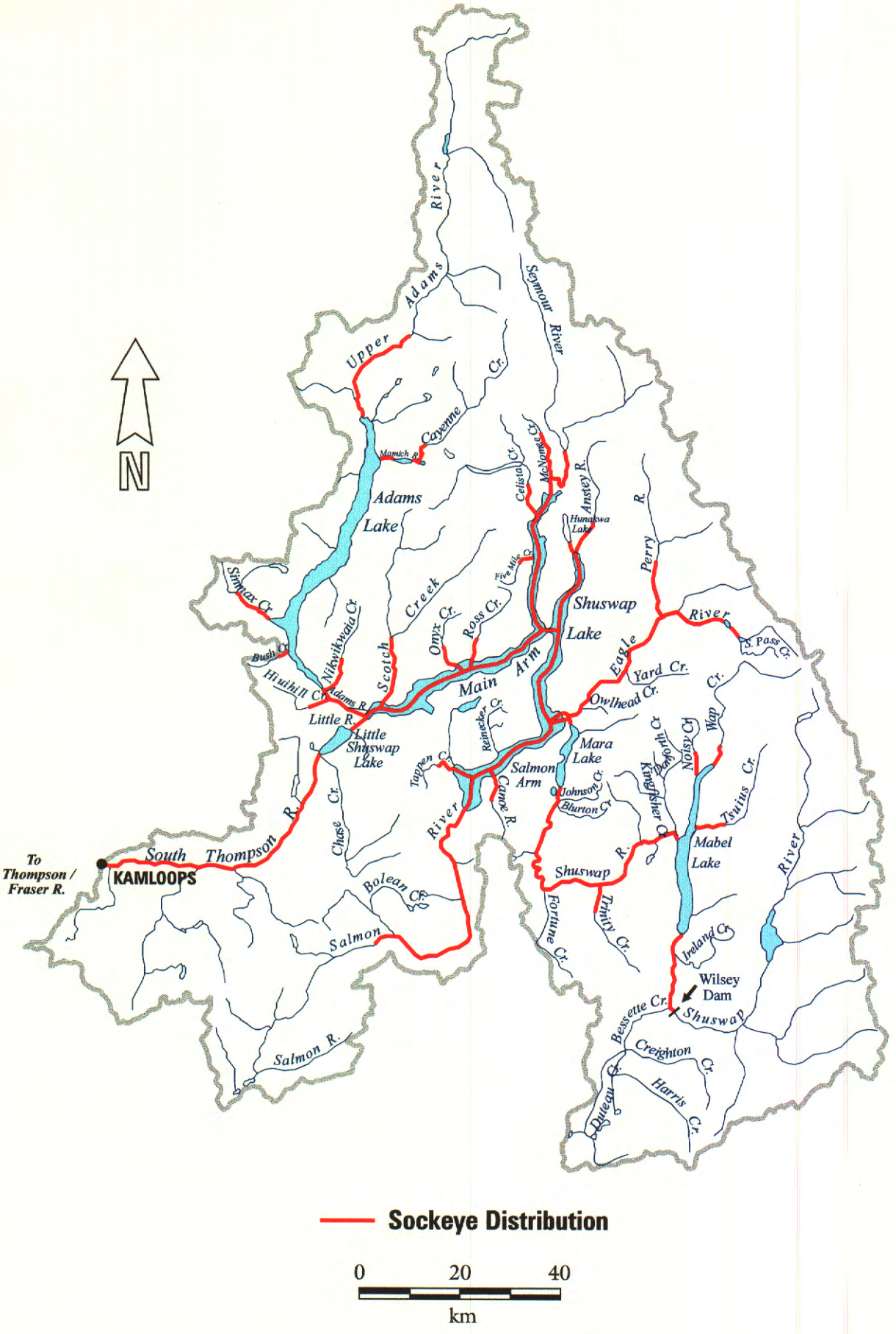


Figure 2.2a. Sockeye spawning streams in the South Thompson-Shuswap HMA.

Figure 2.2b Foreshore spawning of sockeye salmon in Shuswap Lake, 1962 to 1994.[1]

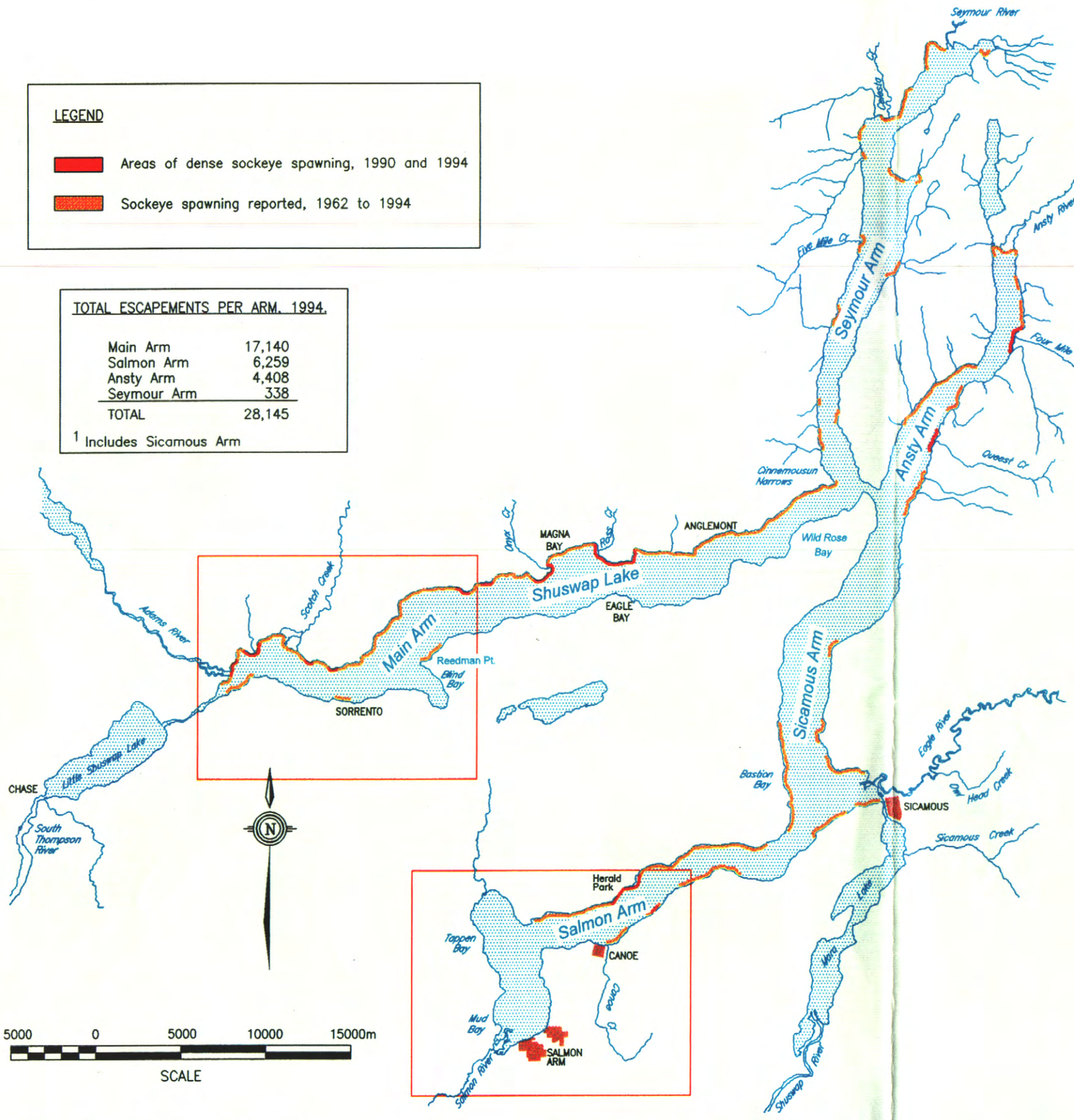
LEGEND

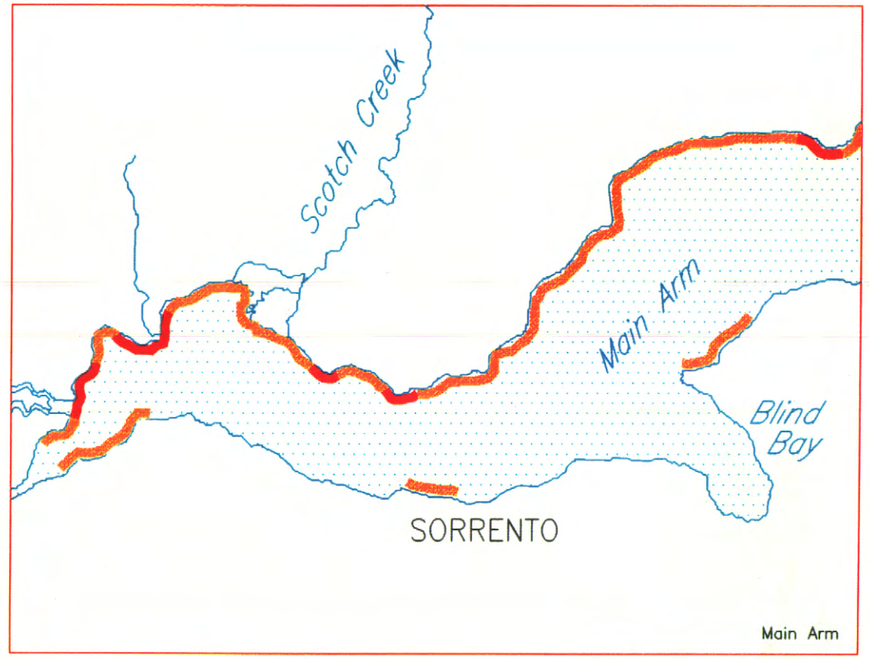
- Areas of dense sockeye spawning, 1990 and 1994
- Sockeye spawning reported, 1962 to 1994

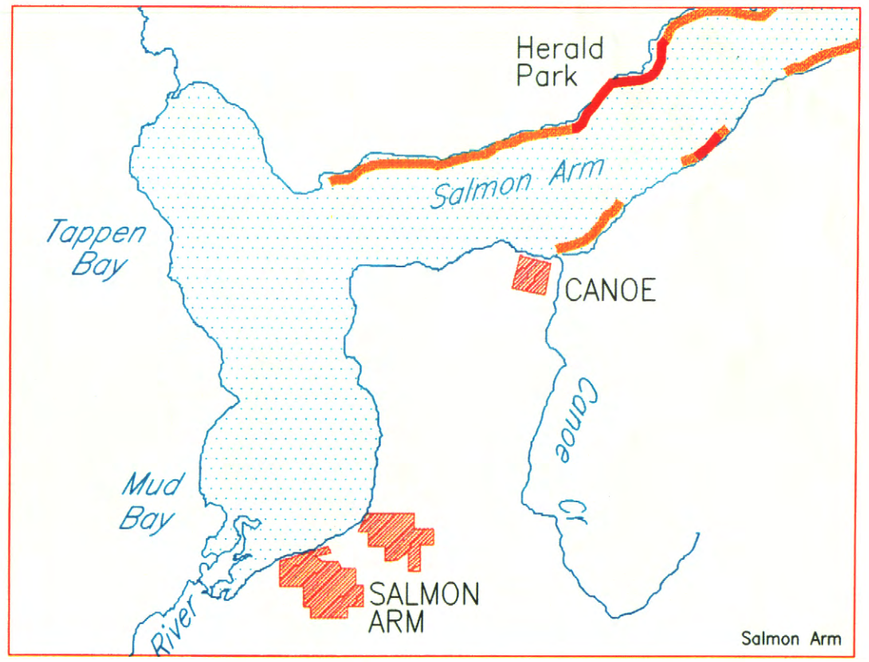
TOTAL ESCAPEMENTS PER ARM, 1994.

Main Arm	17,140
Salmon Arm	6,259
Ansty Arm	4,408
Seymour Arm	338
TOTAL	28,145

[1] Includes Sicamous Arm







Source: Hatfield Consultants Ltd. 1996

Adams River sockeye utilize the Little Shuswap Lake for early rearing, but a large portion of these juveniles migrate back upstream into the Shuswap Lake (see above). The 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. Little is known about the South Thompson mainstem stock. 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). Based on these analyses, the estimated overall catch distribution of Fraser sockeye is approximately 72% in the Canadian commercial fisheries (troll, seine, gillnet), 22% in the U.S. commercial fisheries (Alaska and Washington) and 6% in the native fisheries (1981-1992 data). Depending on the run size, native fisheries on sockeye are conducted on various streams in the HMA, (e.g., South Thompson mainstem, Adams River, Lower Shuswap River, Scotch Creek). However, the majority of the native catch of sockeye from this HMA are taken from the Fraser River mouth to North Bend, B.C. (Macdonald 1991).

Sockeye escapements to individual streams are shown in Appendices A-1 and A-2. Total escapements to the HMA on the dominant and sub-dominant cycles have increased significantly in the recent decade to 1991 (Fig. 2.3, Table 2.1). Over the past five cycle years, the dominant and sub-dominant cycle runs averaged 2.7 million and 0.6 million spawners (Table 2.1); no strong trends are observed for the two off-years.

The Lower Adams sockeye contributed annually around 60% to the HMA's total sockeye escapement (1986-1995 data), peaking at 2.1 million spawners in 1982 and 1990 (Fig. 2.3, Append. A-2). This rebuilding trend was observed also for the other major stocks in the area (Lower Shuswap, Little and Seymour rivers, and Scotch Creek, Append. A-1, A-2) and is attributed to good ocean productivity, and international and domestic harvest management policies. Specifically, since the signing of the Pacific Salmon Treaty by Canada and the U.S. in 1985, the DFO has pursued a policy of placing more adults on the spawning grounds through reduced harvest rates (DFO 1991). The Treaty has established general harvest management regimes to conserve the stocks and allow each country to reap the benefits of rebuilding their respective stocks. At present, the Treaty has not been renegotiated on an annual basis.

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 Fraser River Sockeye Task Force (DFO 1988) developed for Fraser sockeye the preliminary estimates of their stream spawning and lake rearing capacities. 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 (Table 2.2).

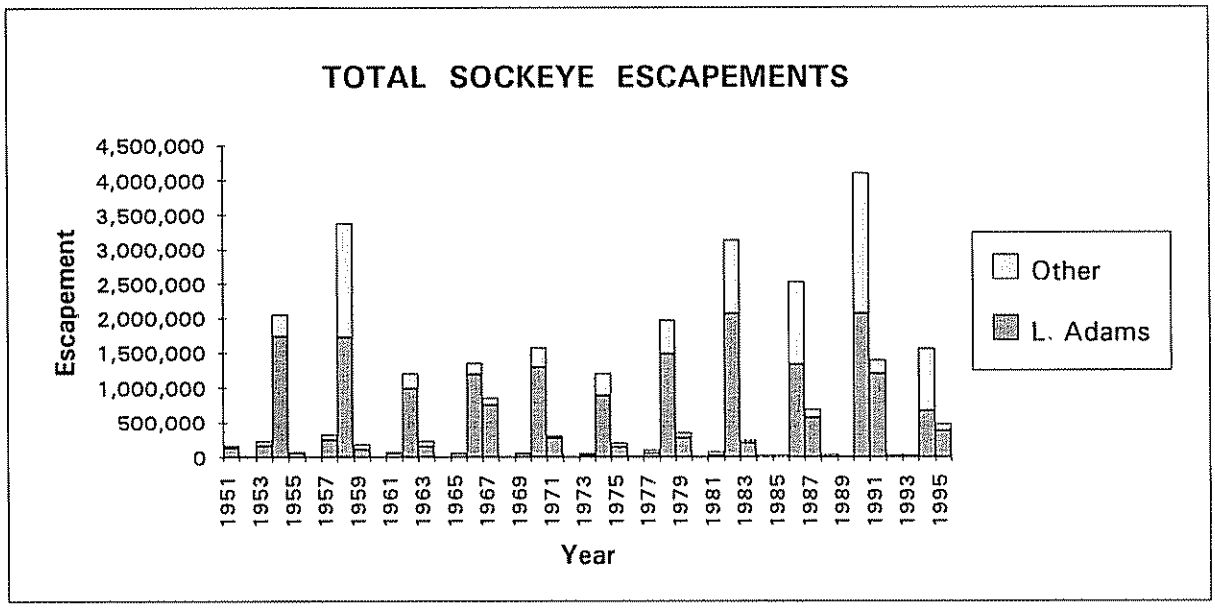


Figure 2.3. Sockeye escapements to the South Thompson-Shuswap HMA, 1951-1995.

Table 2.2. Sockeye spawning and rearing capacity estimates, recent mean escapements and interim escapement targets for selected streams in the South Thompson-Shuswap HMA. *

Rearing Lake	Associated Spawning Streams	CAPACITY ESTIMATES: Spawning Capacity (adults)	CAPACITY ESTIMATES: Lake Rearing Capacity (spawner equivalents)	CAPACITY ESTIMATES: Stock Recruit Analysis Estimate	Recent Mean Escapements on Dominant Cycle ***	Interim Escapement Targets on Dominant Cycle
Shuswap Lake **	South Thompson R.	159,100			40,453	-
	Little River	629,200			256,326	-
	Lower Adams R	1,429,800			1,537,892	2,300,000
	Scotch Cr.	33,100			57,373	84,000
	Seymour R.	116,800			128,700	117,000
	Eagle R.	50,600			50,090	-
	Lower Shuswap R.	713,000			616,590	1,200,000
	Sub-Total	3,131,600	4,019,000		2,687,424	
Mable Lake	Middle Shuswap R.	545,600	809,000		62,272	
Adams Lake	Upper Adams R	1,552,000			3,555	
	Momich-Cayenne Cr.	4,800			4,399	
	Sub-Total	1,556,800	1,923,000		7,954	
TOTAL	**ALL STREAMS**	**5,234,000**	**6,751,000**	**4,161,000 +**	**2,757,650**	

* Data from DFO (1988).

** Includes Little Shuswap and Mara Lakes.

** Recent mean escapements on the dominant cycle were based on the four most recent years that have spawning escapement data (1982, 1986, 1990, 1994, Append 1, 2), except for the Upper Adams R. and Momich-Cayenne where the dominant years were 1980, 1984, 1988 and 1992

+ Stock recruit analysis estimate excludes Upper Adams River due to insufficient data.

Another estimate of the productive capacity, based on the stock recruit analysis which examines the relationship between spawners and the resultant returns (DFO 1995a), gave an optimum escapement of approximately 4.2 million spawners (Table 2.2). However, this is an underestimate since the Upper Adams stock was not included due to insufficient data.

Comparing the first two estimates suggests that the rearing capacity for the combined Shuswap, Mabel and Adams lakes exceeds the spawning capacity in the associated streams. However, the above estimates need to be fine-tuned. For example, Hume et al. (1996) suggested that the lower densities of fry observed in Shuswap Lake following the record-high 1990 escapement may be the result of spawning ground or lake rearing limitations.

2.1.5 Production Objectives

Table 2.2 shows the interim escapement targets developed as part of the Fraser sockeye rebuilding strategy. The DFO has initiated efforts to move towards these interim goals by reducing harvest rates, both domestically and internationally, through the Pacific Salmon Treaty. However, harvest management efforts alone are unlikely to rebuild the stocks quickly since runs, such as the Upper Adams, are harvested in mixed stock fisheries. To rebuild the spawning population more rapidly to the levels that can withstand harvest pressure, a greater concerted effort that includes both harvest management and enhancement measures, is required.

2.1.6 Enhancement Activities

The South Thompson-Shuswap HMA provides a major enhancement opportunity for the Fraser sockeye. In recent years, the mean escapement to major sockeye streams in the area averaged 2.8 million on the dominant cycle, which is well below the estimated spawning ground capacity of 5.2 million fish (Table 2.2). More significantly, the estimated rearing capacity of Adams Lake (1.9 million spawner equivalents) remains greatly underutilized, when compared to the recent mean escapement of only 8,000 spawners to the associated streams (Table 2.2). The once dominant Upper Adams stock was decimated in 1908 as a result of dam construction at the Adams Lake outlet. Although the dam was removed in 1945 and several attempts made since then to reintroduce sockeye from other systems (Williams 1987), these efforts did not result in significant rebuilding of the stock.

The technology to enhance sockeye salmon through hatchery techniques is relatively new but has been proven possible through a recent pilot project conducted by the DFO. Starting In 1992, sockeye eggs were obtained from the Upper Adams and Momich-Cayenne broodstocks, and incubated and reared at the Clearwater River Hatchery. A portion of the resulting fed fry were released directly into the Upper Adams River. The remainder were net pen reared during May and released into the north end of Adams Lake (D. Lofthouse, pers. comm.). In 1996, over 30,000 sockeye spawners returned to the Upper Adams River. This success is attributed to both the enhancement efforts and the reduced harvest rates in the commercial and native fisheries. In addition to the above enhancement program (restricted to the 1996 cycle), a groundwater channel was constructed in the Lower Adams River in 1990. This channel was utilized by approximately 15,000 sockeye spawners (early and late runs) during the 1990-1995 period.

2.2 CHINOOK SALMON

The major chinook producers (>1,000 spawners) in the HMA are Shuswap River (Middle and Lower), Lower Adams River and South Thompson mainstem (Append. A-4). Other important producers (>100 spawners) are the Eagle, Salmon and Little rivers and the Bessette Creek. The Upper Adams, Anstey and Seymour rivers, as well as the Duteau, Hunakwa and Wap creeks also support chinook salmon.

2.2.1 Life History

The majority of the HMA's chinook return to spawn at ages 4 and 5. Eggs incubate over the winter and fry emerge from mid-March through May. Different stocks may show different peak emergence and emigration timing (Stewart et al. 1989, Bowman and Stewart 1984, Fedorenko and Pearce 1983, Whelen et al. 1982).

All chinook stocks in the HMA exhibit a mix of two life history patterns (ocean type and stream type) based on the length of juvenile residency in freshwater. The ocean type chinook rear in freshwater for several months and migrate to sea in their first fall; the stream type chinook rear in freshwater for approximately one year and migrate to sea as yearlings (Fraser et al. 1982). Within a given stock, one life history pattern may predominate; for example, the Adams and Shuswap River chinook are mainly ocean type, while the Eagle and Salmon River chinook are mainly stream type. Table 2.3 compares the major characteristics of these two life history types.

Juvenile chinook rear primarily in the major lakes, with overwintering observed largely in Shuswap Lake and in downstream mainstem rivers; little overwintering occurs in natal streams (Lewis and Levings 1988). 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 (Table 2.3). 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 (based on CWT recoveries in Albion test fishery, N. Schubert, pers. comm.). Those stocks with predominantly a stream type component (i.e., juveniles overwinter in freshwater) typically return to the lower Fraser before July 15 and constitute the spring run group (e.g., Eagle, Salmon, Seymour and Anstey River chinook). Those stocks with predominantly an ocean type component, typically return to the lower Fraser after July 15 and constitute the summer run group (e.g., Lower Adams, Middle and Lower Shuswap, South Thompson and Litter River chinook). Peak spawning occurs from late August to early November (DFO 1990), with the spring run spawning earlier than the summer run (Table 2.3).

2.2.2 Spawning and Rearing Habitats

Spawning distribution of chinook salmon in the HMA is shown in Figure 2.4. 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 the Little River. In the Lower Shuswap, chinook spawn downstream of Mabel Lake to Enderby, and in the Middle

Table 2.3. Major characteristics of the stream type and ocean type life histories exhibited by chinook in the South Thompson-Shuswap HMA.

	OCEAN TYPE	STREAM TYPE
Freshwater Rearing Period	Enter the sea in their first fall as underyearlings.	Overwinter in freshwater and enter the sea as yearlings.
Major Stocks (% of stock with that life history) *	Lower Shuswap R. - 90% Middle Shuswap R. - 60% Lower Adams R. - 60% South Thompson R. - 60%	Eagle R. - 95%, Salmon R. - 95%
Juvenile Migration Timing into / out of Strait of Georgia	Enter the Strait likely in August to September. **	Enter the Strait in April and May (Healey 1980); leave by mid-summer.
Juvenile Migration Route out of Strait of Georgia and Adult Return Route	Mainly via northern route (Johnstone Strait).	Mainly via southern route (Juan de Fuca Strait).
Dominant Age at Maturity	Age 4	Age 5
Marine Catch Distribution	Mainly Alaska and northern B.C. troll fisheries.	Mainly North and Southwest Vancouver Island and Strait of Georgia fisheries.
Return Timing in Lower Fraser	After July 15 - Summer Run	Before July 15 - Spring Run
Peak Spawning	Early October	Mid-September ***

* Note that each stock exhibits both life history type. These are based on age scale analysis (Whelen and Olmsted 1982, and Sebastian 1983 for Adams, South Thompson, Eagle and Salmon rivers; Fedorenko and Pearse 1982 for Middle and Lower Shuswap rivers).

** Based on initiation of seaward migration in late June to mid-July (Stewart et al. 1989).

*** Whelen and Olmsted (1982).

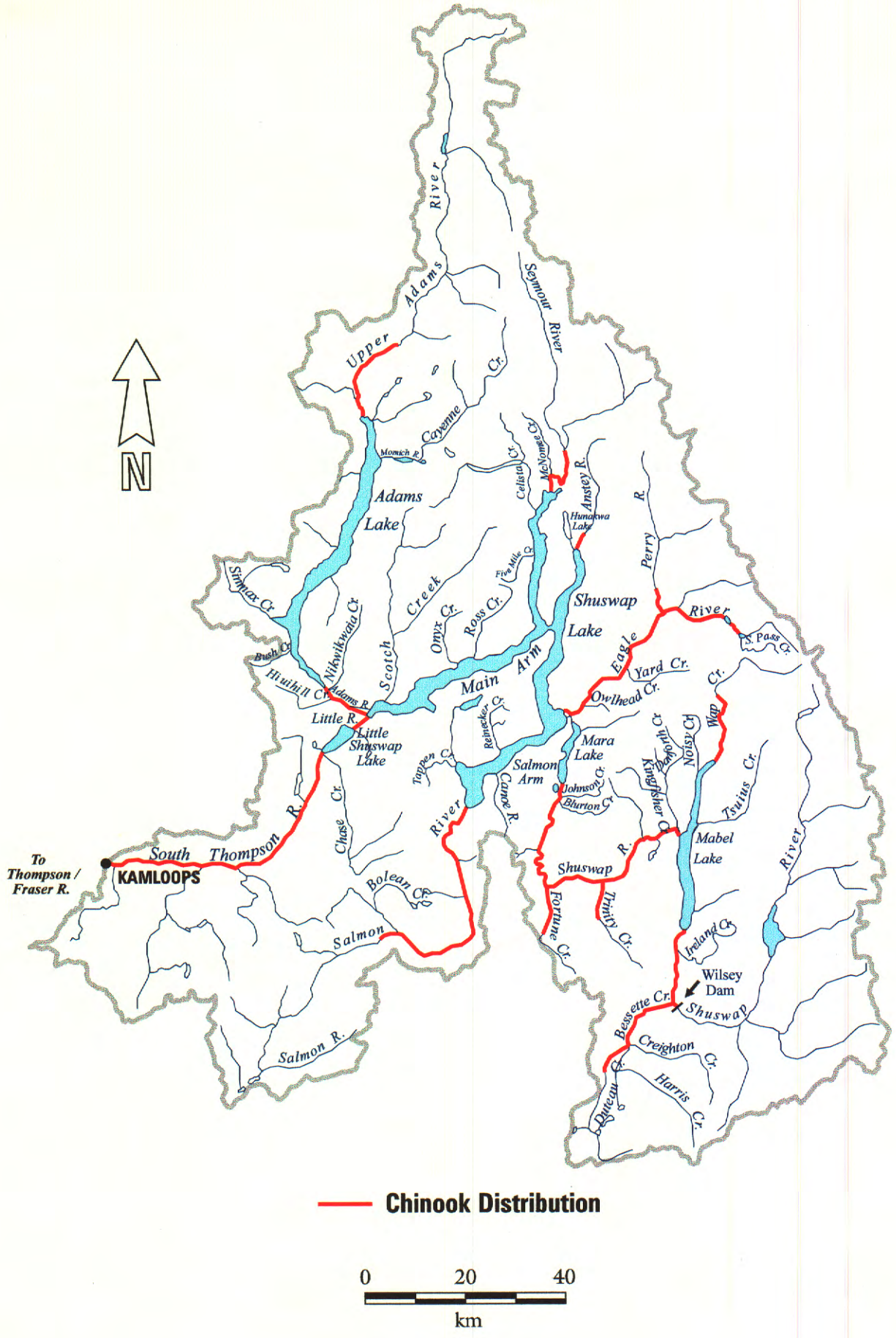


Figure 2.4. Chinook spawning streams in the South Thompson-Shuswap HMA.

Shuswap they spawn downstream of Wilsey Dam (Shuswap Falls) to Mabel Lake. In 1993, 1994 and 1995, chinook were transported above Wilsey Dam and spawned there naturally. 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. while in the Salmon River spawning is scattered between Silver Creek and Falkland. Smaller populations spawn in the Seymour and Anstey rivers below the falls at 6 km and 5 km 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 lakes 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 (Stewart et al. 1989). It is assumed that this high productivity drives the ocean-type life history by enabling the underyearlings to attain a sufficient size to allow salt water adaptation. In contrast, the early growth potential of juveniles in the less productive streams (e.g., 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 (Bowman and Stewart 1984). 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 (Stewart et al. 1989), while rearing densities in Little Shuswap Lake peaked in mid- to late June, then declined in early August.

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

Graham and Russell (1979) studied the littoral (near shore) distribution of juvenile chinook in Shuswap Lake (near the mouth of Adams River) and in Little Shuswap Lake. Those authors observed juveniles from mid-April to mid-July along most of the shoreline, and particularly along the lakes' southern shores. After mid-July, no juveniles were found in the study area. The late July period coincided with rising water temperatures (> 16°C) and falling water levels, possibly leading to stress, reduced growth, and reduced food supplies.

Russell et al. (1980) studied the distribution of juvenile chinook in Shuswap Lake, and suggested that they reared and migrated in the littoral lake zones from late April to mid-July. Those authors identified several important rearing areas: near Mara Lake-Sicamous Narrows, eastern portions of Salmon Arm, southerly portions of Anstey Arm, northern tip of Seymour Arm, and the Main Arm

of Shuswap Lake from Cinnemousun Narrows to lower end of the lake (see Fig. 2.2b for site locations).

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 (Table 2.4) 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 southern route (Juan de Fuca Strait), are harvested primarily in the North and Southwest Vancouver Island and the Strait of Georgia fisheries (Table 2.4). By comparison, the ocean type chinook which tend to return later (when the northern fisheries are open) and mainly via the northern migration route (Johnstone Strait), are harvested primarily in the Alaska and northern B.C. 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 (Galesloot, pers. comm.). 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 indications are that the effort has increased.

The entire 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 (Schubert and Whyte 1992, Schubert 1988, 1989). During 1986 to 1993, the Shuswap sport fishery has averaged 460 chinook annually, with the Shuswap hatchery fish contributing to the catch.

Chinook escapements to individual streams in the HMA are shown in Appendix A-4. The largest producers are the ocean type populations. The Lower Shuswap River has averaged approximately 11,000 spawners annually or 43% of the area's total mean escapement (1991-1995 data). Other significant producers are the South Thompson mainstem, Middle Shuswap, Lower Adams, Eagle and Salmon rivers. Historical chinook escapements to the HMA are shown in Figure 2.5. The total escapements have increased significantly since the early 1980, from a low of approximately 8,000 in 1982 to a high of 34,000 in 1992. This rebuilding trend is attributed mainly 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 the DFO (e,g., closure in 1980 of the Fraser River terminal gillnet fishery targeting on chinook). The enhanced production has made only a minor contribution to the overall escapement (DFO 1995b).

Under the Canada-U.S. Pacific Salmon Treaty of 1985, Canada and the U.S. 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). Table 2.5 compares the mean annual escapements since 1971 for the major chinook stocks in the HMA with the interim escapement targets. The Adams and Shuswap (Middle and Lower) stocks have

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Table 2.4. Commercial and sport catch distribution of ocean type and stream type chinook from the South Thompson-Shuswap HMA (no native fishery data).

FISHERY +	% CATCH of OCEAN TYPE CHINOOK *	% CATCH of STREAM TYPE CHINOOK **
ALASKA	**19**	3
NTR	**52**	11
N & CN	2	-
N & NCTR	-	-
N & CSPT	2	2
N & SCTR	3	4
N & SWTR	5	-
NWTR	-	**12**
SWTR	-	**27**
JSN	5	4
JFN	2	5
JFSPT	-	2
JF & GSPT	2	-
GSPT	-	**19**
GSTR	-	4
FGN	8	7
TOTAL	100%	100%

+ Abbreviations used:
N - North, CN - Central Net, NCTR - North Central Troll, CSPT - Central Sport, SCTR - South Central Troll, SWTR - Southwest Troll, NWTR - Northwest Troll, JSN - Johnstonr Strait Net, JFN - Juan de Fuca Net, GSPT - Georgia Strait Sport, FGN - Fraser Gillnet.

* Based on CWT recoveries for Shuswap River chinook (1989-1993 data).

** Based on CWT recoveries for Eagle River chinook (1988-1994 data).

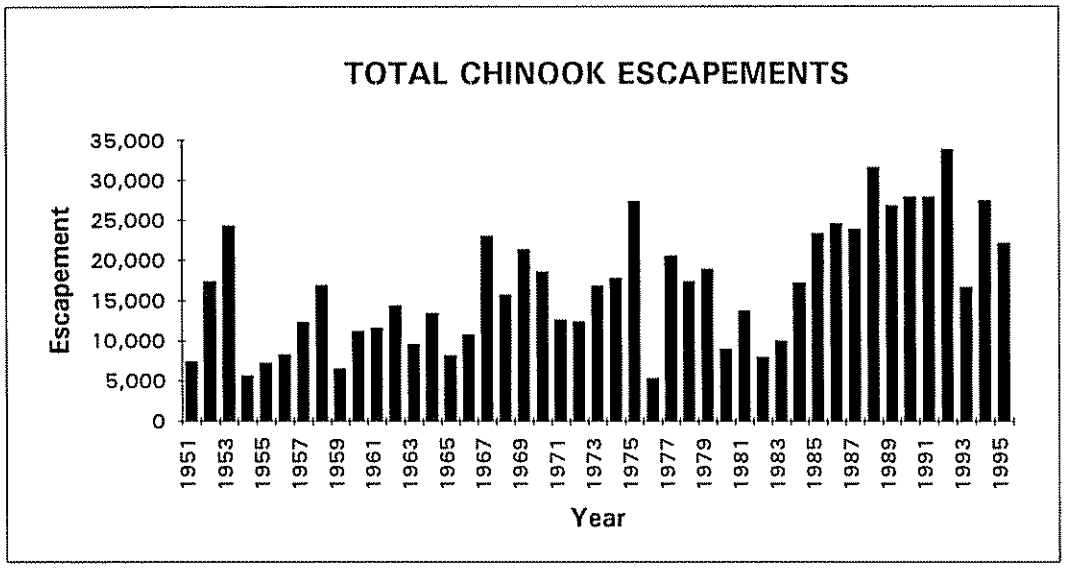


Figure 2.5. Chinook escapements to the South Thompson-Shuswap HMA, 1951-1995.

Table 2.5. Comparison of average chinook escapements to interim escapement goals by stream, South Thompson-Shuswap HMA.

STREAM	AVERAGE ESCAPEMENTS 1971-80	1981-90	1991-95	CANADA - U.S. AGREEMENT (1985) INTERIM ESCAPEMENT GOALS
S. Thompson R.	4,460	6,850	6,460	9,250 a
Adams R.	1,320	1,210	1,760	1,275 a
Lower Shuswap R.	8,490	9,252	11,090	15,784 (~11,000) b
Middle Shuswap R.	495	1,270	3,900	1,400 c
Eagle R.	401	779	991	1,550 d
Salmon R.	266	930	853	1,700 d
Little R.	313	300	375	800 a

a. Double the 1979-82 mean escapement.
b. Double the1984 mark-recapture estimate was ~16,000 fish (double the visual equivalent was ~11,000 fish - this was considered a more realistic estimate, B. Rosenberger, pers. comm.)
c. Double the 1984 visual estimate.
d. Double the 1984 fence count.

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 (Append. A-4).

2.2.4 Habitat Productive Capacity

The total productive capacity of chinook habitat in the HMA is unknown, and the two life-history types of chinook (stream type and ocean type) complicate the estimation. To determine the productive potential, an extensive habitat assessment of the lakes and streams in the area is required. Whelen and Olmsted (1982) have estimated the potential spawning areas for the South Thompson, Adams, Eagle and Salmon rivers. At present, there is no indication that chinook spawning abundance is at capacity. As well, the high productivity of the Shuswap, Mara and Mabel lakes, and their heavy utilization by juvenile chinook suggest that the rearing habitat is abundant.

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 (Russell et al. 1980). Therefore, rebuilding of one species may limit the potential of the other. This possibility needs to be addressed when developing rebuilding strategies.

2.2.5 Production Objectives

Natural production

A major objective of the DFO has been to rebuild chinook runs by increasing escapements through reduced harvest rates in all fisheries. While a rebuilding trend is observed for some chinook stocks in the HMA, the development of sound rebuilding goals will require a reliable estimate of the total productive capacity of the HMA, a greatly improved escapement database, and a better understanding of chinook population dynamics during the freshwater rearing period.

Enhanced production

Significant enhancement efforts have been initiated in the HMA through the Eagle and Shuswap River hatcheries. The Eagle River Hatchery, located at Taft, B.C., had the capacity to produce approximately 5,400 adults to catch and escapement (Cross et al. 1991). This facility was operated from 1984 to 1993 to enhance the Eagle and Salmon River chinook, but was subsequently closed due to financial constraints and poor chinook survival rates (generally <0.6%).

The Shuswap River Hatchery served to enhance the 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 the production divided approximately evenly between the Middle and Lower Shuswap stocks. Although survival rates averaged around 1%, only the Middle Shuswap stock has shown significant hatchery returns. At present, there are no plans to alter the current enhancement strategy.

Chinook transplants were conducted in the HMA between the late 1980s and early 1990s. Eggs from the Lower Shuswap stock were incubated at interior facilities, and the resulting fry released in the Upper Adams River. These transplants appear to have resulted in an annual return of approximately 200 spawners to the Upper Adams (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. 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 the Duteau Creek (Sheng, pers. comm.). 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 demonstration watershed to restore riparian cover, stabilize banks, enhance stream habitat, and promote farming and ranching practices that maintain stream habitat.

2.3 COHO SALMON

Over 30 streams in the HMA have known populations of spawning and rearing coho salmon (Williams et al. 1994, DFO 1990). Many of the streams are not well monitored, and only about half have consistent escapement estimates. 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), and Bessette, Duteau, Harris and Wap creeks (Append. A-5).

2.3.1 Life History

The Thompson coho stocks return to the lower Fraser from late August through October (based on catch per unit effort in the native coho fisheries in upper Fraser and the Cottonwood test fishery, N. Schubert, pers comm). Adults reach their natal streams from mid-October and spawn until mid-December (DFO 1990). Coho return to spawn predominantly at age three (Fraser et al. 1982). Fry emerge from late March though late May and early June (Whelen et al. 1982) and the juveniles remain in freshwater at least a year. They rear initially in natal streams, then move downstream to rear and overwinter in 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 (Stewart et al. 1989, Bowman and Stewart 1984, Whelen et al. 1982). Yearling coho that had overwintered in streams or in Shuswap Lake were most abundant in that Lake in late May and early June (Stewart et al. 1989, Russell et al. 1980, Graham and Russell 1979). A directed seaward migration of marked yearlings out of Shuswap Lake was observed in June and early July (Russell et al. 1980), while the peak catch of yearlings in the Thompson River at Spences Bridge was noted in late May and early June (Stewart et al. 1989).

2.3.2 Spawning and Rearing Habitat

Spawning distribution of coho in the HMA is shown in Figure 2.6. Coho are widely distributed in the accessible streams, with spawning occurring in the slower flowing side channels of larger streams (e.g., Lower Adams and Middle Shuswap), in the Upper Adams River up to Tum Tum Lake, and in many small streams tributary to the Shuswap Lake and the Lower and Middle Shuswap rivers. The South Thompson mainstem and the Little River are used primarily as migration corridors.

Juvenile coho may rear in natal streams and in downstream rivers and lakes (primarily the Shuswap Lake). Bowman and Stewart (1984) have estimated that 65% of the underyearling coho originating from the 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 the Lower Shuswap and Mara and Shuswap lakes.

Fee and Jong (1984) also found little suitable rearing habitat for juvenile coho in the Middle Shuswap mainstem. During the summer, these juveniles moved 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 (Fee and Jong 1984).

Sebastian (1983) assessed several tributaries (including the Perry and Seymour rivers, and Crazy, South Pass, Tappen and Trinity creeks) for coho outplanting opportunities to rebuild the stocks. All these streams have obstructions to upstream migration, with only low numbers of coho spawning in the lower reaches (DFO 1990). Many of these streams appear to lack low velocity areas, pools, and suitable cover required for coho rearing. Sebastian (1983) suggested that overwintering habitat is limited in these tributaries and that juveniles move into larger mainstems or the Shuswap Lake to continue rearing.

A significant dispersal of underyearling coho occurs into Shuswap Lake from the adjacent major watersheds during late April and May. The main lake rearing areas are adjacent to spawning streams and along lake migration routes (Russell et al. 1980). Initially juveniles rear in the littoral (foreshore) areas of Shuswap Lake where planktonic and benthic prey organisms are abundant. After about mid-July, the juveniles move offshore, probably to avoid high water temperatures (>16°C) and take advantage of the abundant food supply in deeper waters (Graham and Russell 1979). Rearing remains pelagic until the following spring when the seaward migration is initiated in May.

Underyearling coho from Salmon River utilize the Salmon Arm basin only during late April and early May (Russell et al. 1980). 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.

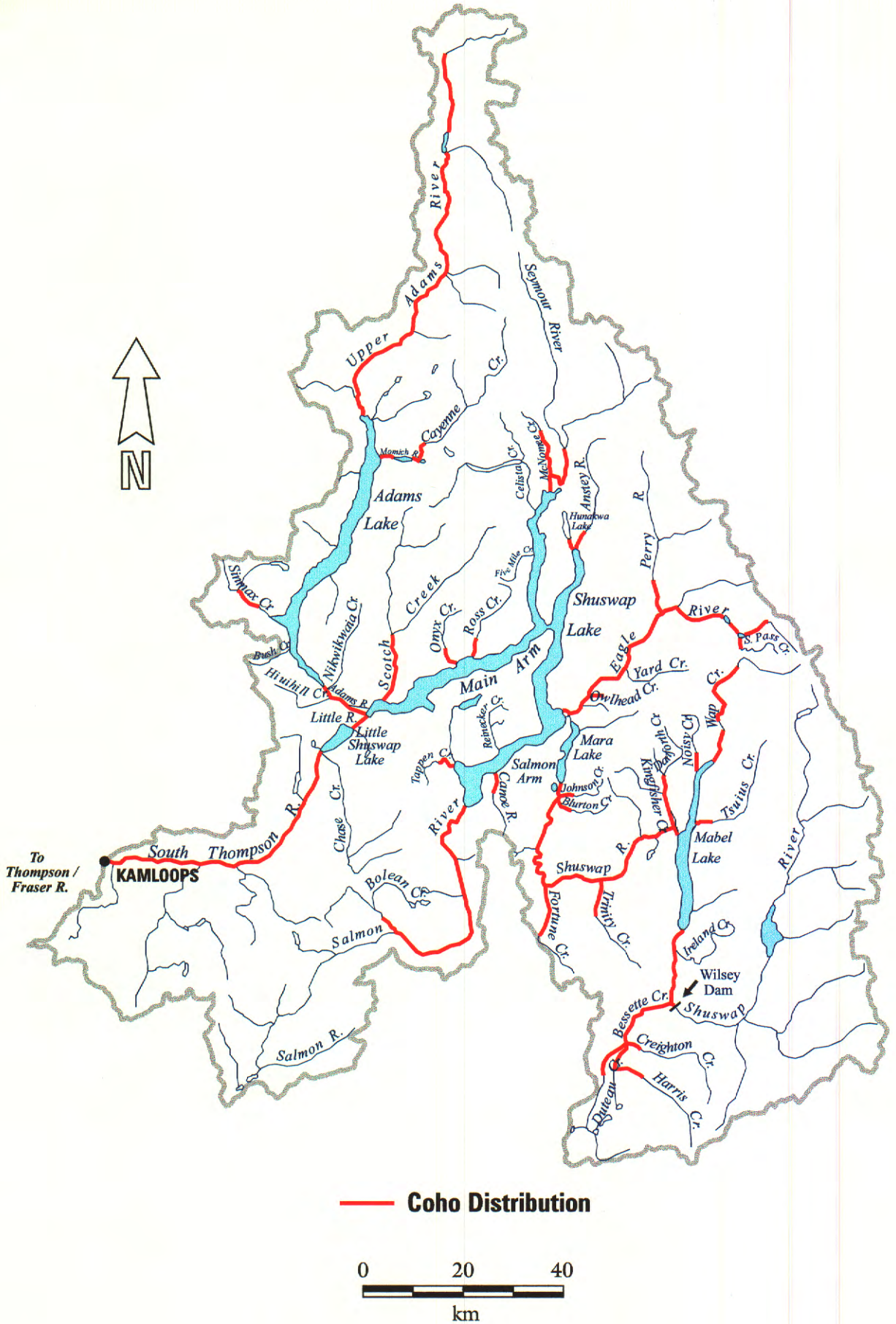


Figure 2.6. Coho spawning streams in the South Thompson-Shuswap HMA.

The highest numbers of coho juveniles were captured in Mara Lake and Sicamous Narrows; these coho were likely the outmigrants from the Shuswap River watershed. Several other Shuswap Lake areas associated with major tributary streams were also utilized heavily by rearing coho (southern portions of Salmon and Anstey arms, northern tip of Seymour Arm and Shuswap Lake outlet).

Overwintering coho have been noted only in the larger streams including the Adams, Seymour, Eagle, Salmon and Shuswap rivers. These juveniles may be the more aggressive, larger fish that take up residency near the spawning grounds (Sandercock 1991, Fraser et al. 1982) and defend their territories until the smolt migration is initiated the following spring.

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

The major harvesters of the South Thompson-Shuswap coho stocks are the Northwest and Southwest Vancouver Island troll fisheries and the Strait of Georgia sport fisheries (based on CWT recoveries of Eagle and Salmon River coho in the commercial and sport catches, Table 2.6). These data suggest that saltwater rearing of these stocks occurs primarily in the southern B.C. waters, with little migration north of Vancouver Island. Coho catches in the Strait of Georgia have been declining for over a decade.

Currently, the native catches of coho in the HMA are minimal; however, the catch data are incomplete. The in-river sport catches in the HMA have declined to very low levels in recent years, although up to 200 coho were taken annually prior to the stock decline. The sport fishing effort on coho in this area is generally low possibly due to the late return timing of this species and inclement weather conditions. In the late 1980s, a sport fishery was promoted on the Eagle River, but the fish were not susceptible to the gear (N. Schubert, pers comm.) and the effort quickly declined. The Thompson sport fishery was terminated in 1995 due to the continued decline in coho returns. However, these fish likely continue to be intercepted in the lower Fraser River sport fishery (Macdonald 1991).

Coho escapements to individual streams in the HMA are shown in Appendix A-5. The average escapements for consistently monitored streams are shown in Table 2.7 and trends in escapements in Figure 2.7. Total escapements have increased from a low of approximately 5,000 fish during the 1970s to a high of over 15,000 in late 1980s, but have declined dramatically since 1989.

Table 2.6. Commercial and sport catch distribution of coho from the South Thompson-Shuswap HMA (no native fishery data). *

FISHERY +	% of TOTAL CATCH
NTR	1
CSPT	1
SCTR	4
JSN	3
NWTR	**18**
SWTR	**39**
GSPTN	**21**
GSPTS	**6**
GSTR	5
FGN	2
TOTAL	100%

+ For abbreviations see Table 2.4 footnote.

* Based on CWT recoveries for Eagle and Salmon River coho (1988-1994 data).

Table 2.7. Average annual escapements for consistently reported coho stocks in the South Thompson-Shuswap HMA, 1971-1995. *

STREAM	AVERAGE COHO ESCAPEMENTS 1971-1980	1981-1990	1991-1995	RANGE (1981-1995) Minimum	Maximum
Adams R. (lower)	185	240	103	20	500
Adams R. (upper)	180	522	100	100	1100
Anstey R.	30	42	55	20	80
Bessette Cr.	471	41	117	10	150
Creighton Cr.	27	70	59	12	150
Duteau Cr.	377	550	237	12	750
Harris R.	128	136	80	20	300
Eagle R.	1,819	4,976	1,730	800	11,015
Salmon R.	1,409	2,263	867	308	4,943
Lower Shuswap R.	192	305	119	20	500
Middle Shuswap R.	410	535	294	20	1,200
Wap Cr.	216	216	151	50	450
TOTAL	5,444	9,896	3,912	-	-

* Data from Append. A-5.

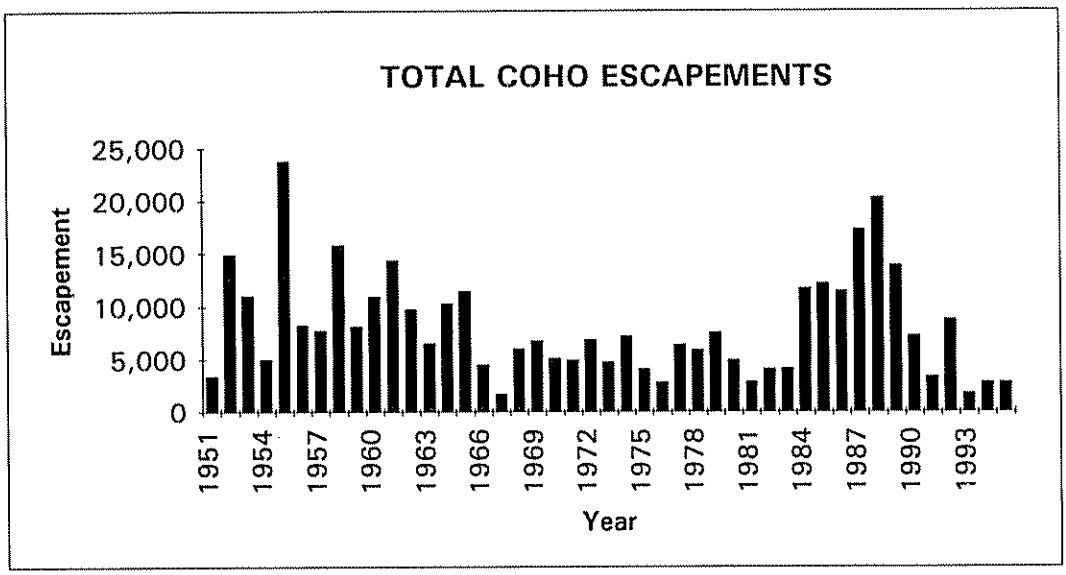


Figure 2.7. Coho escapements to the South Thompson-Shuswap HMA, 1951 - 1995.

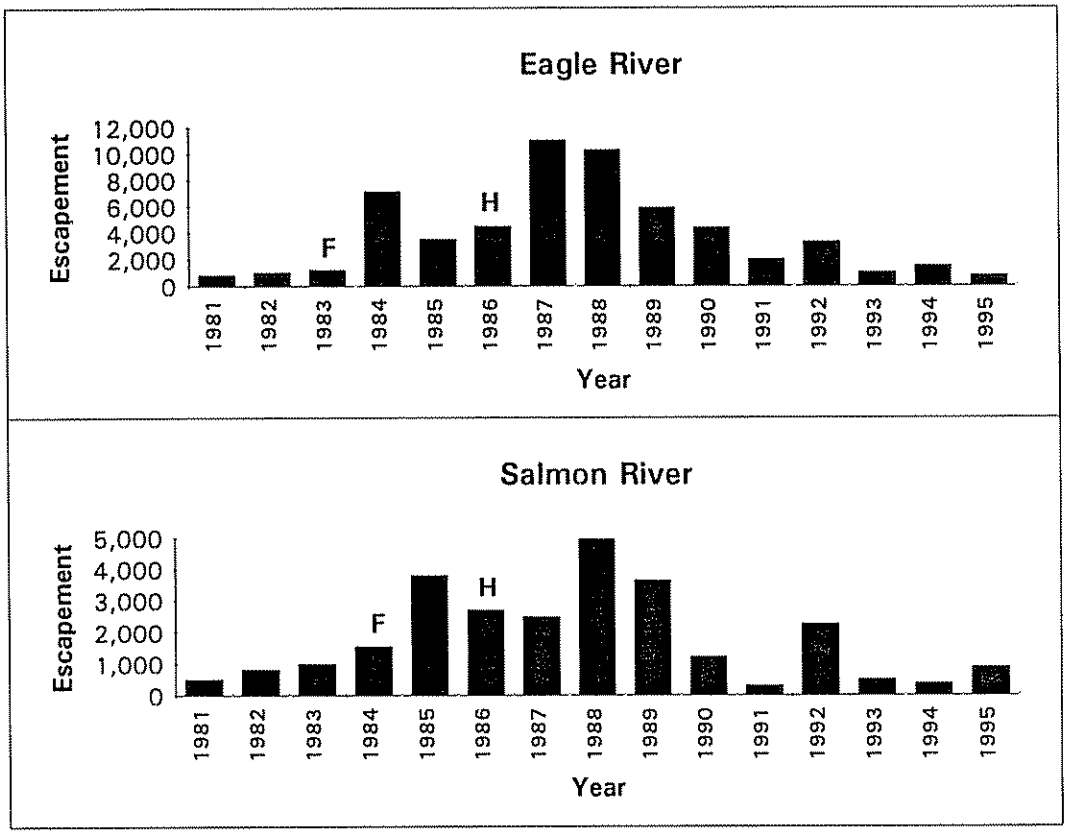


Figure 2.8. Coho escapements (wild and enhanced) to the Eagle and Salmon rivers, 1981-1995. (F indicates start of fence enumeration program; H indicates start of hatchery returns).

Escapement trends for coho must be interpreted with caution since the data are unreliable due to the protracted spawning period of coho; difficult enumeration conditions (poor weather, stream access and visibility); and lack of consistent enumeration methods. However, coho escapements to the Eagle and Salmon rivers and other streams in the Thompson system where fence counts are routinely conducted, have shown major declines since 1989 (Fig. 2.8). This recent major decline in the Thompson coho escapements parallels the overall declining trend observed for coho salmon in the Fraser Basin and the Strait of Georgia streams (DFO 1992a). This declining trend is attributed to poor marine survival and excessive exploitation rates, combined with human impacts on the freshwater environment.

2.3.4 Habitat Productive Capacity

The overall habitat productive capacity for coho in the HMA in not known. However, the available production models may assist in determining the potential level of coho production. These models use the relationship between the length of stream and the number of smolts produced per km, with the assumption that the limiting stage in the coho life history is the summer rearing habitat. Applying such a model shows that coho production could be increased two to six fold; this is based on a range of 20-60 females / km (Bradford 1995) and the accessible stream length of 600 km in the HMA.

In another analysis, the rearing potential of streams in the HMA was graded as poor, good or excellent, and smolt biostandards applied to each category (Salmonid Enhancement Program, unpubl.) The results indicated a potential coho escapement of more than double the average escapement of approximately 10,000 coho observed in the last decade (1981-1990, Append. A-5). These "production models", however, are 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 the extent of natal stream and lake rearing for each stock. 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 the Shuswap Lake. Holtby (pers. comm.) found "lake-type" coho in the Cowichan Lake drainage on Vancouver Island, that were distinct from coho inhabiting streams tributary to the lakes; the lake fish differed morphologically and genetically from the creek fish, and contributed significantly to the total smolt production in the system (Holtby, pers. comm.). It is not known whether the Shuswap Lake also supports "lake-type" coho. However, the extensive shoreline (~400 km) of this lake system undoubtedly provides major coho rearing opportunities and contributes significantly to the overall coho rearing potential in the HMA.

The models assume that spawning and rearing habitat has not been degraded. While overfishing has contributed to low spawner abundance, habitat degradation (through water removal, low instream flows and high water temperatures, poor water quality, loss of riparian vegetation, bank erosion and loss of offchannel habitat) undoubtedly reduces the capacity of many streams to produce coho.

2.3.5 Production Objectives

Natural production

There are no defined escapement goals for Fraser coho salmon. These stocks are managed passively as part of the Strait of Georgia stock complex, based on several indicator streams. The Eagle and Salmon River stocks are used as exploitation rate indicators. The uncertainty in the marine catch of coho by stock, and the poor reliability of escapement data, prevent the estimation of coho exploitation rates. These are necessary for the development of sound harvest management strategies aimed at placing more adults on the spawning grounds.

The major decline in coho escapements requires immediate action. Exploitation rates are to be reduced dramatically in 1997 in order to address this serious conservation concern. However, even with the implementation of such measures, there is a concern that the Thompson coho could still be at risk. The productive capacity of many systems has been impaired as a result of land and water use activities, in addition to the impacts of high exploitation rates and low marine survivals. Ultimately, the carrying capacity and productivity of the freshwater environment will determine the success of stock rebuilding efforts

Hatchery production

The Eagle River Hatchery commenced operation in 1983 to enhance coho stocks in the Eagle and Salmon rivers. This hatchery had the capacity to produce about 17,000 adults to catch and escapement (Cross et al. 1991) but was closed in 1994 due to financial constraints; however, the Salmon River coho continue to be enhanced at the Spius Creek Hatchery. Coho in the Shuswap area are produced only at the Kingfisher Creek Hatchery where the potential production is estimated at approximately 800 adults. No further hatchery projects are being considered for this HMA at the present.

2.3.6 Enhancement Opportunities

At present, the main enhancement opportunities in the HMA are habitat rehabilitation and restoration. The efforts planned or in place (e.g., groundwater channel development on the Lower Adams) are designed to benefit primarily coho and rainbow trout stocks. Much restoration work is being undertaken in the Salmon River watershed (e.g., bank stabilization, riparian revegetation and creation of artificial riffles).

The impacts from water withdrawal, loss of riparian vegetation and silting of river channels, pools and offchannel sites must be better assessed to provide a basis for directed habitat enhancement efforts. These efforts are constrained by lack of information on the stock-specific productive capacity and life history of coho, and the absence of accurate escapement estimates. Only by combining sound harvest management strategies with aggressive habitat management and restoration can we preserve and restore the coho stocks.

2.4 PINK SALMON

Historically, the upper Fraser pink stocks constituted the largest pink salmon populations in the Fraser watershed (Ricker 1989). This species has been recorded in many tributaries to the Shuswap Lake (e.g., Salmon River and Tappen, Scotch and Canoe creeks) and in the South Thompson, Adams and Little rivers (B. Rosenberger, pers. comm.). The Hell's Gate landslide of 1913 completely blocked pink spawner access to streams above the Fraser Canyon. Subsequent remedial work and construction of fishways, 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.

Heard (1991) provides an overall summary of pink salmon life history. Generally, 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 (Healey 1980), 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 (DFO 1990).

Pink salmon populations in the HMA are briefly described below (see also DFO 1990). Pink spawning streams are shown in Figure 2.9 and the available escapement data in Appendix A-6. 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 is 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 of 1,560 spawners were reported in 1981; spawning is concentrated about 2 km below the Little Shuswap Lake. In the 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 native 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.

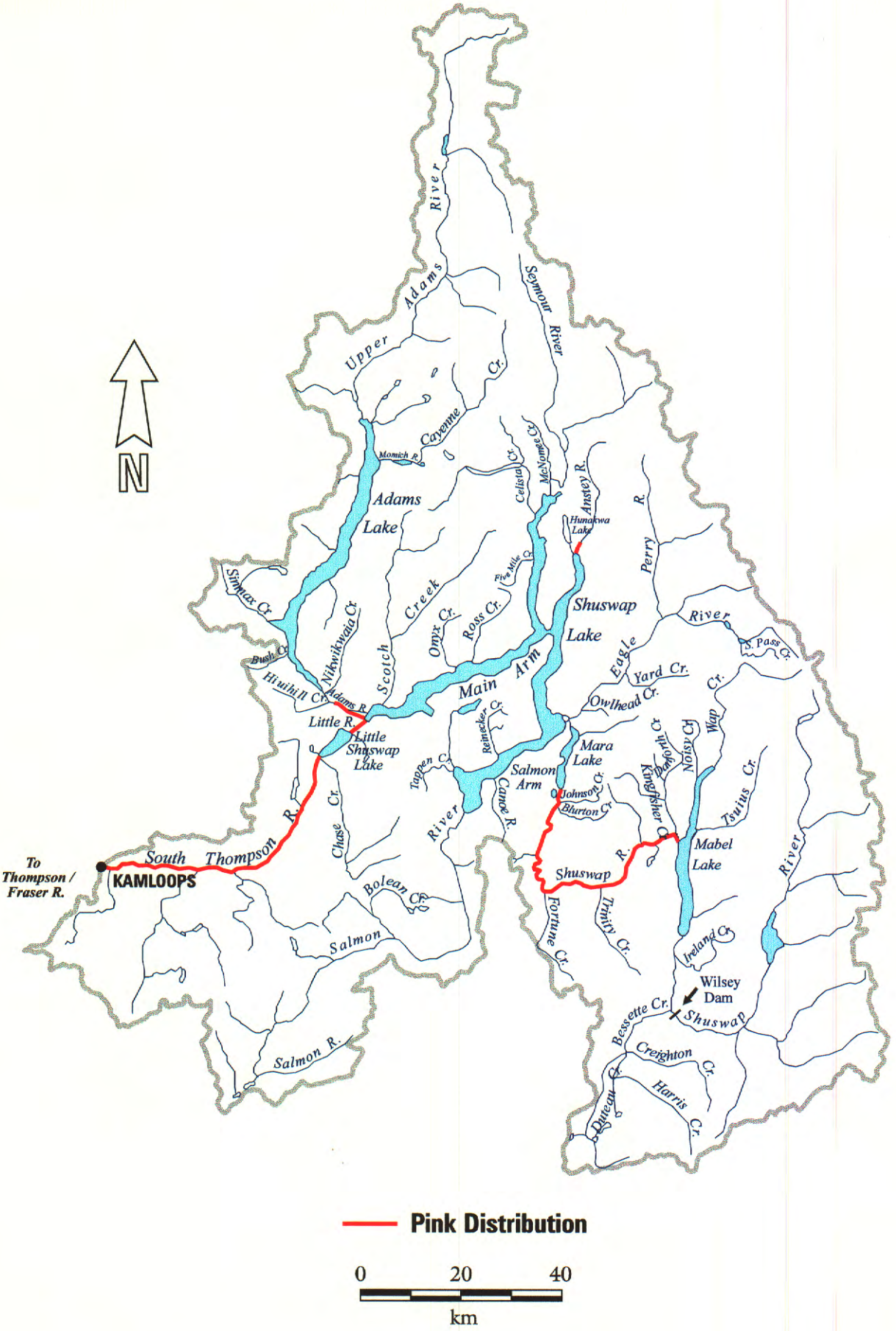


Figure 2.9. Pink spawning streams in the South Thompson-Shuswap HMA.

3. BIOPHYSICAL FEATURES

The productive capabilities of lakes and streams within the HMA are governed directly by the physiography, climate and hydrology of the area. The HMA falls into four physiographic land units within the Interior Plateau of the Canadian Cordillera (Holland 1976). These land units are the Thompson Plateau, Shuswap Highlands, Monashee Mountains and Okanagan Highlands (Fig. 3.1).

The biogeoclimatic ecological classification is based on vegetation, climate and physical site characteristics (e.g., slope). Seven biogeoclimatic zones are identified within the HMA: Alpine Tundra, Engelmann Spruce - Subalpine Fir, Montane Spruce, Interior Cedar-Hemlock, Interior Douglas Fir, Ponderosa Pine and Bunchgrass (Fig. 3.2). General zonal characteristics are described by Harding et al. (1994).

Much of the valley bottom, particularly along the South Thompson drainage, lies within the Bunchgrass biogeoclimatic zone. This open grassland habitat has been generally the first to be colonized and cultivated. However, due to the dry climate, irrigation was needed to maintain good growth of crops. The grasses were ideal for grazing and this led to the establishment of the cattle industry in the HMA.

Settlements have been established along the waterways. Timber for building was accessed along shallow benches at slightly higher elevations or along river valleys of the HMA, often in the Interior Douglas Fir biogeoclimatic zone.

3.1 PHYSIOGRAPHIC DESCRIPTIONS

Thompson Plateau

The Thompson Plateau and the margins of the Shuswap Highlands and Okanagan Highlands all have similar features. The land has generally low relief, flat or rolling terrain which has resulted in the creation of numerous lakes and streams. Streams generally have low gradient channels and small (22,140 ha) to moderate drainage areas, with the largest being the lower South Thompson drainage - below Little Shuswap Lake (196,120 ha). Climate is characterized by low precipitation (400 mm) and low snow pack (80-120 cm), the latter resulting in a shortened spring run-off. Streams in this region warm up earlier, may reach fairly warm summer temperatures, and freeze late in the fall. Low flows can be a problem due to low rainfall and warm temperatures. During the summer, water temperatures can exceed 18°C, which approaches the upper tolerance limit for stream dwelling salmonids.

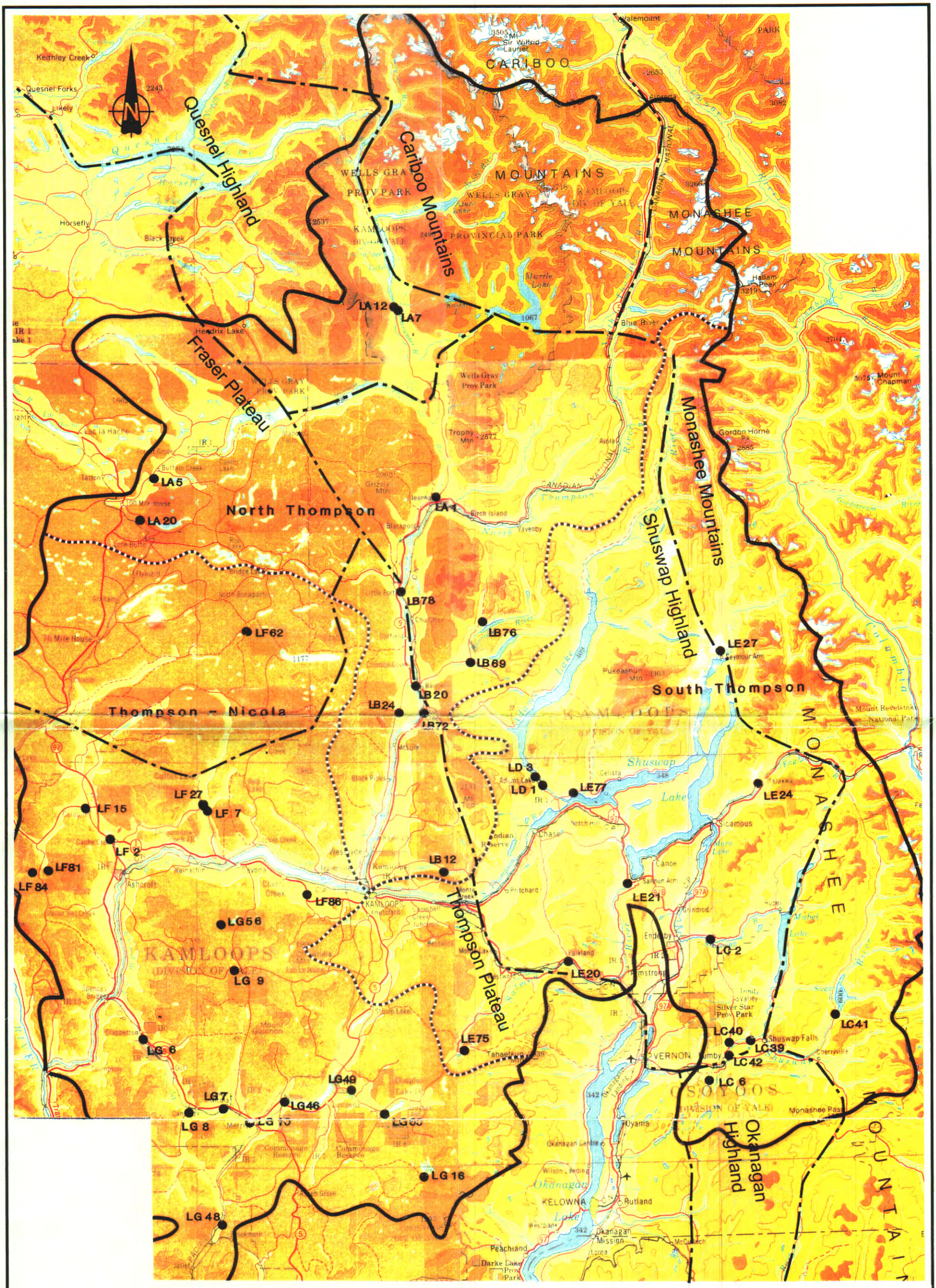


Figure 3.1 Physiographic land units (after Holland 1976) in the Thompson River Basin.

Source: Rood & Hamilton, 1995.

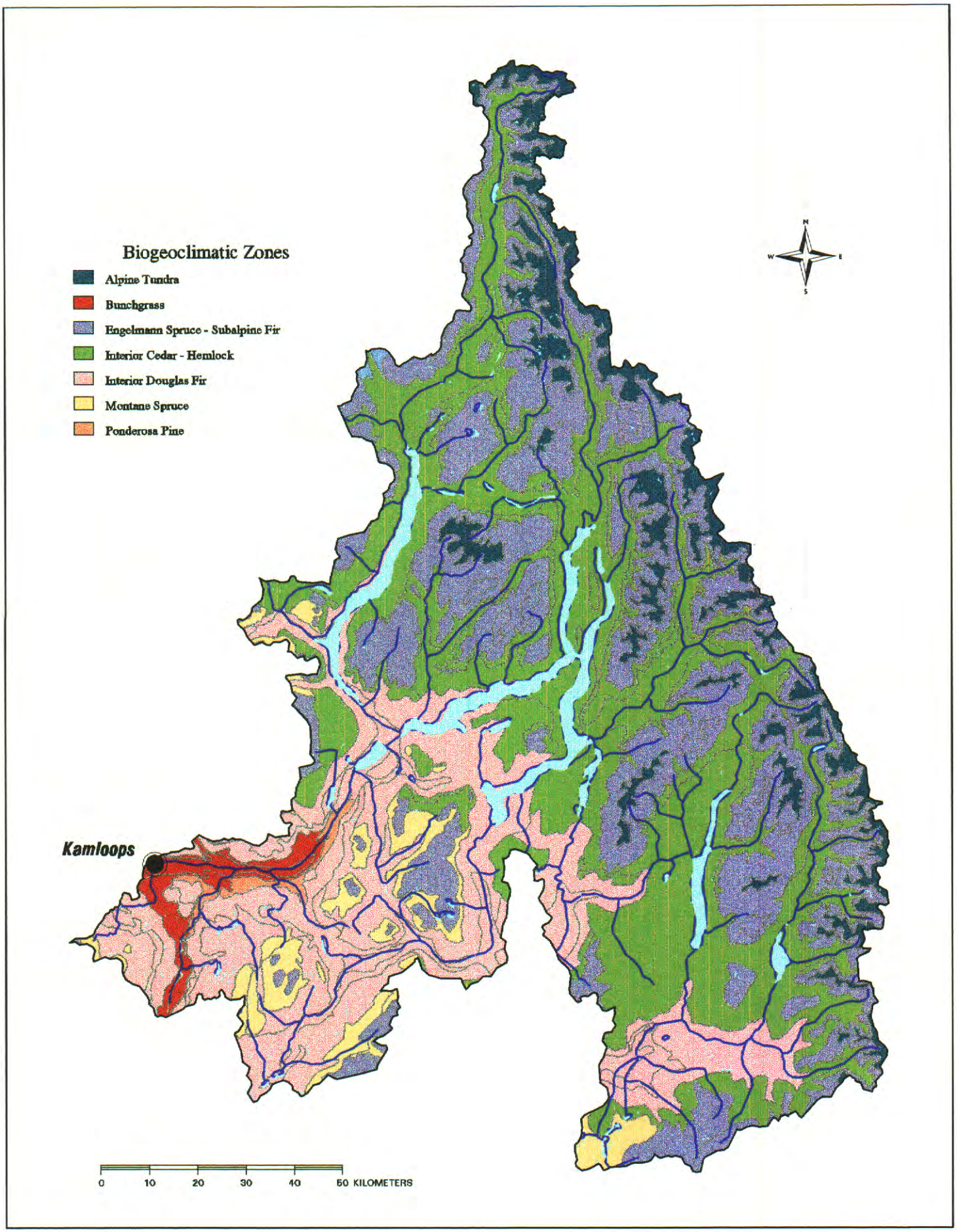


Figure 3.2 Generalized biogeoclimatic zones of the South Thompson - Shuswap HMA.

Shuswap Highlands

The majority of the HMA falls into the Shuswap Highlands physiographic unit. There is a gradual increase from the flat or rolling terrain of the Fraser and Thompson plateaus to the steep, jagged peaks of the Cariboo and Monashee mountains. This has resulted in typically large river valleys and the development of larger drainage basins, like the Upper Adams (308,660 ha) and the Middle Shuswap (402,900 ha). Shuswap Lake is the largest lake in this region. Headwater streams tend to be steep, confined and bouldery channels. Climate in the southern half is characterized by relatively low precipitation (500 mm) and low snow pack (120 cm); however, sharp increases are noted depending on the proximity to the Cariboo or Monashee Mountains. In comparison to the Thompson Plateau streams, the streams in the northern portion of the Shuswap Highlands experience cooler temperatures and hence warm up later, freeze up earlier and are less productive. The potential for rain-on-snow events in this unit may result in larger peak storm events.

Monashee Mountains

The Monashee Mountains are characterized by steep, jagged peaks and ranges. The streams in the Monashee Mountains flow into several major salmon producing systems (e.g., Seymour, Eagle and Shuswap rivers). The headwaters of the tributaries of these creeks are generally small and narrow, and contain few lakes. Only the lower reaches are used by fish. The highest levels of precipitation (800 mm) and snowfall (400 cm) are found in these ranges, and the streams have an extended late spring-summer run-off. Due to glacial melt, higher stream turbidity is often observed over the entire summer period. However, this is mitigated in downstream areas by the influence of larger lakes. Water temperatures are the coldest in the HMA, and these streams are likely the first to freeze over.

3.2 REGIONAL HYDROLOGIC REGIME

Streams in the South Thompson generally display hydrologic regimes typical of the interior B.C. systems, in that they are characterized by a snowmelt hydrograph. The annual peak event usually occurs in June, with the actual timing (ranging from May to July) and the volumes of peak discharge controlled by snowpack volume and weather conditions during the melt period (Watt 1989). The HMA displays a hydrologic regime with a wide range of regional variability (Sigma Engineering Ltd. 1991) that reflects the biogeoclimatic zonation; the trend is for increasing precipitation in the north-east and drier conditions in the south and west areas.

The headwaters of the eastern basins (e.g., Adams, Seymour, Eagle), have numerous, small glaciers present. These contribute a late-summer glacial melt component and reduce the incidence of late-summer low flows common in the other basins of the HMA. Fortune Creek is probably the most representative of the drier south-western portions of the basin where agriculture is predominant and creeks are subjected to higher water withdrawals. This HMA contains several of the largest lakes in the southern interior of B.C. (Shuswap, Adams, Mabel and Sugar lakes) that have a significant influence on the hydrology of their outlet streams. The mainstem South Thompson and Adams rivers demonstrate this influence with increased late summer and winter flows, and a dampening of the snowmelt peak flows.

Most rivers in the HMA, except those reaches below major lake outlets, develop a winter ice cover, ranging from two to four months in duration. Smaller headwater streams freeze over the earliest (November), while the mainstem South Thompson River at Kamloops freezes over in

December (Allen 1977). Break-up ranges from late February to mid-April for the South Thompson River at Kamloops, with the mean draw of March 18 (based on 25 years of data, Allen 1977).

3.2.1 Hydrologic Analysis

A detailed analysis of flow characteristics of the salmon bearing streams in the HMA was prepared by Rood and Hamilton (1995). Appendix B summarizes the hydrology of these streams showing mean annual flow, mean summer monthly flows and mean 7-day low flows (summer and winter), as well as total water licenses and licensed demand. Sensitivity indices were developed to indicate high water demand, low summer/winter flows, and peak flows (Append. C). This appendix highlights the streams with indices in the top 25% of extreme values.

Most of the streams with low flows have small drainage basins and a licensed water demand, while others are unaffected by diversion or storage. Typically, smaller streams are more affected by drought; on the Thompson Plateau and Quesnel Highlands, drainage basins up to 100 km^2 in area and even greater, may have zero discharge during moderate droughts (Rood and Hamilton 1995).

Peak flow indices that compare the mean annual flood to mean annual flow (expressed as a ratio), were also calculated (Append. C). Higher index values may indicate streams with the potential for relatively high flows and possibly lower stream channel stability. Streams with relatively high values include Chase and Reienecker creeks. However, high index values may not necessarily indicate unstable streams, because stability is also affected by other parameters (e.g., channel configuration, bed and bank materials, channel gradient) not included in the analysis.

4. RESOURCE USES

Fish and fish habitat are affected by environmental events that alter hydrologic 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 population. Past actions are no longer acceptable and must be modified to minimize watershed impacts and sustain the fisheries resource in lakes and streams.

The following sections describe land and water uses within the HMA and identify areas where development activities are affecting (or have the potential to affect) fish and fish habitat. Problem areas are identified and information on future trends is provided.

4.1 FORESTRY

The South Thompson-Shuswap HMA lies within the Kamloops Forest Region (Fig. 4.1) and is encompassed by four forest districts (Kamloops, Clearwater, Salmon Arm, and Vernon. The forest land within the Kamloops Forest Region is managed through two Timber Supply Areas -- Kamloops and Okanagan.

Logging is the major resource use in the HMA, with past and/or recent logging activities observed in all the watersheds. Many of these contain in their lower reaches valuable salmon spawning and rearing habitats which are susceptible to stream channel changes and sedimentation from upstream logging activities. Toews et al. (1992) suggested that watersheds with over 20% of their area logged, were 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 (Scrivener and Brown 1993). Reeves et al. (1993) found that the diversity of stream fish communities in basins with relatively low timber harvest levels ($\leq$25% of basin area harvested) was greater than in basins with high harvest levels (>25% of area harvested).

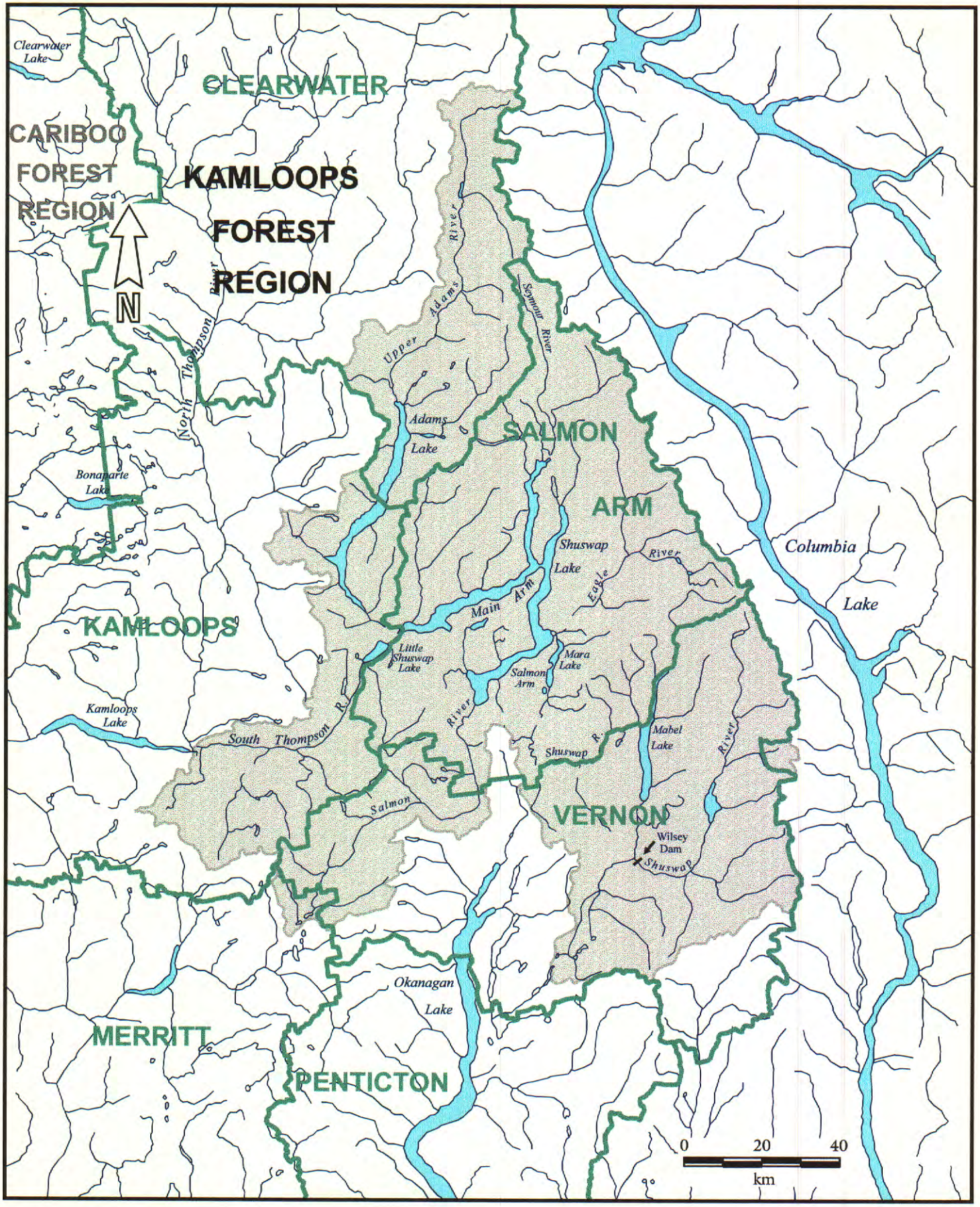


Figure 4.1. Forest Districts (Kamloops Forest Region) in the South Thompson-Shuswap HMA.

4.1.1 Watershed Inventory

Most of the logging activity in the HMA is being conducted in up-slope areas. Skidder logging methods have been used extensively in the HMA, resulting in extensive logging road networks. Construction and operation of logging roads is potentially the greatest source of sediments affecting fish habitat. Many of the older logging roads have not been deactivated, and some of the current roads require upgrading of culverts and maintenance. In addition, some of the older logging roads are classified as "non-status" meaning that their ownership is unknown and maintenance is minimal at best. Past logging practices have resulted in logging up to stream banks in some cutblocks, and the removal of streamside vegetation has led to destabilized stream banks and increased stream temperatures and sediment inputs. Previously logged areas have been converted to other resource uses, such as agriculture, further restricting the regeneration of streamside vegetation.

Total percent logged and the recently logged area in each watershed of the HMA were estimated by Sigma Engineering Ltd. (1991) and are shown in Appendix D. These estimates are visual (based on satellite imagery) and may overestimate the actual Equivalent Clearcut Area (ECA), the latter takes into account the greenup and hydrological recovery. Hydrologic recovery is, however, slow in the interior; it is estimated that 7 m green-up or full hydrologic recovery requires an average of 29-39 years (Sigma Engineering Ltd. 1991). The above estimates provide an indication of the potential risks of logging-related impacts to streams. Figure 4.2 and Table 4.1 show that the majority of the watersheds in the HMA have 20% or more of their drainage logged.

While a high rate of cut can alter stream hydrology, lower rates of cut can also result in increased sediment supply and channel instability due to high road density and logging in steep, unstable terrain. For example, although the upper Adams, Seymour and Harris drainages have less than 20% of their watersheds logged, impacts on these streams have occurred and there is a high level of concern regarding future logging activities.

A number of watersheds in the HMA have been assessed. In the heavily logged Scotch Creek watershed, the observed high number of roads, stream crossings and landslides have led to a more detailed assessment (Borrett Engineering Inc. 1995). Channel shifting and sedimentation in the lower fish-bearing reaches are a major concern. Assessment of the Harris Creek watershed indicated that logging on unstable terrain may have contributed to landslides and that past logging had reduced the riparian zone (Summit Environmental Consultants Ltd. 1995) even though the ECA was less than 15%.

Logging activity in the Hiuihill watershed has resulted in stream channel instability and sediment accumulation (Miles 1995). In both the Hiuihill and Chase creeks, logging in the headwaters coupled with agricultural activities that have removed riparian vegetation from downstream reaches, have also resulted in destabilized channels. This has impacted water quality in the South Thompson River and is a concern in the Lower Adams River. Further logging in the above systems has been either deferred (Hiuihill, Scotch and Chase creeks) or greatly reduced (Harris Creek); more detailed assessments are proposed and restoration activities initiated.

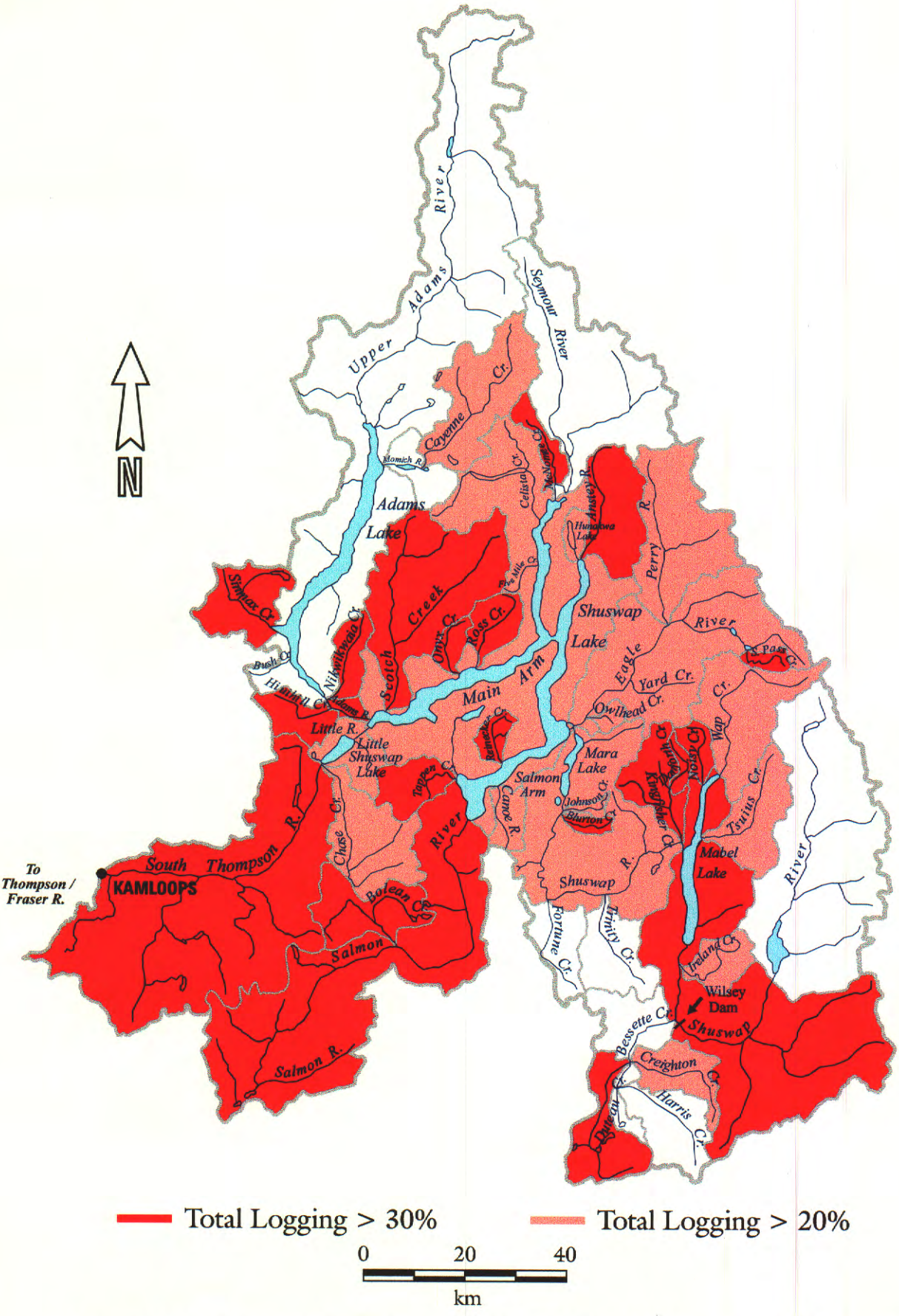


Figure 4.2. Watersheds with greater than 20% of their watershed logged, South Thompson-Shuswap HMA.

Table 4.1. Watersheds showing percentage of the area logged, South Thompson-Shuswap HMA.*

40% LOGGED	30-39% LOGGED	20-29% LOGGED	<20% LOGGED
Scotch Cr.	Hiuihill Cr.	S. Thompson R. (basin)	Momich R.
Onyx Cr.	Nikkwikwaia Cr.	Chase Cr.	Seymour R. (basin)
Ross Cr.	Sinmax Cr.	Little R.	Owlhead Cr.
McNomee Cr.	Anstey R.	Cayenne Cr.	Fortune Cr.
Salmon R. (basin)	South Pass Cr.	Hunakwa Cr.	Trinity Cr.
Bolean Cr.	Reienecker Cr.	Eagle R. (basin)	Harris Cr.
Noisy Cr.	Tappen Cr.	Perry R.	
	Blurton Cr.	Canoe Cr.	
	Kingfisher Cr. (basin)	Shuwap R. (Lower, basin)	
	Danforth Cr.	Johnson Cr.	
	Duteau Cr.	Shuwap R. (Middle, basin)	
		Wap Cr.	
		Tsuius Cr.	
		Ireland Cr.	
		Bessette Cr. (basin)	
		Creighton Cr.	

* Based on Appendix D; "basin" includes mainstem plus tributaries.
Note: % watershed logged was estimated for each salmon bearing watershed using 1:250,000 Landset Imagery (Sep 1990) (includes all visible cutblocks). Source: Sigma Engineering Ltd. (1991).

Watershed specific impacts are discussed in section 5.0 and presented in the stream profiles. Most of the streams in the HMA exhibit logging related impacts (e.g., slides, sedimentation, increased peak flows, bank instability, loss of riparian zone) due to high rate of cut, unmaintained roads and/or unstable terrain. Watershed assessments must be conducted to assess logging-related impacts and provide recommendations for future activities.

4.1.2 Current Trends in Forestry

Five-year development plans propose continued logging in most watersheds of the HMA. However, intensive logging since the 1960s has consumed a large portion of the accessible old growth timber, and lower sustainable harvest levels may be expected as harvesting shifts towards second-growth stands. In addition, forested land is being withdrawn due to an increasing demand for agricultural, residential and industrial land use (Ministry of Forests 1994). As a result, the forest industry will place more emphasis in the next 20 years on intensive silviculture technology, forest health, tree improvement, hardwood management and mill specialization.

The Forest Practices Code (FPC) was brought into law in June 1995. The FPC provides legislation, regulations and guidelines that govern road building and logging practices, including provision for buffer strips in riparian zones of fish bearing streams. The FPC defines a riparian management area (RMA) as consisting of a reserve zone (for streams greater than 1.5 m in width) and a riparian management zone. No logging is permitted in reserve zones, while constraints may be placed on logging in management zones. The width of the RMA is determined by a stream riparian classification based on the presence of fish and the average channel width, as specified in the Riparian Management Guidebook (British Columbia FPC 1995). Stream classifications (S1 - S6) and Best Management Practices are outlined in the Guidebook.

The FPC regulations also require that a watershed assessment be completed for all watersheds with high fisheries values. The Interior Watershed Assessment Procedure Guidebook (IWAP) outlines the method (FPC 1995). The assessment of hydrological impacts focuses on the potential for changes to peak flows, landslide events, accelerated surface erosion and changes to the channel riparian buffer. The Guidebook also provides a guide for interpretation and recommendations to be considered once the appropriate level of assessment is completed.

The Watershed Restoration Program (WRP) initiated in 1994 (Slaney 1994), is a provincial initiative under the Forest Renewal B.C. (FRBC), aimed at accelerating recovery through watershed restoration. The operational projects under the WRP include watershed assessment; impact inventories of the condition of roads, slopes, gullies, riparian zones, channels and fish habitat; prescriptions of treatments; and rehabilitation and monitoring. Table 4.2 shows the status of assessments and projects to date in the HMA.

The provincial Land and Resource Management Planning (LRMP) process, currently underway for the Okanagan-Shuswap area, will designate resource management zones that will influence future land use decisions.

Table 4.2 Status of assessments and projects in the South Thompson-Shuswap HMA (prep. by ARC Environmental Ltd. 1996).

Watershed	FRBC activity (Y/N) (Y/N)*	WRP (CAP, FHAP, Sediment Surveys, Road Assessments)	Operational Inventories (Fish Distributions)
S. Thompson R	Tributary systems	N	N
Chase Cr.	Y	Y	N
Little River	N	N	N
Adams R. (Below Lk.)	Tributary systems	N	N
Hiuihill Cr.	Y	Y	N
Nikwikwaia Cr.	Y	Y	Y
Adams R. (upper)	Y	Overview	Y
Sinmax Cr.	N	N	N
Momich Cr.	Y	Overview	Y
Cayenne Cr.	Y	Overview, IWAP proposed	Y
Scotch Cr.	Y	Y	Y
Onyx Cr.	Y	Y	N
Ross Cr.	Proposed	Y	N
Seymour Cr.	Y	Proposed	Y
McNomee Cr.	Proposed	Proposed	Y
Hunakwa Cr.	N	N	N
Anstey R.	Y	Y	Y
Eagle R.	Y	Y	N
Owlhead Cr.	Y	Y	N
Perry R.	Y	Y	N
SouthPass Cr.	N	N	N
Reienecker Cr.	Proposed	Y	N
Tappen Cr.	Proposed	Y	N
Salmon R.	Y	Y	Y
Bolean Cr.	Y	Y	N
Canoe Cr.	N	N	N
Lower Shuswap R.	Tributary systems	Overview Stream Assessment	Y - In some tributaries
Johnson Crk	Y	Y	N
Blurton Cr.	Y	Y	N
Fortune Cr.	N	NY	N
Trinity Cr.	Y	N	Y
Kingfisher Cr.	Y	Y	Y
Danforth Crk	Y	Y	Y
Middle Shuswap R.	Tributary systems	Y	Y - In tributaries
Noisy Cr.	Y	Y	N
Wap Cr.	Y	Y	N
Tsuius Cr.	Y	Y	N
Ireland Cr.	N	N	N
Bessette Cr.	In upslope tributaries.	N	N
Creighton Cr.	Y	Y	N
Duteau Crk	Y	Y	N
Harris Cr.	Y	Y	N

* A Y value for FRBC Activity denotes projects that are either completed or are currently underway.

Status of projects can be sourced from project coordinators in District FRBC Offices

4.2 AGRICULTURE

Land clearing associated with agriculture affects stream habitat by increasing erosion, decreasing stream bank stability, changing water temperature regimes, and altering nutrient input dynamics (Platts 1990). Livestock access degrades riparian vegetation along streams, while runoff from feedlots and winter feeding, and the use of pesticides and fertilizers reduces water quality in the receiving stream. In addition, water withdrawal for irrigation reduces instream flows to the detriment of spawning and rearing fish and invertebrate populations.

4.2.1 Existing Resource Use

Agricultural activity in the HMA is intensive, particularly along the South Thompson corridor and in the arable lands lying to the south of the Shuswap Lake system (Fig. 4.3). Cattle grazing and feedcrop production (the main agricultural activities) are concentrated in the southern HMA, particularly the Chase, Salmon, Creighton, Duteau, Bessette Creek and Shuswap River drainages. Dairy farms are located mainly in the latter four drainages.

Beef cattle grazing is conducted on Crown and private rangelands during summer and fall, and the breeding herd is overwintered in the valleys in fenced pastures close to the ranches where the dairy cattle are also maintained. Winter feed is generally produced on private lands, using sprinkler or ditch irrigation.

Improved farmland area and livestock densities in the salmon bearing watersheds of the HMA were estimated by Sigma Engineering Ltd. (1991). Appendix E shows these estimates for 1990 and gives the predicted estimates for the year 2010. Table 4.3 lists those watersheds (Fig. 4.3) in the HMA with the highest agricultural development. These watersheds also have relatively high livestock densities (Append. E).

It should be noted that those streams with a relatively low percentage of agricultural activity in the watershed (e.g. Hiuihill and Chase creeks) can also be impacted. This is because agricultural activities are often concentrated along stream channels and valley bottoms where fish values are the greatest, and erosion and sedimentation problems can extend far downstream. The three main concerns associated with agricultural activities - water withdrawal, water quality degradation and loss of riparian vegetation - are discussed below.

Water use

Low flows caused by agricultural water use (particularly irrigation) are one of the major impacts on fisheries resources culminating in reduced spawning and rearing habitat, impeded migration access to spawners and increased risk of high stream temperatures. Other fish related problems associated with agricultural water use include lack of adequate screening on water intakes and entrapment of fish in irrigation canals. Streams with high water demand and low summer/winter flows are shown in Figure 4.4 and Table 4.4, and discussed more fully in section 4.3.

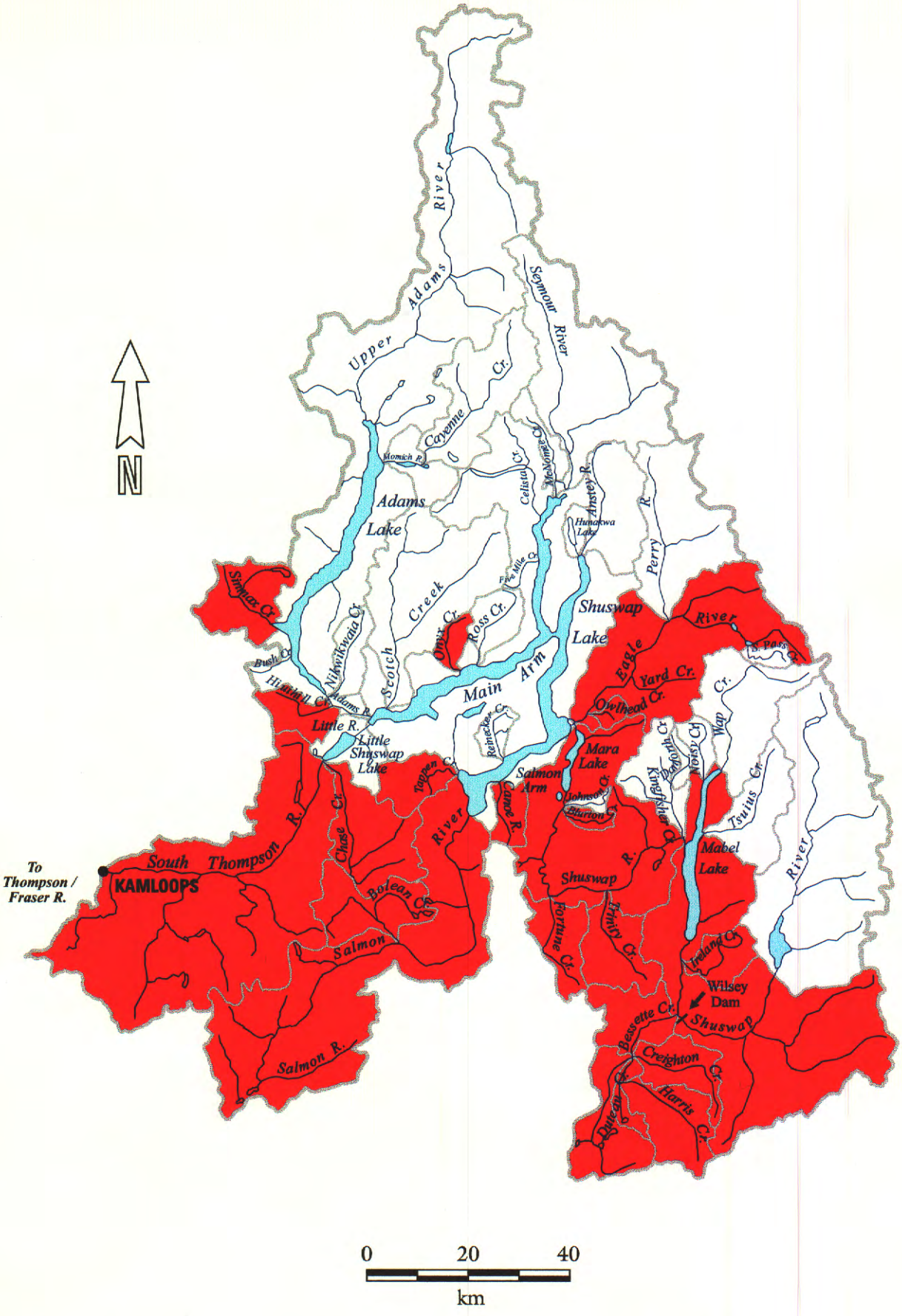


Figure 4.3. Watersheds with high level of concern related to agricultural activities, South Thompson-Shuswap HMA.

Table 4.3. Watersheds showing percentage of the area consisting of improved farmland (1990 estimates), South Thompson-Shuswap HMA.*

% IMPROVED FARMLAND		
3% or over	1 - 2.9%	<1%
Salmon R. (basin)	S. Thompson R. (total basin)	Hiuihill Cr.
Tappen Cr.	Chase Cr.	Nikwikwaia Cr.
Canoe Cr.	Little R.	Momich R.
Shuswap R. (Lower, basin)	Sinmax Cr.	Cayenne Cr.
Fortune Cr.	Owlhead Cr.	Scotch Cr.
Creighton Cr.	Bolean Cr.	Ross Cr.
Duteau Cr.	Johnson Cr.	Seymour R. (basin)
Onyx Cr.	Blurton Cr.	McNomee Cr.
Bessette Cr.	Trinity Cr.	Hunakwa Cr.
	Shuwap R. (Middle, basin)	Anstey R.
		Eagle R. (basin)
		Perry R.
		South Pass Cr.
		Reienecker Cr.
		Kingfisher Cr.
		Danforth Cr.
		Noisy Cr.
		Wap Cr.
		Tsuius Cr.
		Ireland Cr.

* Based on Appendix E; "basin" includes mainstem plus tributaries.
Streams in bold type have the highest percentage (7-40%) of their watershed as improved farmland.

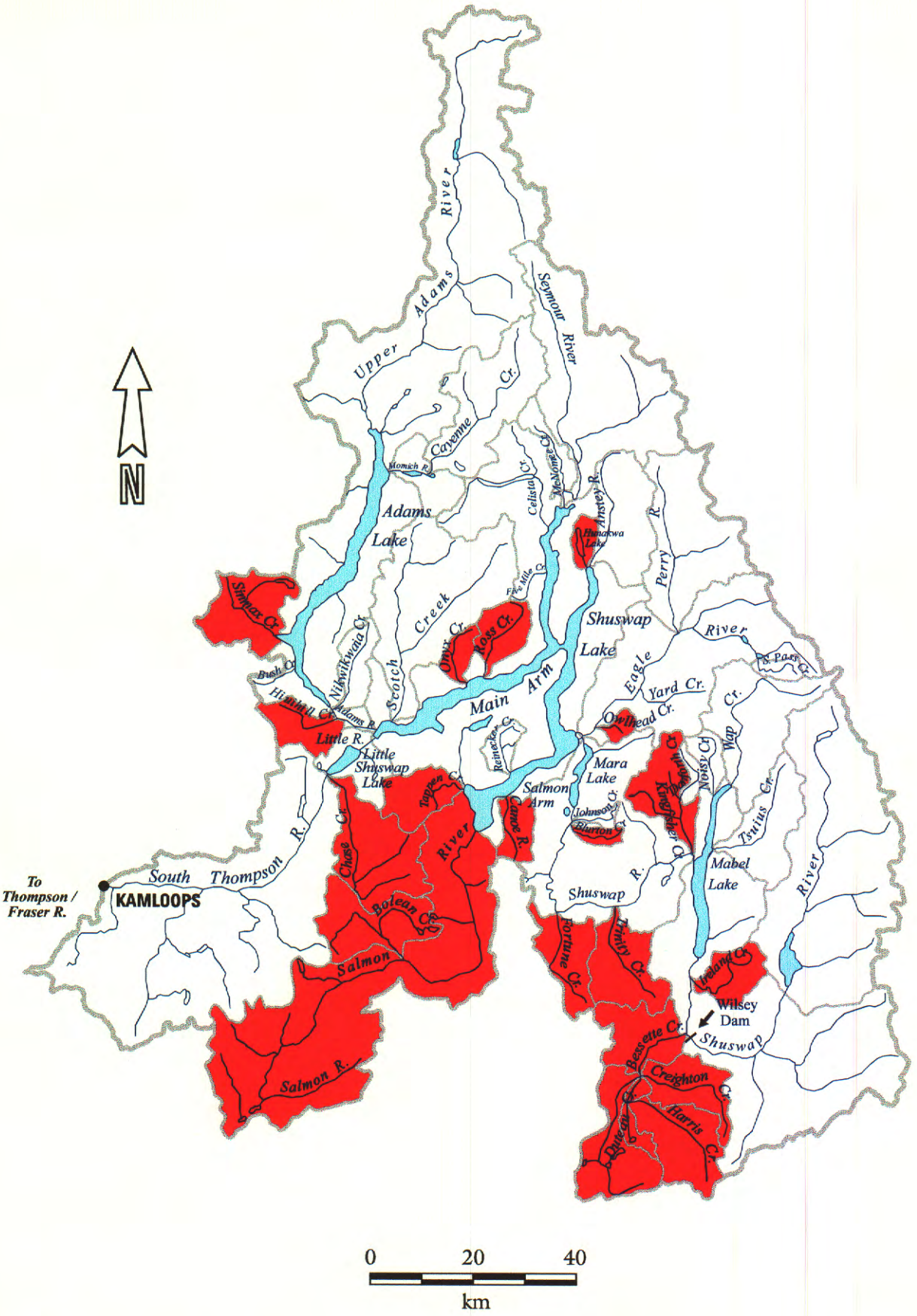


Figure 4.4. Watersheds with high level of concern related to water demand and/or low instream flows, South Thompson-Shuswap HMA.

Table 4.4. Most sensitive streams regarding high summer water demand (greater than 40% of summer mean low flows) and low summer/winter flows (at or below 10% of mean annual flow), South Thompson-Shuswap HMA. *

STREAM	Water demand	Low Flows Summer	Low Flows Winter
Chase Cr	**X**	**X**	**X**
Hiuihill Cr	**X**	**X**	**X**
Nikwikwaia Cr			**X**
Sinmax Cr	**X**		
Momich R			x
Cayenne Cr			x
Onyx Cr	x	x	x
Ross Cr		**X**	x
McNomee Cr			**X**
Hunakwa Cr		**X**	x
Anstey R			**X**
Owlhead Cr		x	**X**
Perry R			x
Reienecker Cr			x
Tappen Cr	x		
** Salmon R	**X**		

STREAM	Water Demand	Low Flows Summer	Low Flows Winter
Bolean Cr	x		x
Canoe Cr	**X**	**X**	**X**
Johnson Cr			x
Blurton Cr		**X**	**X**
Fortune Cr	**X**	**X**	**X**
Trinity Cr	x	**X**	**X**
Kingfisher Cr		**X**	**X**
Danforth Cr		**X**	**X**
Noisy Cr			**X**
Wap Cr			x
Tsuius Cr			**X**
Ireland Cr		**X**	**X**
** Bessette Cr	**X**		
** Creighton Cr	**X**		
** Duteau Cr	**X**		x
** Harris Cr	**X**		

* Based on Appendix C. Bold **X** highlights streams in the top 25% of extreme values for high water demand or low flows (also highlighted in Appendix C).

** These streams (Salmon River and Bessette, Creighton, Duteau and Harris creeks) have known flow problems despite low flows exceeding 10% of the mean annual flow. In Duteau Creek, flows are particularly limited in late summer and winter due to water diversion to the Okanagan basin.

Water quality

Surface runoff and contaminated groundwater seepage from feedlots, winter feeding grounds and dairies contribute to high nutrient (phosphorus) loads (John and Geier 1994). During spring runoff, phosphorus from fertilizers is also washed into streams, along with elevated coliform levels from animal wastes. Water quality is also impaired by increased bank erosion resulting from cattle access to streams. Livestock stocking densities provide an indication of potential problems of nutrient absorption into the watercourse. Many watersheds have high livestock densities, with Fortune and Canoe creeks showing the highest values (35.5 and 19.1 AU/km^2, respectively, Append. E). (See also section 4.4 on water quality).

A survey of agricultural practices in the Thompson Basin was conducted to identify runoff and contaminant sources. The inventory identified 103 sites of potential environmental impacts from agriculture (John and Geier 1994). Proximity of feeding areas and cattle access to watercourses were the most common practices of concern and were the primary source for the loading of pollutants to surface and groundwater.

Riparian losses

A major impact of agricultural activity in many streams has been the removal of riparian vegetation, as well as channelization along the stream. This has resulted in increased erosion, loss of shade and instream cover, and loss of pool and offchannel habitat. Burt and Wallis (1997) observed that the quality of rearing habitat is also diminished by the high percentage of fines in the gravel; this reduces both the survival of salmonids and the production of invertebrate food. Many coho streams in the HMA have been impacted and continue to be vulnerable.

Studies in several interior streams, including Salmon River and Hiuihill and Chase creeks in the HMA, have documented many of the above impacts (Miles 1995, Beeson and Doyle 1995). In the Salmon River, for example, 28% of the stream bank has no woody riparian vegetation and an additional 22% has only a narrow riparian vegetation fringe. This River also shows significant increases in river width and channel instability in those areas where riparian vegetation was removed (Miles 1995). A wider and shallower river can be expected to have warmer water temperatures, reduced number and size of pools, less undercut bank habitat, and possibly lower minimum flows (due to increased subsurface flows within the wider river bed). Rip-rap placement and ploughing of fields has also reduced the number of back channel and wetland areas.

4.2.3 Current Trends in Agriculture

Sigma Engineering Ltd. (1991) identified a number of watersheds in the HMA that may experience considerable future growth in agricultural activity; these include the lower South Thompson River (below Little Shuswap Lake), Little River, Chase Creek, lower Adams River and Hiuihill Creek. Other watersheds where modest growth is possible include the upper Adams River, Middle Shuswap River; and Sinmax, Scotch, Tappen, Trinity, Ireland, Bessette and Duteau creeks.

While the requirement for riparian reserve and management zones is regulated on Crown Range Lands by the Forest Practices Code, it does not apply to private agricultural land. Nevertheless, protection and reestablishment of riparian zones on salmon streams are a priority in protecting the fisheries resource. Protection and restoration of the riparian corridor, and improved water quality and instream flows, will require the combined efforts of government agencies, local communities and landowners. For example, the Salmon River Watershed Roundtable is an

initiative by stakeholders, supported by the Department of Fisheries and Oceans (DFO), to manage the watershed in an integrated and sustainable way. The stakeholders have heightened public awareness of many habitat issues in watershed management and have undertaken many watershed restoration projects in order to reestablish the riparian corridor. Activities in the Salmon River basin can serve as a model for managing other watersheds. In the Duteau Creek watershed, individual ranchers are also working with the DFO in an extensive program involving fencing and other restoration activities. The watershed stewardship guide for agriculture practices (Anon. 1997) provides strategies and practices to improve farming operations and protect fish habitat.

4.3 WATER USE

Water demand is immense, particularly in the southern part of the HMA (Fig. 4.4), with irrigation the major consumer of water. The nearly 5,000 water licenses held in the HMA represent 20% of the total Fraser Basin licenses (Dorcey 1991). The resulting low stream flows have significantly impacted fish populations through reduced critical spawning, incubation and rearing habitat; impeded upstream fish access; increased summer water temperatures and other changes.

4.3.1 Existing Resource Use

Water use

The intensive use of water in the HMA can be attributed primarily to the relatively high population density, high irrigation demand and a semi-arid climate. Over 30% of the streams in the HMA are fully subscribed (i.e., no further licenses are issued by Water Management, Sigma Engineering Ltd. 1991).

Appendix C shows for each watershed in the HMA the sensitivity indices for summer water demand (expressed as a ratio of summer water use over summer mean 7-day low flows) and indices for low flows (expressed as a ratio of 7-day low flows over mean annual flow). The most sensitive streams (those in the top 25% of extreme values for high water demand or low flows) are highlighted in Appendix C. Note that low-flow index values indicate streams with large water demands or with steep recession curves during summer drought.

Table 4.4 lists all streams in the HMA that have a relatively high water demand (greater than 40% of summer low flows) and low summer/winter flows (10% or less of mean annual flow). Based on criteria developed by Tennant (1976), 10% of the mean annual flow in summer and winter is considered a poor base-flow for fish. To sustain good survival of aquatic life, 30% of the mean annual flow is recommended for streams.

Although the low flow indices calculated for the Salmon River and Bessette Creek drainages are greater than 10% of mean annual flows, water demands in these systems are extremely high and low flows are a concern. Salmon River is the only large stream in the HMA where potential water demand represents a significant portion of the low summer flows (89% in August, Appendix C). A section of the stream at Westwold is dewatered during parts of the summer and licensed storage is limited (Rood and Hamilton 1995). Groundwater wells are not monitored or regulated, and are also affecting surface flows. A number of studies on the Salmon River have indicated that a combination of low flows, high water temperatures (>20°C), erosion and siltation (due to loss

of riparian vegetation) have impacted salmon habitat (Burt and Wallis 1997, Aquametrix Research Ltd. 1994).

Low flows are also a concern on the Bessette system. On one tributary, Duteau Creek, storage licenses are sufficient to compensate for irrigation extractions by the Vernon Irrigation District. However, flows are diverted to the Okanagan basin thereby severely limiting downstream flows in Duteau Creek, particularly in late summer and winter. Additional downstream demand on the Bessette system, which is only partly compensated by storage licenses, further reduces flows in this system.

Hydro development

The HMA contains one B.C. Hydro project on the Shuswap River and 11 small hydro projects (Sigma Engineering Ltd.1991). The B.C. Hydro project on the Shuswap River consists of the 13 m high Peers Dam at the outlet of Sugar Lake, the 30 m high Wilsey Dam located 31 km downstream of Sugar Lake, and the Shuswap Falls Generating Station at the Wilsey Dam (Fig. 1.1). The project was originally licensed and built in 1929 and refurbished in 1942 (Hirst 1990). New penstocks were constructed in 1994 and the flow-release control was improved. The Shuswap facility generates power for the city of Vernon and 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 7 m 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 the Wilsey Dam (e.g., emergent rainbow trout fry may be stranded, Triton Environmental Consultants Ltd.1995).

The Wilsey Dam has minimal storage. The previous operational strategy of reducing flows during the fall and winter to conserve for later power generation, has impacted the fisheries resources downstream of Wilsey Dam. Sigma Engineering Ltd. (1993) developed rule curves for the facility operation, giving consideration to storage, snowpack data and biological issues. Fall flows were monitored in 1993 and 1994 to assess the impact of changing flow levels on chinook, sockeye and kokanee redds (Triton Environmental Consultants Ltd. 1994), and to assess the effectiveness of the rule curve system. The rule curves provide a limited predictive ability and are currently under review (Stahlberg, pers. comm.). A study to assess the efficacy of existing guidelines to prevent the stranding of fish is also being undertaken (Hebden, pers. comm.).

Currently, a pilot study is underway where chinook adults are transported upstream past the Wilsey Dam. The aim is to use the upstream habitat presently inaccessible to anadromous salmon. Evidence suggests that chinook historically accessed the Middle Shuswap River above Shuswap Falls (French 1995). Utilization of habitat upstream of the dam (either through transport of adults or construction of a fish ladder), can potentially enhance salmon production in the Middle Shuswap system.

The Upper Shuswap River basin and the Mabel Lake area were rated as having a significant small hydro potential (Sigma Engineering Ltd. and Fawkes 1989, Sigma Engineering Ltd. 1983).

4.3.2 Current Trends in Water Use

Continued development (agricultural, industrial and municipal) and increasing conflict over water resources are forecast for the HMA. Systems where the fisheries resources are affected by inadequate instream flows will require changes in water management. Water management plans need to be developed on a watershed basis to ensure adequate instream flows for fish. This will require a coordinated effort by government agencies and communities. One tool for handling future water demand may be the construction and management of storage projects by multi-purpose water user groups. Currently, the coordination of water use management is minimal.

The greatest increased water demand for agriculture can be anticipated in watersheds that include the South Thompson mainstem, Little River, Lower Adams River, Chase and Hiuihill creeks and the Bessette system). However, in other systems (e.g., Salmon River and Onyx, Canoe, Fortune and Creighton creeks) future agricultural growth is expected to be limited due to severe water resource constraints.

4.4 WATER QUALITY

4.4.1 Existing Conditions

Water quality concerns may arise from many activities in the HMA (e.g., logging, agriculture, settlement, industry). Current water quality conditions in the HMA vary considerably from basin to basin due to different land and resource uses, and different climatic and geologic conditions. In the past, the South Thompson mainstem had good water quality, based on the 1973 data collected at Chase (Nordin and Holmes 1992). However, further downstream near Kamloops, higher turbidity and nutrient levels were noted likely due to increased population and agricultural activity in that area (Nordin and Holmes 1992).

More recent evidence suggests that water quality in the South Thompson mainstem is deteriorating (see section 5.0 below). NHC and Urban Systems (1995) found that Chase Creek is the primary source of sediments into the South Thompson River.

Water quality in Shuswap Lake varies in each of the five arms: the Main, Seymour and Anstey arms have very good water quality; the Sicamous Arm has generally good water quality with some localized problems at the Narrows; while portions of the Salmon Arm have poor water quality and eutrophic areas (Columbia Shuswap Regional District - CSRD 1988, Ross 1984). The higher nutrient levels in Salmon Arm are attributed to inflows from the Salmon River and White Creek (both drain agricultural areas and have nutrient problems) and from the Salmon Arm Sewage treatment plant (CSRD 1988). Non-point pollution that affects all portions of the Shuswap Lake includes septic leachate, agricultural runoff, and greywater from recreational boats (Holmes 1990).

The Salmon River contributes the highest loadings of phosphorous and ortho-phosphorous to Salmon Arm (9-15 kg/day of total phosphorous and 7-10 kg/day of orthophosphorous, CSRD 1988). These high loadings are the result of high background levels, agricultural runoff, domestic effluent from disposal fields, and forestry and corridor development in the Salmon River watershed (CSRD 1988, Evenden 1988).

The Bessette Creek is of particular concern due to both industrial and agricultural activity in the watershed. Currently, the levels of phosphorous, total iron and turbidity in this stream exceed the existing guidelines for the protection of freshwater aquatic life (Swain 1991). Ministry of Environment, Lands and Parks - MELP 1996) found that the criteria for coliform levels, suspended sediments and pH values were also not being met. In addition, chlorophenol concentrations in sediment samples collected adjacent to the Bell Pole operation, exceed the Fraser River water quality objective. Other developments affecting water quality in this watershed include woodwaste landfill along the Duteau Creek, logging activities in headwaters and agricultural activities throughout the system.

Table 4.3 lists those watersheds in the HMA with a high level of agricultural activity and hence an increased risk to water quality. Other watersheds in the HMA could potentially experience water quality problems due to recent extensive logging (Table 4.1).

There is also an ongoing concern over potential toxic spills into salmon bearing waters resulting from train derailments and other events. The risk is considerable since highways and railways follow valley bottoms and run along rivers and lakeshores.

4.4.2 Current Trends in Water Quality

Trends in water quality are dependent on several factors including future resource use (forestry, agriculture, residential and industrial development), and changing standards and regulations as set by the federal and provincial governments.

Non-point discharges are the main concern in the HMA. These affect larger areas and are much more difficult to isolate and treat than point discharges. For example, the few large point discharges in the HMA (Shuswap Hatchery and Salmon Arm treatment plant) can be controlled through effluent treatment, and the associated problems are more localized. The CSRD (1988) has stressed that future phosphorous control in Salmon Arm should be directed at non-point sources.

Population growth in the HMA was projected by Sigma Engineering Ltd. (1991) at less than 2% over the next 20 years. Water quality concerns may be expected since septic problems may increase with increasing foreshore development. The Scotch Creek area adjacent to Shuswap Lake has been identified as having septic leaching problems since clay soils limit infiltration into the ground. Currently, a South Shuswap Liquid Waste Management Plan is being set up between Sorrento and Wild Rose Bay. The objective is to assess the feasibility of community sewer systems. Foreshore water quality will be monitored for possible water quality problems associated with the development (Stahlberg, pers. comm.).

Forestry will continue to be a major resource use in the HMA. To help protect and restore fish bearing streams from sedimentation associated with logging activities, restoration activities and changes in logging practices are needed. The Forest Practices Code and the Forest Renewal B.C. initiatives should help improve water quality conditions.

To deal with toxic spills along the transportation corridors, adequate emergency response protocols must be established. The South Thompson River is vulnerable to contamination from spills from the adjacent transportation corridor (particularly from train derailments). The City of

Kamloops which depends on this River for water supply, has proposed an emergency intake to be located on the North Thompson River.

Watershed-specific water quality objectives proposed by the B.C. Environment also provide an indication of future water quality trends. Although the objectives have no legal standing, they can be considered policy guidelines for B.C. Environment resource managers. The B.C. Ministry of Environment, Lands and Parks also conducts monitoring programs to assess how well the objectives are being met. Water quality objectives for this HMA are currently available for the South Thompson River (Nordin and Holmes 1992) and the Bessette Creek (Swain 1991). Currently, a strategic review and water quality plan is being developed for the Fraser River Basin. This document outlines the key issues and recommendations for each sub-basin including the South Thompson-Shuswap HMA (Nener and Werneck, in prep.).

4.5 POPULATION / SETTLEMENT, RECREATION AND TRANSPORTATION

4.5.1 Existing Resource Use

The current population in the HMA totals approximately 113,000 people (Statistics Canada 1996). Modest growth is expected over the next 20 years (Sigma Engineering Ltd. 1991). Residential developments extend along the South Thompson River, the Lower Shuswap River, Eagle River, Salmon River, Bessette Creek, Chase Creek and other smaller streams. Residential and other developments are also centred along the lakeshore areas of Shuswap Lake, Mara Lake and Mabel Lake, as well as other lakes. Urban settlements include Kamloops, Chase, Salmon Arm, Sicamous, Enderby, Lumby and the associated satellite districts (Fig. 1.1). Semi-urban settlements include Monte Lake, Falkland, Celesta, Seymour Arm and Sorrento.

The Shuswap Lake system is the focus of recreational activities in the HMA with some 21 resorts and 13 marinas located on the Lake (Sigma Engineering Ltd. 1991). Summer activities on the Lake include boating and fishing, with many other recreational activities pursued on the surrounding lands. The numerous recreational developments throughout the HMA include fishing lodges - principally in the Salmon River area, resorts throughout the area, marinas on Mara Lake and Mabel Lake, the Silver Star Mountain ski resort, and numerous provincial parks and recreation sites. Golf courses are located in Kamloops and Chase, as well as in the Shuswap Lake area.

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 (Fig. 4.5).

4.5.2 Impacts on Fishery Resource

Urban developments increase the amount of impervious surface area in a watershed and can affect the long-term hydrology by increasing runoff and flood peaks (Anon. 1996). Residential developments can also encroach on streams through removal of riparian vegetation and stream channelization. The result is the loss of habitat complexity and increased erosion and sedimentation.

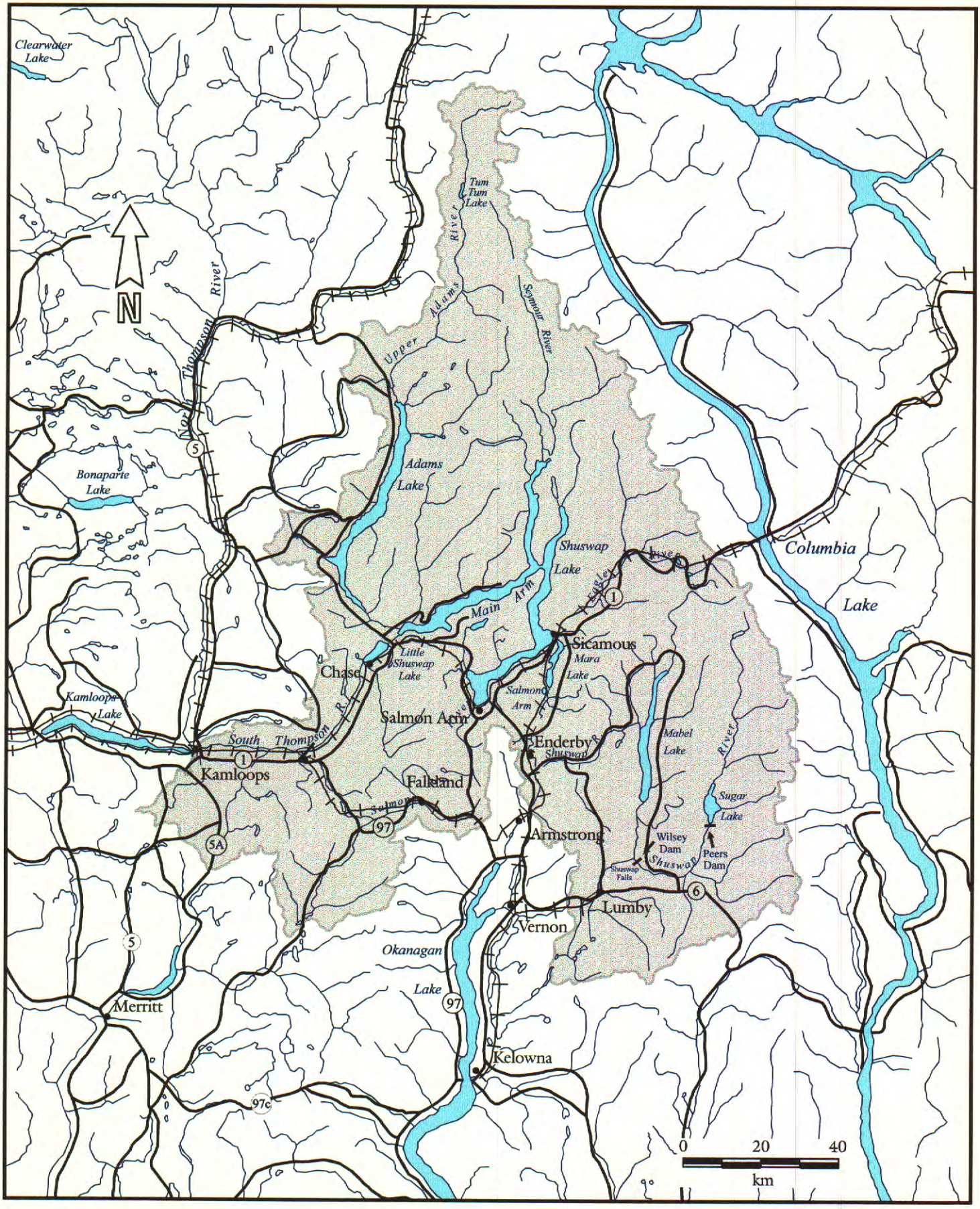


Figure 4.5 Roads and Railways in the South Thompson-Shuswap HMA.

Upland developments are having a significant impact on the fish habitat of Shuswap Lake and South Thompson River. Land clearing and stream diversions have resulted in upland and foreshore erosion, and water quality degradation. The foreshore lake habitat is directly affected by diking, dredging and filling, and by construction of marinas, boat launches and breakwaters. These activities result in the removal of foreshore and riparian vegetation which is vital for maintaining foreshore habitat for spawning and rearing. The removal of gravel and cobble from shorelines to create sandy beaches also impacts salmon habitat. As discussed earlier, settlement and recreational activities affect water quality in streams and lake foreshore habitat though septic seepage and stormwater runoff.

Transportation corridors can encroach on stream channels. Often rip-rapping is added for channel containment and this reduces channel complexity through loss of side channels and offchannel habitat. This has occurred adjacent to the Trans-Canada Highway along the South Thompson and Eagle rivers. There are also concerns regarding toxic spills along the transportation corridors, particularly from train derailments.

4.5.3 Current Trends in Settlement, Recreation and Transportation

Population growth in the HMA is increasing. A resource analysis conducted in 1994 projected the overall increase in participation rate for outdoor activities in B.C. at 3% annually (Ministry of Forests - MOF 1994). In the Shuswap lake area, resort development is the primary form of projected recreational growth. Expansion and upgrading of existing highways is the only projected transportation/utility development in the HMA. The main project of concern is the Trans-Canada widening between Sicamous and Revelstoke.

A significant portion of the HMA falls within the jurisdiction of the Columbia Shuswap Regional District. The CSRD has only a limited number of regulations affecting land development and this is a major concern. The DFO presently reviews development proposals on a project by project basis as part of the referral system. Although the DFO's Land Development guidelines are used and protective covenants can be applied to new properties adjacent to streams and lakes, this process is largely reactive; also it does not address the cumulative impacts that are degrading the shoreline spawning and rearing habitat of the Shuswap Lake system.

Provincial planning initiatives, including the Growth Strategy planning, transportation plans and Land and Resource Management Plans, have been started in the area and need to incorporate the protection and restoration of fish habitat. At the local government level, Official Community Plans could identify sensitive areas which could then be incorporated into zoning bylaws. These bylaws would direct development away from sensitive areas and provide appropriate guidelines where development could occur. This approach would address cumulative impacts of lake foreshore alienation and water quality concerns. For example, designated Environmentally Sensitive Areas and bylaws defining setbacks from the mean annual high water mark, as well as bylaws for sediment control, would provide needed tools for fish habitat protection.

Zoning policies are in place in some communities, including Anglemont, Blind Bay to Reedman Point, Rural Sicamous north to Cinnemousun Narrows, Deep Creek/Ranchero and Salmon Valley. Some initiatives are underway, including a proposed zoning bylaw for the entire south shore of the Main Arm (Cruickshank Point west of Sorrento and east to Wild Rose Bay). In addition to the planning tools this bylaw provides, building setbacks will be defined from the mean annual high

water mark (348.3 geodetic meters above sea level). This is an improvement over the boundary commonly used to determine setbacks, and will reduce the conflicts between development and fish habitat. The South Shuswap Liquid Waste Management Plan for the same area will involve assessing the feasibility of community sewer systems, and monitoring foreshore water quality.

The residents along the north shore of the Main Arm of Shuswap Lake have rejected community planning in the past. However, a Planning Needs Assessment review is currently underway for this area.

4.6 MINERAL RESOURCES AND PLACER MINING

There are 36 past producers of minerals in the HMA. The 312 known mineral occurrences in the region cover a wide spectrum of deposit types and commodities. There are currently no operating metal mines in the HMA. The Samotosum mine operated by the Minnova Inc. in the early 1900s has since ceased operation and reclamation work is currently underway (Britton, pers. comm.). Recent industrial mineral mines and potential mining projects, pending environmental assessment within the HMA, include mines near the South Thompson at Kamloops (limestone), Falkland (gypsum), Kingfisher (marble) and Lumby (graphite / sericite) (Ministry of Energy, Mines and Petroleum Resources 1995). Placer mining is conducted in the Monashee and Heckman Creek areas as it has for over a century (Heckman Creek is a tributary to Cherry Creek which flows into the Middle Shuswap River).

Mineral related impacts in the HMA have not been significant due to limited mining activity, particularly near important salmon bearing streams. In Sinmax Creek, mining related concerns regarding water quality are being addressed through a new wastewater treatment facility (section 5.2).

5. 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 3.0. Landforms range from flat, rolling terrain to steep, jagged mountains, while climatic conditions range from very dry to above average 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 earlier (e.g., logging, road building, agriculture, grazing, irrigation, residential development) have affected fish habitat by altering or degrading the riparian ecosystem, degrading water quality, altering channel morphology, and promoting erosion and sedimentation. The severity of the impact will depend not only on the activity, but on the sensitivity and resilience of the stream and its watershed.

The priority in managing fish habitat in the HMA is to ensure protection of the fisheries resource by protecting and managing the stream ecosystem including the uplands, riparian zones, and floodplains of rivers and lakes. Firstly, proper land management practices must be promoted to maintain integrity of the streams and lakes, and their riparian zones, and prevent impacts on spawning and rearing fish. Additionally, in watersheds where impacts have already occurred and continue to damage fish habitat, the natural water and sediment regimes and riparian communities need to be restored. Beschta et al. (1994) observed that the removal of land use activities that cause adverse impacts to riparian and aquatic ecosystems are of the highest priority if restoration is to be accomplished; furthermore, restoration alone cannot substitute for vigorous stewardship of riparian systems and their surrounding watersheds.

Monitoring of escapements to salmon streams throughout the HMA is imperative to managing the stocks and ensuring adequate spawner returns. Intensive ocean harvesting rates need to be reduced. This is of particular concern regarding the rebuilding of the area's coho stocks which are in a serious decline.

DFO has defined seven measurable and achievable goals for sustainable fisheries development (Table 4.5). Watershed specific strategies are presented in Salmon Watershed Planning Profiles for the South Thompson-Shuswap HMA, and are outlined in the following sections.

Table 4.6 summarizes for each watershed in the HMA the concerns over impacts to the stream or lake habitat as a result of various resource uses. The current state of watersheds is the result of past and present practices on Crown and non-Crown lands that have resulted in cumulative impacts on fish habitat. Most salmon bearing watersheds in the HMA have logging activities in the headwaters, and agriculture and settlement activities in the lower reaches. Studies on a number of streams in the interior indicate that clearcutting, roadbuilding, land clearing, cattle grazing, loss of riparian vegetation and channelization have resulted in severely impacted streams. These streams require restoration and considerable time for recovery, and are vulnerable to further development. It is therefore vital that land and water management practices in the watershed be improved and past impacts addressed.

Table 4.5. Measurable and achievable goals for sustainable fisheries development (O. Langer 1993 in Harding et al. 1994).

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1. **Avoid irreversible human induced alterations to fish habitats.** Alterations to fish habitat that reduce its capacity to produce fish populations and cannot be reversed within a human generation will be avoided.

2. **Maintain the genetic diversity of fish stocks.** No fish stock, however small, will be arbitrarily eliminated and, where possible, efforts to conserve and rebuild small and remnant stocks will be made.

3. **Maintain the physical and biological diversity of fish habitats.** Physical and biological diversity of habitat provides fish with an opportunity to adopt alternative life history strategies, thereby providing protection from natural habitat variation.

4. **Provide a net gain in productive capacity through proper habitat management.** Ecological limits control productive capacity of a stream system. Natural and self-sustaining production systems are preferred over semi-natural, artificial or non-self-sustaining systems.

5. **Maximize the value of commercial, sport, and aboriginal fisheries.** All market and extra-market values are to be considered, and measured in a way that permits comparison of competing users of the fisheries resources.

6. **Maximize the non-consumptive values of the fisheries resources.** Intangible and cultural values associated with fishery resources are to be given due consideration in decision making.

7. **Distribute fishery net benefits in a fair and equitable manner.** Local communities are to be involved in the decision-making process pertaining to habitat conservation, enhancement, and restoration, and particularly who is to benefit and who is to pay.

Table 4.6. Streams with concerns over impacts due to forestry (F), agriculture (A), water demand (WD), low flows (LF), water quality (WQ), settlement / recreation / transportation (SRT), and mining (M) activities in the South Thompson-Shuswap HMA. *

STREAM	F	A	WD	LF	WQ	SRT	M	STREAM	F	A	WD	LF	WQ	SRT	M
S. Thompson sub-basin								**Salmon R. system**							
S. Thompson R.	X	X			X	X		Salmon R	X	X	X	X	X	X	
Little R.	X	X			X			Bolean Cr.	X	X	X	X	X		
Chase Cr.	X	X	X	X	X			Canoe Cr.	X	X	X	X	X		
Adams R. system								**Lower Shuswap R. system**							
Upper Adams R.	X							Lower Shuswap R.	X	X			X	X	
Lower Adams R.	X	X						Johnson Cr.	X	X		X	X		
Cayenne Cr.	X			X				Blurton Cr.	X	X		X	X		
Momich R.	X			X				Fortune Cr.	X	X	X	X	X		
Sinmax Cr.	X	X	X		X		X	Trinity Cr.	X	X	X	X	X		
Hiuihill Cr.	X	X	X	X	X	X		Kingfisher Cr.	X			X	X		
Nikwikwaia Cr.	X			X				Danforth Cr.	X			X	X		
Shuswap Lake system								**Middle Shuswap R. system**							
Shuswap Lake					X +	X		Noisy Cr.	X			X	X		
Scotch Cr.	X				X	X		Wap Cr.	X			X	X		
Onyx Cr.	X	X	X	X	X	X		Tsuius Cr.	X			X			
Ross Cr.	X			X		X		Middle Shuswap R.	X	X			X		
Seymour R.	X				X			Ireland Cr.	X	X	X	X	X		
McNomee Cr.	X			X				Bessette Cr.	X	X	X	X	X	X	
Hunakwa Cr.	X			X				Creighton Cr.	X	X	X		X		
Anstey R.	X			X	X			Duteau Cr.	X	X	X	X	X		
Eagle R.	X	X			X	X		Harris Cr.	X	X	X				
Owlhead Cr.	X	X		X	X										
Perry R.	X			X	X										
South Pass Cr.	X														
Reienecker Cr.	X			X											
Tappen Cr.	X	X	X	X	X	X									

* Based on information in sections 4 0 and 5 0

+ Water quality concerns in Salmon Arm of Shuswap Lake

There is a need for assessment and planning at the watershed level. This should allow for hydrological stability or recovery, stream channel integrity, reestablishment of a riparian corridor, and protection of water quality and fisheries sensitive areas, based on watershed specific guidelines and prescriptions. Watershed planning needs to incorporate activities on both Crown and non-Crown lands. Instream flow requirements for fish must be recognized in the provincial Water Act, and strategies for achieving improved flows must be developed.

The watershed-specific management issues and priorities discussed below are presented for each of the following six sub-basins in the HMA:

1. South Thompson sub-basin,
2. Adams River system,
3. Shuswap Lake system,
4. Salmon River system,
5. Lower Shuswap River system (from Mabel Lake to Mara Lake),
6. Middle Shuswap River system (Mabel Lake and above), and

5.1 SOUTH THOMPSON SUB-BASIN (from Little River downstream, including Little River, Chase Creek and South Thompson mainstem).

The South Thompson sub-basin lies within the Bunchgrass, Ponderosa Pine and Interior Douglas Fir biogeoclimatic zones, and is situated in the Thompson Plateau and Shuswap Highlands physiographic areas. This region has generally very high land use including urbanization, agriculture, recreation and linear development.

South Thompson River and Little River

The South Thompson River is a moderate to large river that flows from the Little Shuswap Lake into Kamloops Lake. The Little River flows from the Shuswap Lake into Little Shuswap Lake (Fig. 1.1). Both rivers are well buffered from the Shuswap Lake system and have relatively low seasonal flow fluctuations.

Fishery resources in the South Thompson and Little rivers are extremely high. Both rivers have significant escapements of chinook and fall run sockeye, as well as some pink salmon. The chinook stock in the South Thompson is the second largest in the HMA (after the Lower Shuswap), while the sockeye stock in the Little River has reached 360,000 in 1990. The rivers also serve as migration corridors for salmon that spawn and rear in upstream areas. The mainstem and non-natal tributary streams (usually lower reaches) also provide early rearing habitat for chinook juveniles natal to the rivers, as well as transient rearing habitat for downstream migrants.

The river habitat (instream, shoreline and riparian) between Kamloops and Monte Creek, has been mapped, assessed and rated as to its importance to fish populations (Envirowest Consultants Ltd. 1994). The 1994 study was revised and shoreline habitat classified in the study area (Environmental Dynamics Inc. 1996). These studies indicated that 83% of the stream bank has been altered (29% by agriculture, 2% by bank stabilization, 29% by linear development, 23% by urban encroachment), leaving only 17% of the streambank habitat unchanged.

The disruption of the riparian community has lead to concerns regarding the potential increase of sedimentation due to erosion, loss of large woody debris input, loss of shade, and overall loss of protective streamside habitat used for shelter by rearing juveniles. The loss of overhead riparian cover can lead to reduced nutrient input due to lowered detrital input and insect drop. In addition, the extensive development in the region affects water quality due to non-point discharges (sediments, agricultural wastes) and point toxic discharges. Sediments generated from erosion on newly developed lands have resulted in degraded water quality in tributary streams, contributing to an overall increase in sediment input to the South Thompson River. Additional erosion of the river banks is attributed to increased use of motorized watercraft on the South Thompson.

Linear developments (mostly roads, railways and highways) follow the river corridor and 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 of hazardous chemical spills and the resultant fish mortality (Kosakoski, pers. comm.).

Upslope logging has been conducted throughout the South Thompson drainage. The benches surrounding the South Thompson River are composed primarily of lacustrine silts that can be destabilized and eroded if land use practices alter hydrologic regimes. Logging coupled with agricultural activities carried out in Chase Creek, for example, can affect salmon spawning areas directly downstream of this tributary.

The average annual turbidity in the South Thompson River and the number of days that critical values are exceeded have increased steadily, raising concerns over the deterioration of water quality in the South Thompson River and the City of Kamloops water supply (NHC and Urban Systems 1995). The South Thompson/Chase Creek Turbidity Committee was formed to address this issue and undertake the first phase of the Watershed Management Plan for the South Thompson. The watershed study has identified the primary sediment sources as Chase Creek and some tributaries between Little Shuswap Lake and Kamloops (e.g., Stobbart and Juniper creeks),

In the Little River drainage, the potential for future development on reserve lands creates the potential for future resource impacts (Kurtz, pers. comm.). Encroachments from the potential expansion of the highway are also a concern.

Chase Creek

Chase Creek enters the South Thompson mainstem just below the Little Shuswap Lake near the municipality of Chase. 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 downstream chinook spawning areas) due to streambank erosion and channel degradation. There are also concerns for the resident fish species in the Creek.

A number of land use practices have lead to high bedload and sedimentation in Chase Creek (Doyle, pers. comm.), with slope instability and slide areas identified in the upslope areas. Logging in the upper watershed has resulted in loss of riparian cover, while the construction and

operation of logging roads has contributed to destabilization of banks, erosion and siltation (Doyle, pers. comm., Grace, pers. comm.). Loss of riparian vegetation along stream bend sections has lead to significant increases in erosion rates (Beeson and Doyle 1995). Major sources of sediment to Chase Creek are the upper logged areas, lacustrine sediments downstream of Charcoal Creek, and channel erosion form Charcoal Creek to Turtle Valley Bridge (NHC and Urban Systems 1995). The Salmon Arm Forest District has deferred greenwood timber harvesting due to water quality concerns (Harding, pers. comm.).

The lower reaches of Chase Creek are heavily utilized for agriculture, resulting in livestock encroachment into the stream and removal of streamside vegetation. These impacts have contributed to channel destabilization and increase in sediment input. Water withdrawal for agricultural purposes is high, contributing to summer low-flow problems, while water quality has been affected by non-point source inputs from grazing and ranching activities.

Management Priorities

The major management priorities for the South Thompson River are protecting and restoring the riparian zones, and maintaining good water quality. This includes managing the streams to minimize downstream water quality impacts.

Management objectives for Chase Creek include improving water quality, restoring riparian zones and fish habitat, and ensuring that the chinook spawning areas in the South Thompson downstream of Chase Creek are not impacted by sedimentation.

Strategies

- 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 Official Community Plans and zoning. (A similar study has inventoried and classified riparian zones along stream banks from Kamloops to Pritchard (Environmental Dynamics Inc. 1996, Envirowest Consultants Ltd. 1994). Protect undisturbed riparian habitat and restore riparian zones where vegetation has been lost or reduced.

- Promote stream stewardship and public awareness on the importance of riparian zones to facilitate a program of revegetation 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. Initiatives would include stream clean-ups, sediment control measures and habitat development, where appropriate. Small tributaries (Dairy, Paul, Monte, Campbell and Peterson creeks and Tranquille River) have been identified as requiring a high level of protection (Environmental Dynamics Inc.1996).

- 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.

- 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 small tributaries outlined in a study on the South Thompson watershed (NHC and Urban Systems 1995). A Level 2 Channel Assessment is underway on Chase Creek to assist in the development of the plan.

- Ensure spill contingency plans are in place to deal with potential toxic spills along the transportation corridor.

- Promote stream stewardship to develop a riparian restoration plan for Chase Creek, aiming to reestablish a riparian corridor by fencing livestock, revegetating stream banks, and stabilizing banks using bioengineering methods.

- Identify areas of terrain instability, conduct inventory of logging roads, and identify areas where logging activity has reduced riparian vegetation in Chase Creek (through Watershed Assessment (IWAP) and Level 2 Channel Assessment). Implement activities identified from this process, including decommissioning of inactive logging roads and maintenance of existing roads (e.g., by replacing and upgrading culverts) (through WRP).

5.2 ADAMS RIVER SYSTEM
(including Upper Adams River (above Adams Lake), Cayenne Creek, Momich River, Sinmax Creek, Lower Adams River (below Adams Lake), Hiuihill Creek and Nikwikwaia Creek).

Lower Adams River (below Adams Lake)

The Lower Adams River enters Shuswap Lake at the base of Main Arm. This River 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 utilize the Lower Adams, as do resident rainbow trout and bull trout. Given these extremely high fisheries values, an environmental incident could severely impact fisheries resources in the area.

The Lower Adams lies within the Roderick Haig-Brown conservation area which provides protection to the River and its riparian corridor. Outside this area, the Lower Adams has been subjected to land use practices associated with urban encroachment. There are Native reserve settlements along the lower reaches and a low-density population sprawl along the Adams Valley. The upslope areas have been logged and there is extensive agricultural activity along benchland areas above the river valley.

Resource use along the Lower Adams is relatively low at present. A potential development of Reserve Lands along the Adams River will need to be monitored to ensure the protection of fisheries resources. This also applies to the intensive logging and/or agricultural activities in the tributary streams, Hiuihill and Nikwikwaia creeks (see below), as these can potentially impact fish habitat downstream (Miles and Associates Ltd. 1995). On the Adams River, the use of motorized watercraft is restricted both for public safety and to reduce the potential for fish harassment (Stahlberg, pers. comm.).

The Roderick Haig-Brown conservation area is a focal point for recreation, especially during the sockeye spawning period in October. During years of high returns, thousands of visitors come to the "Salute to the Sockeye".

Hiuihill Creek and Nikwikwaia Creek

Hiuihill and Nikwikwaia creeks flow into the Lower Adams River. Sockeye and coho salmon utilize the lower kilometre in each Creek, while chinook have been recorded in the Hiuihill Creek.

In the Hiuihill watershed, logging, agriculture and to a lesser extent, settlement activities have resulted in a loss of riparian zone and channel destabilization (Doyle, pers. comm., Kurtz, pers. comm.) The riparian loss has contributed to increased flooding and bank erosion (Beeson and Doyle 1995, Doyle, pers. comm.).

In the past, the Hiuihill watershed has been logged extensively. Further harvesting has been deferred pending the development of an Integrated Watershed Management Plan in 1997 (Harding, pers. comm.). Of the total area logged, 87% remains in a hydrologic state equivalent to clearcut and represents roughly 18% of the total watershed area; this likely has a substantial effect on peak flow timing (Eremko and Butt 1989). The upper drainage has been destabilized by past logging practices (Miles and Associates 1995). Sediment input has increased due to loss of riparian zones and the construction and operation of logging roads.

Landowners have channelized stream sections and armoured sections of the bank, resulting in a loss of streamside vegetation and habitat complexity. Also road networks that cross the Creek have resulted in narrowing of the channel and further removal of streamside vegetation. Water quality has been affected through non-point source inputs of nutrients, and summer flows have been reduced through water withdrawal for agriculture (Rood and Hamilton 1995, Doyle, pers. comm., Kurtz, pers. comm.).

In the Nikwikwaia watershed, logging has occurred in an estimated 35% of the basin (Append. D) and is the primary disturbance. Further harvesting has been deferred pending the development of an Integrated Watershed Management Plan (Beeson, pers. comm.) A terrain stability report identified instability within the system. A wide variety of debris flows along colluvial slopes, and cutbanks of the Creek lead to sedimentation. Slide activity is also present (Dobson Engineering and Foxview Management Ltd. 1995). The combination of heavy logging activity and terrain instability, with the resulting bank erosion and sedimentation, place risks on the downstream fisheries production.

Agricultural activity in the Nikwikwaia watershed is currently low and confined mainly to the lower reaches. Rangeland use, however, is increasing in the upper areas which are being cleared by logging.

Management Priorities

Management objectives for the Adams River focus on the protection of the spawning grounds through maintenance of good gravel and water quality for its salmon stocks. To reduce sediment input and potential downstream impacts to the Lower Adams, restoration and improvement of water quality in tributary streams (particularly Hiuihill and Nikwikwaia creeks) are a priority.

Strategies

- Assess the potential to create additional coho spawning and rearing habitat through the development of side channels in the Lower Adams River. Add instream complexing (e.g., large woody debris) to side channels in the Adams River fan.
- Continue to monitor activities on the Hiuihill and Nikwikwaia creeks for potential risks to gravel and water quality in the Lower Adams River.
- Continue to defer logging plans in Hiuihill Creek until an Integrated Watershed Management Plan is completed in 1997, and the Hiuihill Watershed Committee can review the strategy for the watershed.
- Defer further logging in the Nikwikwaia basin pending a roundtable review of a completed IWAP (to FPC standards), stream channel assessment and restoration programs.
- Apply DFO/MELP Land Development Guidelines to future developments in the area to protect instream and riparian habitats.
- 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.
- Promote riparian restoration on private lands along the lower reaches of Hiuihill Creek. Promote the concept of a riparian corridor along presently unvegetated or sparsely vegetated areas. Protect existing riparian vegetation, revegetate denuded areas, and fence livestock away from stream banks. Where required, stabilize eroding banks focusing on bioengineering techniques, and reestablish habitat diversity in the system.
- Complete and evaluate IWAP (to FPC standards) conducted on Hiuihill and Nikwikwaia creeks to identify restoration opportunities that could be implemented (through WRP).
- Restore upslope areas through road deactivation, replanting riparian zones and channel stabilization. On Hiuihill Creek, upslope sections must be stabilized before stabilizing downstream areas. Upgrade culverts to restore previous drainage patterns (Miles and Associates Ltd.1995).
- Continue DFO activities at the Roderick Haig-Brown Park to educate the public on the importance of salmon stocks.

Adams Lake

The Adams Lake has considerable fisheries resources that include lake spawning sockeye (Panko, pers. comm.), rearing sockeye and chinook juveniles from the Upper Adams River, shore-spawning kokanee, as well as resident salmonid species (e.g., bull trout, rainbow trout, lake char). Numerous non-salmonid species also utilize the Lake (e.g., burbot, largescale suckers, mountain whitefish, northern squawfish, peamouth chub, slimy sculpins and prickly sculpins.

Developments on Adams Lake include a logging dump at the north end of the Lake, booming areas and a sawmill at the south end. Urban development is observed primarily at the lake outlet. Some recreational sites and properties are scattered around the Lake and there is recreational development at Squaam Bay.

Management Priorities

The management priority for Adams Lake is to protect foreshore spawning and rearing habitat and water quality.

Strategies

- Inventory and classify foreshore habitat, and minimize impacts of foreshore development on the Lake.
- Ensure log handling operations are consolidated at existing sites.

Upper Adams River

The Upper Adams River flows into the upper end of Adams Lake. Fisheries resources in the Upper Adams include sockeye, chinook and coho salmon. Fish populations in this River have been greatly reduced from historic levels following the construction in 1908 of a logging splash dam at the outlet of Adams Lake, and the Hell's Gate landslide of 1913. Enhancement efforts to restore sockeye and chinook to the system have shown limited success. In 1996 however, approximately 30,000 sockeye spawners returned to the Upper Adams River. Despite this success, attributed in part to outplanting of hatchery fry, the Upper Adams continues to represent a major enhancement opportunity in the Fraser watershed.

Logging is the major resource use in the Upper Adams area (Photo 5.1). The terrain is steep and sensitive to logging impacts; in the last 20 years, logging has impacted the area north of Tum Tum Lake (Fig. 1.1). The lower portion has been burned in the 1940s and consists mainly of immature timber (Panko, pers. comm.). Several tributaries have been harvested close to or exceeding 20%; the possible changes in hydrology may be affecting channel stability (NHC and Urban Systems 1995, Sigma Engineering Ltd. 1991). An extensive logging road network exists in the Upper Adams area; past maintenance (e.g., ditches and culverts) has been poor resulting in sediment input into the Adams River.

An overview assessment of the Upper Adams River indicates that bank erosion along the mainstem contributes to sediment input below Tum Tum Lake (NHC and Urban Systems 1995). Goat and Harbour creeks are unstable on the fans, while snow avalanches and failures in the steep upper parts of the Sunset and Gold creeks appear to contribute significant quantities of sediment (NHC and Urban Systems 1995). The Upper Adams is an active system in its lower reaches possibly due to extreme freshet from rain on snow events (Panko, pers. comm.).

Agricultural activity is minimal, with some grazing observed on private land in the Burton Creek watershed.

The Kamloops Land Resource Management Plan (KLRMP) has designated the valley bottom of the Upper Adams drainage as a protected area (KLRMT 1995). However, while the River's valley floor will be excluded from any future development, logging may continue in the watershed.

Sinmax Creek

Sinmax Creek flows into the lower Adams 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 a similar timing as the Adams River run, suggesting that they may be of Adams River origin. Coho rearing area in Sinmax Creek is limited; this species is on a declining trend typical of most interior coho stocks.



Photo 5.1 Logging in the Upper Adams drainage, 1992. (L. Jaremovic)

Logging is extensive in the Sinmax Creek watershed. Logging on Crown lands is conducted north of Sinmax Creek, while logging on private lands takes place mainly adjacent to the Creek. Degradation of riparian zones due to past logging activities has led to bank instability and associated sediment input.

Timber removal for conversion of land to agricultural use has been high, and the entire creek length with adjacent riparian zones has been affected by agricultural use (Grace, pers. comm., Panko, pers. comm.). Landowners have installed several bridges and channelized the Creek in several places (Panko, pers. comm.). Extreme water withdrawal is a concern for this Creek (Doyle, pers. comm., Maricle, pers. comm.) Water quality is moderate to poor due to siltation from agricultural activities (nutrient input, run off, fertilizer and chemical use). Poor water quality is a concern to the residents (Sinmax is a community watershed), and can also affect downstream fish stocks, including kokanee which spawn along the Adams Lake shoreline adjacent to the Creek.

The sediments carried downstream have resulted in an accelerated development of the fan entering Adams Lake. During years of low flows, returning spawners may experience difficulty entering the Sinmax Creek. To increase the flow and improve fish passage, local landowners have occasionally deepened one of the channels in the fan and blocked smaller channels (Panko, pers. comm.).

Mining activity in the area has been extensive due to the development of a mine by Minnova Resources. Water quality is a concern due to potential input of heavy metals and nitrogen to the system from the Samotosum, Reagold and Homestake mines (Sigma Engineering Ltd. 1991, Doyle, pers. comm.). This concern is being addressed through a new wastewater treatment facility (Panko, pers. comm).

Recreational activity is high at the lower end of the Creek (mainly as an extension of Adams Lake recreational use), with private cabins situated along the lowest 200-300 m of the Creek. An extensive road network is present in the system, and the numerous bridges crossing the Creek have impacted stream channel habitat and riparian vegetation.

Momich River and Cayenne Creek

Momich River and its tributary (Cayenne Creek) enter the upper Adams Lake. Sockeye and coho salmon utilize the Momich/Cayenne watershed, along with rainbow trout, bull trout and non-salmonid species. Sockeye from Cayenne Creek have been used as a broodstock to establish a sockeye run in the Upper Adams on the dominant cycle (1992).

Logging is the primary activity in this drainage. Some roads at high elevations (on the south side of Momich River) have contributed to gully failures due to road building, and the logging company is considering road deactivation (NHC and Urban Systems 1995). DFO and MELP have concerns regarding the continuing slope instability and effects on fish and fish habitat (Kosakoski, pers. comm.). A watershed assessment has been completed on the Momich system, and further stability and hydrological studies are underway.

Past logging in Cayenne Creek has been concentrated in the north-west upland areas, with little logging in the valley bottom. Leave strips of large cedar near the creek edge have blown down, and the area was subsequently salvage-logged. This has generally occurred well above the main salmon spawning area (Panko, pers. comm.).

A 1,650 ha portion of the Momich Lake area that encompasses the valley bottom has been classified under the KLRMP as a Protection Resource Management Zone (PRMZ). The objective for this zone is to protect viable, representative examples of B.C.'s natural diversity and recreational opportunities, and to protect special natural, cultural and recreational features. The management category for the Momich Lake area is "Natural Environment". One of the main planning issues is road access (KLRMT 1995).

Management Priorities

An important management objective for the Upper Adams River is rebuilding its salmon populations, particularly the historically dominant sockeye run. Management priorities for this system include protecting habitat and water quality, rehabilitating watershed from past logging impacts, and minimizing impacts from future logging activities. Management objectives for Sinmax Creek include reestablishing riparian habitat, reducing sediment input, increasing channel complexity and ensuring fish access to the Creek.

Strategies

- Review IWAPs for the Upper Adams, Momich and Cayenne watersheds to guide future logging activities and identify restoration opportunities.
- Defer logging in the Momich watershed pending review of completed IWAP and stability assessments, and the development of recommendations to prevent further slope failure.
- Review and develop programs to remedy site-specific impacts (Northwest Hydraulic Consultants Ltd 1995) on the Upper Adams and tributaries and prioritize the sites (e.g., Burton Creek requires restoration of fish habitat). Programs will involve restoration of riparian vegetation, landslide rehabilitation, improvement to bridges or crossings and bank stabilization.
- Develop a road access plan for the Upper Adams watershed. Deactivate or upgrade / maintain logging roads, restore riparian zones by planting, and where possible, restore areas of terrain instability impacted by past logging activity (through WRP).
- Continue sockeye rebuilding efforts through transplants to the Upper Adams. Also continue to monitor the transplanted chinook population.
- Develop stewardship arrangements with landowners along the Sinmax Creek to reclaim lost riparian areas (replanting, cattle fencing), stabilize eroding banks (using bioengineering techniques), and mitigate impact of poorly designed roads and bridges. Increase landowner awareness of the importance of riparian vegetation, habitat complexity and adequate instream flows.
- Determine instream flows for Sinmax Creek and assess storage opportunities prior to considering further water withdrawals.
- Apply DFO/MELP Land Development Guidelines to recreational developments at the mouth of Sinmax Creek.
- Ensure fish access to Sinmax Creek during low fall flows. Assess fish barriers that may be restricting upstream access to Cayenne Creek.

5.3 SHUSWAP LAKE SYSTEM

(including Scotch Creek, Onyx Creek, Ross Creek, Seymour River, McNomee Creek, Hunakwa Creek, Anstey River, Eagle River and its tributaries -- Owlhead, Perry and South Pass creeks; Reienecker Creek and Tappen Creek).

Shuswap Lake (including Mara Lake)

The Shuswap Lake system includes the four arms of Shuswap Lake (Main, Anstey, Seymour and Salmon), as well as Mara Lake. The Shuswap Lake supports a significant population of lake-spawning sockeye. This lake system also support diverse and important fish populations that include chinook, coho, rainbow trout, kokanee, lake , mountain whitefish, lake whitefish, burbot, bull trout; as well as many non-sportfish species (e.g., carp, redsided shiners, sculpins, leopard dace, longnose dace, northern squawfish, suckers and peamouth chub) (Stewart et al. 1989, Fedorenko and Pierce 1983, Goodlad et al. 1974).

Salmon spawn in the fall (trout in the spring) in tributaries to the lakes. Shore spawning of sockeye is observed in many areas of the Shuswap Lake, with concentrations in the Main Arm. Lake char spawn in the fall in shoal areas associated with lakeshores. Eggs incubate during the winter. 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 summer temperatures increase, 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.

The primary resource use on the Shuswap and Mara lakes is settlement and recreation. This includes medium-density residential developments around the lakes and a significant expansion of the houseboat industry centered in Sicamous Narrows (Photos 5.2, 5.3). Although a foreshore plan is in place, development pressure is affecting the habitat (G. Kosakoski, pers. comm.). Urbanization and nutrient input from Salmon River have compromised water quality in the Salmon Arm. Also the lakeshore habitat has been compromised by the four log-storage sites on the Lake (at Lee Creek near Adams River, at Albas in Seymour Arm, near Herald Park, and the Federated Coop Mill adjacent to Canoe Creek).

Diking, dredging and filling, and construction of docks and breakwaters, have resulted in further loss of foreshore habitat (Photos 5.4, 5.5). The removal of gravel and cobble from shorelines to create sandy beaches also impacts salmon habitat. The potential effects on salmon of increased use of motorized watercraft on Shuswap Lake, have not been assessed. However, the increase in boating activity on the lake system has increased the spread of water milfoil. Although recent studies indicate that the presence milfoil may not impact salmonid spawning and rearing (Hatfield Consultants Ltd. 1996a, Stahlberg, pers. comm.), the removal of this weed for recreational reasons should be conducted in such a way as to minimize any impacts on fish.

Water quality is degraded from seepage of septic tank and agricultural wastes, chemical spills and log booming activities. Residential development of alluvial fans of tributary streams also impacts the lake foreshore and water quality. A recommended environmental strategy for Shuswap lake was developed by MELP in a 1986 Shuswap Lake Environmental Management Plan (MELP 1986).



Photo 5.2 High density development on Mara Lake. (B. Harding)



Photo 5.3 Houseboats on Shuswap Lake. (G. Kosakoski)



Photo 5.4 Foreshore fill on Shuswap Lake.



Photo 5.5 Foreshore disturbance on Mara Lake.

Management Priorities

Protection of water quality, foreshore and riparian habitats; protection of upland hydrologic integrity of Shuswap and Mara lakes; and development of foreshore management plans are the management priorities for these lakes.

Strategies

- Map existing habitat values along lakeshores, classify habitat, and provide development guidelines that can be incorporated into zoning and Official Community Plans of local governments (e.g., Sicamous Narrows and Blind Bay foreshore plan). Habitat classification is completed for the Main Arm (Hatfield Consultants Ltd. 1996b) and should be extended to the other lake arms. The management guidelines must incorporate the results of the habitat classification study.
- Work with local governments to implement zoning and foreshore management plans that recognize and protect fish habitat (Fisheries Sensitive Zones).
- Work with local governments to develop and incorporate guidelines into bylaws. Guidelines would focus on issues such as stormwater management (stormwater sediment control), community intakes and sewer systems.
- Work with local governments to restrict / regulate the expansion of the houseboat industry in areas with high fish values, like Sicamous Narrows.
- Encourage better enforcement of existing legislation, such as the Soil Deposition Bylaw in the Municipal Act, to enable removal of unauthorized fills.
- Protect the integrity and water quality of tributary streams. These contribute greatly to the productivity of Shuswap Lake and influence sockeye spawning areas along the lake foreshore.
- Work with DOE, MELP and landowners to monitor and control non-point sources of water pollution (e.g., agricultural and domestic wastes).
- Ensure milfoil control does not impact on sockeye spawning areas.
- Ensure that log handling sites are consolidated at existing locations (Shuswap Lake log marshalling study).
- 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.

Shuswap Lake System Streams

The streams tributary to Shuswap Lake are typified by productive low-gradient lower reaches adjacent to the lake, and steeper upland portions. The lower reaches of many of the streams are subjected to high land use through urbanization, agriculture and linear development, while the upper reaches are subjected to logging activities. Obstructions on several of the streams (e.g., Seymour and Anstey rivers) block upstream fish passage.

Scotch Creek - Main Shuswap Arm

Scotch Creek enters Shuswap Lake at the lower end of Main Arm. Scotch Creek is an important sockeye producer (especially the early summer run), and both sockeye and coho utilize the lower creek reaches. Until recently, upstream migration has been impeded by a difficult passage located 16 km from the creek outlet; however in 1995, fish were observed above the falls (Kurtz, pers. comm.).

Logging activities in upslope areas constitute the major land use in this watershed (Photo 5.6); the current ECA status is 20% (Borrett Engineering Inc. 1995). The loss of streamside riparian buffers associated with logging cuts contributes to bank erosion, sedimentation and channel destabilization. Maintenance or deactivation are required for the majority of logging roads within the 647 km of road network constructed in the past 35 years (Borrett Engineering Inc. 1995). Fisheries concerns are related to channel shifting and sedimentation in lower reaches; these impacts are associated with changes in hydrologic regime, possibly due to past logging activities (Borrett Engineering Inc. 1995).

Recreational developments and rural settlements are located along the lower reaches of Scotch Creek and on the fan, with an Indian Reserve (Adams Lake Band) along the lower creek section. The lower reaches and the fan are unstable, with considerable braiding, woody debris and log jams present; possible channel re-routing during flood events could impact any development on the fan (Photo 5.7). Attempts have been made to re-route the Creek to protect urbanized areas (Doyle, pers. comm.) and to stabilize the channel through placement of large organic debris (e.g., programs conducted by the Shuswap Nations Fisheries Commission).

A Watershed Assessment (IWAP) has been conducted in preparation for restoration activities. An IWAP confirmed the high level of concern with roads and landslides, and a Level 2 Channel Assessment is underway. A Level 2 fish and fish habitat assessment conducted in 1995 indicated generally sub-optimal rearing values for rainbow trout; also riparian zones in some stream reaches have been reduced and require replanting (Grinton et al. 1994).

Management Priorities

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

Strategies

- Defer logging in Scotch Creek pending a roundtable review of a completed IWAP (to FPC standards).
- Conduct Level 2 Channel Assessment Procedure (CAP) to further assess stability of Scotch Creek and identify restoration opportunities.
- Restore riparian zones in logged upslope areas, deactivate old logging roads, and improve and maintain active roads (through 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.
- Explore the opportunity to open up old side channels on the Scotch Creek fan (work with Adams Indian Band and Federated Co-op). A side channel inventory to assess potential for offchannel habitat development is currently being conducted through FRBC.

Onyx Creek and Ross Creek - Main Shuswap Arm

Onyx and Ross creeks enter Shuswap Lake approximately halfway along the Main Arm. Both sockeye and coho utilize the streams. Sockeye are documented on the dominant Adams River cycle (DFO 1992b) and beach-spawn at the creek mouths. At Onyx Creek, an impassable cascade restricts salmon to the lower 2 km reach. Ross Creek is mostly dry in the summer (DFO 1992b) but may be utilized by coho and trout during their various life cycle stages.



Photo 5.6 Logging in Scotch Creek watershed, (B. Harding)



Photo 5.7 Foreshore and submerged vegetation near the mouth of Scotch Creek, August 1994.

Logging is extensive in the upper Onyx Creek watershed (current ECA status is 22%, Dobson Engineering Ltd. 1994) and may potentially affect channel integrity due to significant stream flow increases. There are debris avalanches throughout the system (Dobson Engineering Ltd. 1994) and landslides in the upper watershed due to road construction. The extensively logged Ross Creek also exhibits stream channel instability; however, this is likely the result of extensive forest fires (DFO 1992b, Doyle, pers. comm., Grace, pers comm.).

The high agricultural activity along Onyx Creek has resulted in impacts to the riparian zones and low instream flows (Maricle, pers. comm.). Increased erosion and reduced channel complexity are attributed to armouring of stream banks, removal of streamside vegetation and cattle access to stream banks. Water quality concerns are related to non-point source inputs of nutrients to the system (Sigma Engineering Ltd.1991).

Settlement activity along Onyx Creek is associated with agricultural use and with rural residential development along the lower reaches and on the fan of the creek. Riparian vegetation has been removed by landowners.

Agricultural activity is minimal in Ross Creek. However, the lower reaches are affected by residential development, and channelization by landowners has reduced riparian vegetation and decreased channel complexity. Residential development in this area also contributes nutrients from septic systems (Grace, pers. comm.).

Management Priorities

Management objectives for Onyx and Ross creeks are to restore riparian vegetation in upslope areas and along lower reaches, improve instream flows and water quality, and ensure no adverse effects on lakeshore spawning and rearing habitat.

Strategies

- Revegetate streambank sections in previously logged upslope areas, deactivate old logging roads and upgrade / maintain active roads, and ensure that future road development does not increase risk of landslides (through WRP process).
- Promote stream stewardship arrangements with local landowners to revegetate stream banks along the lower reaches. Bank stability efforts should utilize bioengineering techniques, where feasible, to reduce the loss of habitat through channelization.
- Restrict further developments on the fans of Onyx and Ross creeks.
- Ensure that future water withdrawals do not create critical summer low flows and do not affect beach spawning on the fans.

Seymour River- Seymour Arm

Seymour River enters Shuswap Lake at the head of Seymour Arm. This River is an important sockeye producer (early summer run). Chinook and coho salmon are also observed. A falls restricts anadromous salmon and resident trout to the lower 14.6 km of the River. The McNomee Creek, a tributary to Seymour River, is utilized by sockeye and coho salmon spawners. An impassable barrier restricts anadromous fish passage to the lower 8.7 km of the Creek. A Level 2 fish and fish habitat assessment conducted by MELP in 1994 has indicated that the system has high habitat values in the lower reaches (Murdoch and Nishimura 1995).

Logging in the Seymour River Valley is currently concentrated at lower elevations (Photo 5.8), with upslope logging planned for the future. There are high concerns that forest related impacts (e.g., changes in hydrology and increased sedimentation) could affect fisheries resources (Grace, pers. comm., Kosakoski, pers. comm., Maricle, pers. comm.). Inputs from Ratchford Creek (tributary to Seymour River) have resulted in downstream sedimentation, scouring and channelization that risk downstream fish habitat. Riparian habitat of Ratchford Creek has been reduced by past logging (Murdoch and Nishimura 1995).

Logging activity in McNomee Creek has also been high. Construction of new logging roads is a major concern due to the risk of downstream sediment transport affecting fish habitat in the lower reaches.

Other resource use activities are limited, although some settlement and recreational activity is noted along the lower reaches of Seymour River and McNomee Creek where salmon habitat values are the highest.

Management Priorities

Protecting existing habitat conditions, restoring impacted areas, and rebuilding local salmon stocks are the objectives for the Seymour system.

Strategies

- Complete and review an IWAP (to FPC standards) on Seymour River and McNomee Creek, and conduct additional assessments (FHAPs, CAPs and terrain stability mapping) as required, to guide future logging activities to prevent watershed impacts.
- Restore upslope areas through revegetation of stream banks; and deactivate or upgrade and maintain logging roads (through WRP). Ratchford Creek which contributes significant bedload to the system, should be the focus of restoration efforts. A watershed assessment initiated on McNomee Creek, will help define areas where restoration efforts should be directed.
- Apply DFO/MELP Land Development Guidelines to recreational and urban developments along the lower Seymour River.

Hunakwa Creek - Anstey Arm

Hunakwa Creek enters Shuswap Lake at the head of Anstey Arm. The lower creek reaches are buffered by Hunakwa Lake. The Creek is utilized by sockeye and coho salmon, with sockeye contributing the majority of spawners. Records indicate two sockeye stocks in Hunakwa Creek, an early (August to September) stock and a late (September to October) stock (DFO 1992b).

Logging is the major resource use in Hunakwa Creek, although currently there is little documented impact from this activity (Sigma Engineering Ltd. 1991, Kosakoski, pers. comm., Maricle, pers. comm.). Although resource use in the system is minor, low flows during both winter and summer are noted (Rood and Hamilton 1995). Beaver activity in the area has resulted in ponding of water and is also restricting upstream fish access.

An application to list Hunakwa Creek as a protected area has been forwarded under the Okanagan Shuswap Land Resource Management Plan for the area (Maricle, pers. comm.).



Photo 5.8 Extensive logging in the Seymour River Valley, 1994. (MELP)

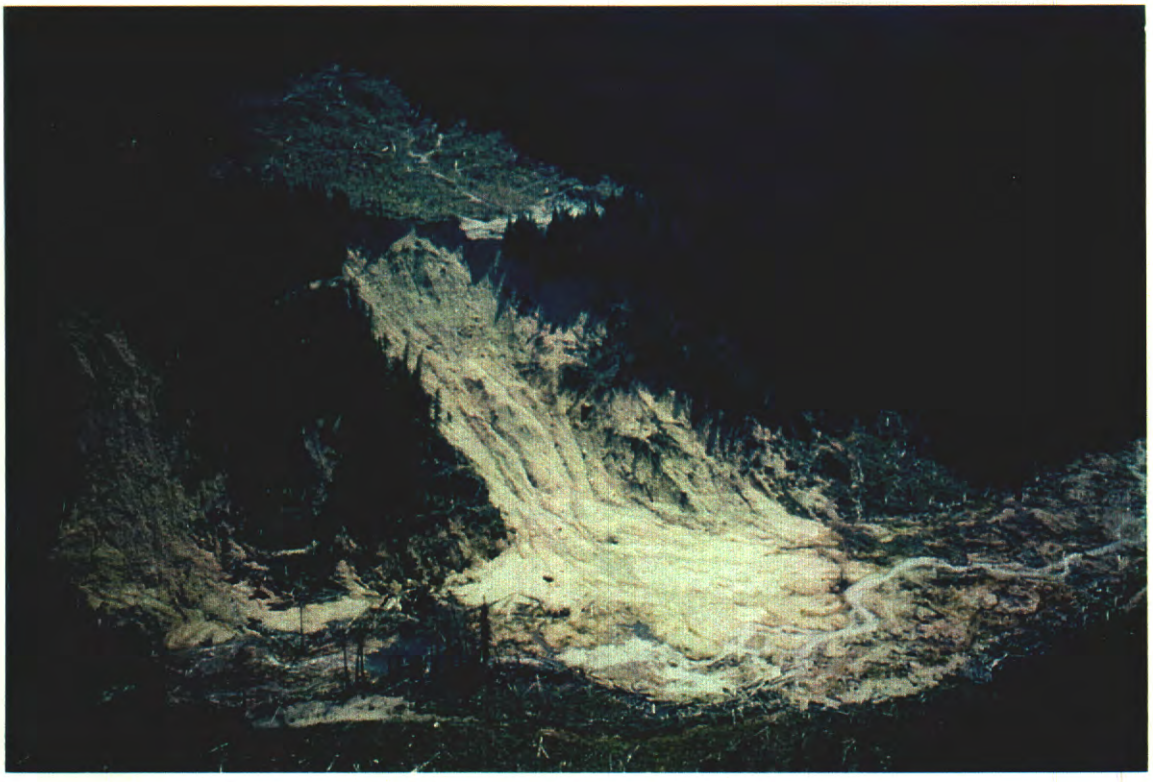


Photo 5.9 Slope erosion below a clearcut on a tributary to the Anstey River, 1994. (MELP)

Management Priorities
Protecting fish habitat and rebuilding salmon stocks have been identified as management priorities for this system.

Strategies
- Assess impacts of logging and conduct restoration activities in upslope areas impacted by logging (through IWAP).
- Monitor beaver activity to ensure access to upstream areas.

Anstey River - Anstey Arm

The Anstey River enters Shuswap Lake at the head of Anstey Arm. Sockeye are the dominant salmon stock, with chinook, coho and pink salmon also utilizing the system. Resident fish species include rainbow trout, bull trout and kokanee. A barrier at km 5.7 from the creek mouth restricts upstream fish passage.

Logging is the main resource use in this remote tributary of Shuswap Lake. Recent logging activity is creating major instability problems (Photo 5.9) in the lower watershed where fisheries values are the highest (DFO 1992b, Maricle, pers. comm.). Logging in headwater areas could severely impact water quality in tributaries, and subsequently in Anstey River and foreshore areas of Anstey Arm (Maricle, pers. comm., MELP 1986). Logging has resulted in riparian loss and risk to channel stability (Kosakoski, pers. comm., Kurtz, pers. comm.).

Management Priorities
Management objectives for this system focus on rebuilding salmon stocks and reducing the risks of increasing terrain instability due to logging.

Strategies
- Initiate an IWAP (to FPC standards) to assess logging impacts and to guide future logging activities to prevent watershed impacts.
- Revegetate riparian vegetation lost as a result of past logging practices. Deactivate old logging roads, and upgrade / maintain active roads.
- Determine terrain instability problems and avoid construction of new logging roads in erodible areas. Assess terrain instability problems in Myass Creek to determine the feasibility of stabilization initiatives.

Eagle River- Sicamous Arm

The Eagle River enters Shuswap Lake at the south end of Sicamous Arm, just north of the municipality of Sicamous. This River supports the largest coho population in the HMA, as well as a significant chinook population (coho escapements declined markedly in recent years, Append. A-5). Sockeye (early summer and late runs) and pink salmon are also observed. The Eagle River Hatchery has operated from the mid-1980s to the early 1990s with the goal of increasing chinook and coho production.

The lower reaches of Eagle River show degradation of riparian habitat due to agricultural, residential, industrial and linear development. Past clearing of land, and more recently channelization by land owners, have contributed to riparian degradation (Kurtz, pers. comm.).

Residential development is observed throughout the Eagle valley bottom which also serves as a transportation corridor. The Canadian Pacific Railway and the widened Trans-Canada Highway have resulted in channelization of some river sections, degradation of riparian zones, and loss of offchannel habitat along right-of-ways. To offset the loss of habitat between Malakwa and Cambie towns, compensatory rearing ponds for coho were developed by Ministry of Transportation and Highways (MOTH). The three sawmills located along the Eagle River have led to degraded streamside vegetation due to bank protection initiatives.

The above developments have resulted in an overall loss of channel complexity, especially offchannel habitat which is particularly important to coho salmon. There are also water quality concerns in the lower Eagle River due to non-point source inputs and the potential for toxic spills along highway and railway corridors (Grace, pers. comm., Kosakoski, pers. comm.).

Logging has impacted the upper Eagle watershed. Cutblocks and road development activities in this area, particularly in tributaries, have contributed sediment to the lower reaches of Eagle River (Rood and Hamilton 1995, DFO 1992b, Kosakoski, pers. comm.). The terrain in the upper watershed is unstable, a problem which can be exacerbated by road building and timber removal (Kosakoski, pers. comm., Kurtz, pers. comm.) Logging activities and channel destabilization are a concern in some of the tributaries due to the presence of a rare stock of cutthroat trout (Yellowstone cutthroat) (Maricle, pers. comm.).

Owlhead Creek

Owlhead Creek enters the Eagle River approximately 5 km from the River mouth. Spawning and rearing by coho, as well as limited rearing by chinook, are observed in the lower creek reaches (DFO 1992b).

Logging in the upper Owlhead watershed has resulted in flooding and sediment deposition (Sigma Engineering Ltd. 1991, Kosakoski, pers. comm., Kurtz, pers. comm.). Residential development and agricultural activity in the lower watershed have led to potential water quality concerns, particularly due to non-point source pollution from intensive cattle use. Landslides in the upper watershed, and logging and other activities have impacted the riparian zones and stream bank integrity, and resulted in a high degree of bedload movement and raising of streambed.

The Trans-Canada Highway crosses the Owlhead Creek. Fish passage problems were reported at a culvert under the highway. These problems were alleviated when local fish and game club members modified the culvert (Kurtz, pers. comm.). Concerns exist that future highway expansion may aggravate fish passage problems and impact the riparian zone.

Perry River

Perry River enters the Eagle River near Craigellachie. This tributary is used by sockeye and chinook spawners, with some coho rearing observed in the lower 2 km. A partial obstruction approximately 6 km upstream of the mouth may restrict fish passage at some water levels. Fisheries production in Perry River may be low due to glacial melt and cold water temperatures (Lewis 1986).

Logging in upslope areas has contributed to loss of riparian habitat and channel degradation (Sigma Engineering Ltd. 1991, Kurtz, pers. comm.). Channel instability is high due to steep valley walls in upland areas, and channel movement has taken place as a result of logging activities and the input of large woody debris into the system (Doyle, pers. comm.).

South Pass Creek

South Pass Creek includes the 3 Valley Lake and enters the Eagle River upstream of Perry River. Coho and sockeye utilize the Creek, and are restricted by an impassable falls 1.2 km upstream of the creek mouth.

Logging in the upper watershed is the major land use. Continued logging activities including road building, can further destabilize the numerous slides and avalanche chutes in the upper watershed (Sigma Engineering Ltd. 1991, Doyle, pers. comm., Maricle, pers. comm.). Additional concerns arise from the potential expansion and encroachment of the Trans-Canada Highway .

Management Priorities

Management priorities for the Eagle River include protecting and restoring riparian corridors and offchannel habitat; improving instream habitat complexity; and reversing the decline in salmon stocks, particularly coho. A high priority is the protection of the Eagle River habitat in relation to future development, specifically the Trans-Canada Highway expansion. Objectives for the Perry and South Pass systems include the reduction of bedload and sediment contribution to the Eagle River. For the Owlhead Creek, stream and riparian restoration are a priority.

Strategies

- Complete and review IWAPs (to FPC standards) on Perry and Eagle rivers, and conduct additional assessments (FHAPs, CAPs, Terrain Stability Mapping) as required, to guide future logging activities to prevent watershed impacts.
- Initiate an IWAP (to FPC standards) on Owlhead Creek to assess past hydrological impacts, implement restoraton initiatives, and guide future logging activities to prevent watershed impacts.
- Inventory and classify riparian vegetation and juvenile rearing habitat along the Eagle River (offchannel habitat, small tributaries, wetlands, groundwater fed channels), and develop guidelines for habitat protection and restoration.
- Promote stream stewardship to revegetate stream banks and increase awareness of the importance of protecting streamside vegetation and critical rearing habitats. Reestablish riparian corridor in Owlhead Creek, including replanting and fencing livestock away from the Creek.
- Assess fish habitat and utilization of Perry River.
- Revegetate 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).
- Monitor fish passage at the Owlhead Creek culvert previously modified to restore fish passage under the highway.
- Assess potential impacts of future highway expansion, and ensure there is no encroachment and loss of rearing habitat (i.e., offchannel habitat, small tributaries, etc.).
- Ensure that contingency plans for toxic spills are in place.

Reienecker Creek - Salmon Arm

Reienecker Creek enters the Salmon Arm of Shuswap Lake. Sockeye are the only anadromous species in the area, and spawn at the creek mouth on the dominant Adams cycle (1994 year). Lake spawning sockeye are concentrated along the shoreline near the Reienecker Creek outlet. Both kokanee and rainbow trout also spawn at the creek outlet.

The concern to fisheries resource in this system is the sedimentation of egg incubating substrate. The considerable logging activity in the western portion of the watershed (DFO 1992b, Sigma Engineering Ltd. 1991) has resulted in degraded riparian zones, while construction and operation of logging roads contribute sediments to the system and affect the survival of incubating eggs.

The Herald Park campsite and campground are located at the mouth of Reienecker Creek, with trails running along the Creek.

Management Priorities

Protecting habitat and water quality of Reienecker Creek, and protecting the prime sockeye spawning area along the lakeshore adjacent to the creek outlet, are the management objectives for this Creek.

Strategies

- Restore riparian vegetation affected by past logging practices; deactivate old logging roads and maintain active roads (through WRP).
- Develop an interpretative stream program in association with Herald Park staff, to educate the public on the importance of streams and lake foreshore areas to fisheries resources.
- Ensure that milfoil control activities do not impact on sockeye beach spawning.

Tappen Creek - Salmon Arm

Tappen Creek enters the northwest end of Salmon Arm. Both coho and sockeye utilize this system, along with resident rainbow trout. Fish use is concentrated in the lower several kilometres of the Creek (below a dam at an abandoned CPR weir and a culvert at 1.7 km above the creek mouth that is impassable at high flows).

Fish habitat is impacted by extensive logging in the upper watershed, and agricultural and residential development in the lower reaches. The upslope logging has resulted in reduction of riparian streamside vegetation, and in sediment input from construction and operation of logging roads. The residential and agricultural activity in the lower reaches has led to degraded riparian conditions and reduced channel complexity. High bank instability in the lower reaches has contributed to localized erosion, while cattle activity has led to stream bank degradation and water quality concerns over non-point source inputs. Additional water quality concerns arise from possible leaching of contaminants into the Creek from a landfill located about 10 km away from the system (Kosakoski, pers. comm.). Water withdrawals for irrigation purposes raise concerns over water flow levels (Rood and Hamilton 1995, Kurtz, pers. comm.).

Management Priorities

Restoration of riparian vegetation, improvement of water quality and quantity, and provision for good upstream passage of fish are the management objectives for Tappen Creek.

Strategies

- Restore upslope areas impacted by logging through road deactivation and/or maintenance, riparian planting in affected areas and stabilization of terrain (through WRP process).
- Control siltation from stream banks and explore the use of bioengineering techniques.
- Promote stream stewardship programs to revegetate and fence livestock away from stream banks.
- Determine instream flow requirements, and monitor water withdrawals to ensure compliance with water licences, particularly during periods of low summer flows. Restrict further water licensing.
- Upgrade the culvert at 1.7 km upstream of the creek mouth, to allow fish passage at all water levels.

5.4 SALMON RIVER SYSTEM (including Salmon River, Bolean Creek and Canoe Creek)

Salmon River and Bolean Creek

The Salmon River flows into Shuswap Lake at the head of Salmon Arm, near the municipality of Salmon Arm. Bolean Creek enters Salmon River at the municipality of Falkland.

Salmon River supports the second largest coho population in the HMA (after Eagle River) and is an important chinook producer (coho escapements declined markedly in recent years, Append. A-5). In addition, late run sockeye return to the River on the dominant 1994 Adams River cycle (historical summer runs of Salmon River sockeye had been decimated following the Hell's Gate landslide of 1913). The Salmon River near Westwold runs below surface during low flow periods presenting a natural barrier to migrating salmon (Rood and Hamilton 1995).

Bolean Creak is a major producer of rainbow trout in the Salmon River system, and is also utilized by coho salmon which spawn from the creek mouth to approximately 6.4 km upstream (DFO 1992b). Juveniles likely rear throughout the system, with fish distribution affected by location of beaver dams. Beaver activity restricts upstream passage in the Creek.

The Salmon River watershed has been severely impacted by upslope logging practices, extensive agricultural activity and residential development. Habitat degradation has resulted from removal of riparian vegetation, sediment input, channelization, water withdrawal (including groundwater), and water quality deterioration from nutrient input (Quadra Planning Consultants 1995, Aquametrix Research Ltd. 1989). Linear development (highways, roads, and gas, railway and hydro lines) is also extensive in this watershed.

The loss of riparian vegetation in Salmon River (Photos 5.10, 5.11) is the single most important cause of increased bank erosion, sediment transport and sediment accumulation in the area between Westwold and Salmon Arm (Miles 1995). Beeson and Doyle (1995) analyzed four interior streams, including Salmon River, and concluded that non-vegetated stream bends were almost 5 times more likely to undergo detectable erosion as vegetated bends. Other concerns affecting coho habitat are the increase in water temperature due to loss of streamside shade, increased channel width and reduced stream flow (due to irrigation withdrawals); loss of habitat complexity (e.g., loss of pools, large woody debris, undercut banks and overhanging cover); and nutrient loading during early melt / runoff periods.



Photo 5.10 Riparian loss and erosion along Salmon River. (G. Kosakoski)



Photo 5.11 Landowner cutting riparian vegetation to improve view of Salmon River. (M. Crowe)

Settlement is mainly rural and associated with agricultural activity, except for a concentration of people / communities at Falkland and at Silver Creek. Impacts from agricultural activities are added to impacts from urbanization that include seepage from septic tanks and discharge of chlorinated domestic sewage into Shuswap Lake (from the Village of Salmon Arm near the mouth of Salmon River) (DFO 1992b). Nutrient inputs from Salmon River have affected water quality in Salmon Arm which exhibits a much higher trophic status than the remainder of Shuswap Lake (MELP 1986).

Concerns for the Salmon River watershed have resulted in the formation of the Salmon River Roundtable in 1992. This is a partnership of stakeholders (public, industry, government and First Nations) working to restore and maintain a healthy Salmon River watershed. Projects involve water use allocation, groundwater legislation, water quality protection, rebuilding of fish stock and protection and restoration of fish habitat, restoration of riparian cover (Photo 5.12), erosion control, and land use practices in forestry, farming and ranching. Cooperative efforts between the DFO, Roundtable and landowners have resulted in a major restoration program involving tree revetments, fencing, revegetation and bank stabilization, with the overall goal to create a healthy and stable riparian corridor. A multi-year WRP study was initiated in 1996 to identify logging related impacts and develop restorative treatments for these impacts.

Management Priorities

Rebuilding of coho stocks and habitat restoration, including improvement of water quality and instream flows, are the management priorities for Salmon River.

Strategies

- 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.
- Continue to develop a riparian corridor along the Salmon River by protecting existing vegetation, stabilizing and revegetating stream banks, and fencing livestock away from stream banks.
- Stabilize upslope areas affected by past logging practices, through road deactivation and/or maintenance, riparian revegetation of stream banks, and slope stabilization (through WRP process).
- Increase habitat complexity by creating additional pool and offchannel habitat, and identify opportunities to redevelop lost wetland.
- 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.
- 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.
- Apply DFO/MELP Land Development Guidelines for urban developments.
- Continue to work with Salmon River Roundtable to promote public awareness and educate user groups on the importance of riparian restoration in the Salmon River watershed (e.g., shade, temperature, nutrients, bank stability, pools), and the resulting benefits to landowners.
- Monitor the effectiveness of restoration programs.



Photo 5.12 School volunteers planting at a restoration site on Salmon River. (M. Crowe)

Canoe Creek

Canoe Creek enters the Salmon Arm of Shuswap Lake approximately 10 km east of the Salmon River outlet. Sockeye, coho and rainbow trout utilize this system. Fish access is restricted by a poorly installed culvert located approximately 4.5 km upstream of the creek mouth.

Logging in the upper watershed is impacting downstream areas through increased sediment input from construction and operation of logging roads, and from stream banks that have lost riparian vegetation (DFO 1992b)

Agriculture activities are intensive and include livestock grazing and crop production. These have resulted in a loss of streamside cover, reduced flows, and water quality deterioration due to non-point pollution sources (Sigma Engineering Ltd. 1991, Kosakoski, pers. comm.). Water withdrawals are high and contribute to summer low-flow problems (Rood and Hamilton 1995).

Urbanization is mainly rural/residential in the upper areas, and is generally associated with agricultural operations. Canoe Creek is a community watershed providing the domestic water supply for the Salmon Arm area (Doyle, pers. comm.). A well developed road system parallels the Creek.

Management Priorities

Restoration of riparian vegetation, improvement of water quality and instream flows, and improvement of upstream fish access are the management priorities for Canoe Creek.

Strategies

- Initiate IWAP (to FPC standards) to assess logging related impacts in upslope areas and develop restoration initiatives.
- Promote stream stewardship to restore riparian vegetation by replanting streamside vegetation and fencing livestock away from stream banks.
- Protect eroding stream banks through bioengineering techniques, to maintain habitat complexity, where appropriate.
- 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.
- Upgrade culverts that restrict fish passage, and assess other fish passage problems (e.g., beaver dams).

5.5 LOWER SHUSWAP RIVER SYSTEM
(from Mabel Lake to Mara Lake, including Lower Shuswap River and tributaries--Johnson, Blurton, Fortune, Trinity, Kingfisher and Danforth creeks)

The Lower Shuswap River is a major producer of sockeye and chinook salmon (see below). Impacts from agriculture and urban development are the main concerns in the Lower Shuswap basin (downstream of Enderby), while impacts from logging are the main concern in the upper tributaries. Habitat in the smaller tributaries of this system has been impacted to a greater extent than in the mainstem. This is because the effect of riparian loss on stream hydrology and temperature regimes is often greater in small tributaries than in larger lake-fed mainstems.

However, the fisheries values in the Shuswap mainstem are significant and must be considered in the development of any land use plans.

Lower Shuswap River

The Lower Shuswap River flows from Mabel Lake to Mara Lake. This River is the largest chinook producer in the HMA and a major producer of late-run sockeye (nearly one million sockeye spawners recorded in 1990). Coho salmon also spawn and rear in the system (primarily in tributary streams). The documented presence of pink salmon represents the edge of their current range.

The Lower Shuswap River is valued for the spawning and early rearing habitat. Consequently, any environmental impacts (e.g., sedimentation during incubation period or degradation along river margins) could potentially impact the River's fish stocks. Sockeye spawning in the system produce fry that migrate upon emergence, immediately downstream into Mara Lake. Emergent chinook fry rear in streamside grasses, then also migrate downstream into Mara Lake. The current enhancement activities include the Shuswap River Hatchery and a small hatchery on Kingfisher Creek, both of which focus on chinook production.

The valley bottom of Lower Shuswap has been logged historically, and much of this land is currently used for agriculture and rural residential development. Although direct logging impacts on the mainstem are low, the significant logging in the tributary basins represents potential risks to the downstream fisheries resources. Consequently, the overall concern over logging in the Lower Shuswap drainage is high.

Cattle grazing and crop production have contributed to the removal of much of the riparian cover, resulting in bank erosion, particularly along the lower reaches downstream of Enderby (Jantz, pers. comm., Jensen, pers. comm.). Streambank vegetation has been trampled by cattle, resulting in erosion and sedimentation. Sediment inputs from non-point sources are noted along the length of the river (Jantz, pers. comm., Townson, pers. comm.).

The considerable urbanization along the lower Shuswap River is mainly rural residential. There are also several small communities and the municipality of Enderby. The latter discharges treated sewage into the River, while the smaller settlements contribute to non-point source pollution.

Recreational activity is of low impact and generally associated with canoeing and fishing. A chinook sport fishery has been developed on the Shuswap River as a result of increases in Shuswap Hatchery returns. Fishing takes place upstream from Enderby but is concentrated mainly in the upper section, below Skookumchuck.

Management Priorities

Due to the high fisheries values, protection of the river corridor is a major management priority. Maintaining good gravel and water quality, and restoring riparian zones are the management objectives for the Lower Shuswap River.

Strategies

- Inventory riparian zones along the River and develop a riparian restoration plan (in cooperation with land users) that includes revegetation of stream banks and fencing cattle away from streams.
- Protect Shuswap River habitat by restoring tributary systems affected by past logging activities (through WRP).
- Continue operation of the Shuswap River Hatchery.
- 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.

Johnson Creek and Blurton Creek

Johnson Creek enters the Lower Shuswap River immediately upstream of Mara Lake, while Blurton Creek enters the River about 3 km upstream of Mara Lake. Coho are documented in both the Johnson Creek (lower 1 km) and Blurton Creek (lower reaches below a cascade at 1.5 km from the mouth) (DFO 1992b).

Logging activity is high in upslope areas of both creeks although little information is available on logging related impacts. Agricultural activity is noted along the lower salmon-producing reaches of Johnson Creek. The lower reaches of Blurton Creek are utilized for alfalfa production, dairy farming and hog production. This Creek has been noted for summer and winter low flows (Rood and Hamilton 1995).

Management Priorities

Management objectives for Johnson and Blurton creeks are the protection and restoration of riparian and instream habitat.

Strategies

- Promote stewardship programs to inventory fish populations and habitat utilization, assess and restore riparian habitat, and improve instream flows and fish migration access.
- Initiate IWAP (to FPC standards) to assess logging impacts in upslope areas and implement restoration activities (through WRP).

Fortune Creek and Trinity Creek

Fortune Creek flows into the Lower Shuswap River near the municipality of Enderby. Trinity Creek enters the Lower Shuswap near the town of Ashton Creek, upstream of Enderby.

Rearing coho, chinook and rainbow trout have been documented in Fortune Creek, and coho spawning is suspected in the system (DFO 1992b). In Trinity Creek, coho, chinook and kokanee have been documented to spawn; anadromous fish are confined to the lower reaches due to a poorly designed culvert (1.4 km from the mouth) and a falls (1.8 km from the mouth). In addition, bull trout, rainbow trout and mountain whitefish have been documented in Trinity Creek (DFO 1992b).

Fortune Creek has been heavily impacted throughout its length. The upper watershed has been logged and the lower reaches have been dredged and channelized. Agricultural activity, including

beef and dairy operations, is extremely high, and the riparian zones along the lower reaches have been extensively degraded by removal of streamside vegetation (Jantz, pers. comm.). The Municipality of Armstrong withdraws water from Fortune Creek and stores it in two natural lakes (Wagner, pers. comm.). Water withdrawal results in low summer flows and consequently higher water temperatures, with a range of 6°C between vegetated and unvegetated areas. The increased water temperatures place rearing salmonids at risk (Fortune Creek FCSB 1994, DFO 1992b, Jensen, pers. comm.).

In Trinity Creek, logging in the upper watershed has resulted in channel changes in downstream reaches (McRae, pers. comm.). Grain and dairy farming are conducted along the valley bottom, and streamside vegetation has been degraded due to agricultural use (Kosakoski, pers. comm., Kurtz, pers. comm., Nuttal, pers. comm.). Both summer and winter low flows have been noted for Trinity Creek (Rood and Hamilton 1995).

Management Priorities

Reestablishment of riparian vegetation, improvement of instream flows, reduction of erosion and sedimentation, and restoration of habitat values to the system are the management objectives for the Fortune and Trinity creeks.

Strategies

- Promote stewardship initiatives with landowners to inventory riparian vegetation and develop a riparian restoration plan; include revegetation of stream banks and fencing cattle away from the banks.
- Increase awareness of stakeholders on the importance of streamside vegetation for aquatic ecosystems. Control bank erosion by using bioengineering methods, where feasible. Continue to work with local groups, such as the Spallumcheen Indian Band, in stream restoration initiatives, and the Armstrong Fish and Game Club who have released coho into this system.
- Conduct IWAP (to FPC standards) on Fortune and Trinity creeks to assess logging impacts in upland areas and implement restoration measures (through WRP).
- Assess upstream habitat and migration blockages in Trinity Creek, and develop bypass facilities around barriers if feasible.
- Assess for Fortune and Trinity creeks the feasibility of using flow control for storage and release opportunities to improve instream flows for fish.

Kingfisher and Danforth Creeks

Kingfisher Creek enters the Lower Shuswap River approximately 1.4 km downstream of Mabel Lake. Danforth is a tributary to Kingfisher Creek, and enters it approximately 10 km upstream of the mouth. Coho salmon, as well as rainbow trout, are documented in these two creeks. Coho spawn in the middle reaches of Kingfisher Creek and in the lower 2 km of Danforth Creek. The small hatchery on Kingfisher Creek in run by the Kingfisher Community Club.

Forestry is the major resource use in the watershed, with extensive logging in the upper areas. This has resulted in altered hydrology and degraded riparian cover, both of which may potentially affect downstream fisheries (Sigma Engineering Ltd. 1991, Jantz, pers. comm., Kosakoski, pers. comm.). Valley walls in the drainage are classified as unstable, although Danforth Creek is more stable than Kingfisher (Jantz, pers. comm.). Hunter Creek, a tributary to Kingfisher, contributes a high amount of bedload to Kingfisher Creek during freshets, thereby affecting downstream

fisheries production (Rood and Hamilton 1995).

The major sediment input comes from the tributaries to Kingfisher Creek (Summit Environmental Consultants Ltd. 1995). Several cases of accelerated bank erosion, associated with large accumulations of woody debris, were noted on the mainstem. Woody debris also frequently blocks access to side channels used by fish (Summit Environmental Consultants 1995). However, these impacts are counterbalanced by creation of pools in some areas. The negative and positive impacts of woody debris on stream habitat need to be addressed in the restoration plans. Major flooding occurred in 1997 and the severity of impacts is related in part to past logging (Kosakoski, pers.comm.).

The B.C. Hydro ROW crossing the lower Danforth Creek, has raised some concerns over herbicide input into the Creek (Jantz, pers. comm.).

Management Priorities

Restoration of riparian zones and instream habitat, as well as access to upstream habitat, are the management objectives for Kingfisher and Danforth creeks.

Strategies

- Conduct IWAPs (to FPC standards) on Kingfisher and Danforth creeks to assess past logging impacts and prevent further logging impacts.
- Focus on restoration of upper watershed; deactivate or maintain logging roads, revegetate streambank areas impacted by past logging practices, and stabilize eroding slopes, where practical (through WRP).
- Remove / bypass obstructions to upstream fish passage, including a series of beaver dams in the lower Danforth Creek.
- Enhance coho through hatchery supplementation by the Kingfisher Community Club.

5.6 MIDDLE SHUSWAP RIVER SYSTEM
(Mabel Lake and upstream, including tributaries to Mabel Lake--Noisy, Wap and Tsuius creeks; and Middle Shuswap River and tributaries--Ireland, Bessette, Creighton, Duteau and Harris creeks)

Noisy Creek, Wap Creek and Tsuius Creek

All three creeks drain into the northern portion of Mabel Lake and are typified by steep terrain, with some lower gradient sections closer to the creek outlets. Both coho and sockeye spawn in the lower reaches of Noisy and Tsuius creeks, with sockeye generally present only on the dominant cycle (1994 year). Wap Creek has a diverse fish community which includes sockeye, coho and chinook salmon, as well as non-anadromous species (e.g., bull trout, rainbow trout, kokanee and mountain whitefish). Anadromous species can access Wap Creek from Mabel Lake up to an impassable falls 29.3 km upstream from the creek mouth.

Logging is the main resource activity in all three drainages. In Noisy Creek, extensive logging in the upper watershed has resulted in increased sediment input (Sigma Engineering Ltd. 1991, Jantz, pers. comm.), with 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 Tsuius Creek, much of the logging has occurred on steep (>50%) slopes (McRae, pers. comm.). The impacts include altered runoff patterns, channel instability and increased sediment input (Jantz, pers. comm., Summit Environmental Consultants 1995). The latter have identified 11 sources of sediment, 6 of which were found in tributary streams and 3 were generated by road fills. In addition, two landslides were noted that were not present prior to the 1950s.

In Wap Creek, logging activities prior to the 1950s had resulted in destabilized lower reaches, creating heavy erosion and log jams (Jantz, pers. comm.). Summit Environmental Consultants Ltd. (1995) have identified nine sources of sediment in Wap Creek, none of which were present before the 1950s; this suggests that subsequent logging activity has contributed to bank instability. Currently, logging is conducted in the upper watershed, and sediment input together with altered hydrologic regimes, continue to destabilize the lower reaches. Impacts from logging are aggravated by the natural instability in valley walls and floor (Sigma Engineering Ltd. 1991, Jantz, pers. comm.). A small hydro project is also present on Wap Creek.

Management Priorities

Maintenance of anadromous fish values in Noisy and Tsuius creeks, and restoration of stream habitat in Wap Creek are the management priorities.

Strategies

- Conduct and review IWAPs (to FPC standards) to assess past logging impacts and guide future logging activities to prevent watershed impacts.
- Restore upslope areas affected by logging, through road deactivation and/or maintenance, riparian revegetation and stabilization of eroding banks (through WRP).
- Inventory stream habitat in the lower reaches, and assess barriers to upstream fish migration in Noisy and Tsuius creeks.
- Reduce erosion in Tsuius Creek by seeding exposed slopes with hydroseeding or geotextiles, if more surface protection is required (Summit Environmental Consultants Ltd. 1995).
- Assess opportunities to develop offchannel refuge habitat in the lower creek reaches.

Middle Shuswap River and Tributaries

The Middle Shuswap River and tributaries upstream of Mabel Lake, flow through a broad flat valley which has been heavily settled, with much of the land converted to agricultural use. Logging is prevalent in the upper reaches of tributary creeks. The combined resource uses in many of these creeks have severely impacted stream habitat, contributing to a reduction in fish productive capacity.

Middle Shuswap River

The Middle Shuswap River flows from Sugar Lake and enters Mabel Lake at its southern end. The river flow is regulated by B.C. Hydro through two dams, the Peers Dam at the Sugar Lake outlet and the Wilsey Dam at Shuswap Falls (Fig. 1.1, Photo 5.13).

The 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 (kokanee, rainbow trout, bull trout and mountain whitefish). Salmon access is currently limited to the river segment

below Wilsey Dam. A chinook sport fishery has developed on this River in response to increasing chinook returns; this increase is attributed largely to the Shuswap Hatchery production. Recently, adult chinook were transplanted upstream of the Wilsey Dam. Coho, on the other hand, are in a serious decline.

Much of the River's valley floor has been modified. Logging has resulted in clearing of bottomlands which have been converted to agricultural use. Intensive logging continues on upslope areas, particularly along the River's tributaries above the Wilsey Dam, at Cherry and Ferry creeks. These logging activities contribute sediments to the Middle Shuswap River due to increased erosion of stream banks, road runoff and logging related slides. The lower reaches of Middle Shuswap River have extensive sections with unstable banks. These are further destabilized by removal of riparian cover, with flooding adding to erosion problems.

Agricultural activity along the Middle Shuswap River is intensive and includes pig farming and cattle ranching. Large sections of riparian cover have been removed, and landowners are containing some river sections and redirecting flow away from side channels, thereby impacting fish habitat (Jantz, pers. comm., Kosakoski, pers. comm., Kurtz, pers. comm.). Water quality is also a concern due to non-point pollution sources resulting from livestock activity.

Fisheries resources in the Middle Shuswap River (above and below Wilsey Dam) have been affected by flow fluctuations, loss of habitat and high water temperatures (Hirst 1991). Summer spills over the Sugar Lake Dam have altered natural flow patterns downstream, leading to possible stranding of emergent rainbow trout fry (Triton Environmental Consultants Ltd. 1995). Operation of the Wilsey Dam has also resulted in flow fluctuations that can impact chinook, sockeye and kokanee habitat downstream, particularly during sensitive fish life stages (see also section 4.3.1 on Hydro development). Currently, B.C. Hydro is conducting flow fluctuation studies at Wilsey Dam, aimed at protecting downstream fisheries resources (Hebden, pers. comm.). Removal of sediments in the forebay has been an ongoing process resulting in downstream siltation problems. Recent land disposal of sediments has resolved this problem.

The Shuswap development (Wilsey, Sugar Lake) has been identified as one of the priorities for a review of B.C. Hydro facilities. This should lead to new water-use plans and revisions to water licences to help mitigate the impacts of hydro activities on fish resources and other values in the area.

Stream restoration projects conducted by DFO with the cooperation of landowners, include an experimental tree revetment project and a groundwater channel being developed 3 km below the Wilsey Dam that will accommodate 5,000 coho spawners (Sheng, pers. comm).

Management Priorities

Development of appropriate instream flows from hydro facilities, protection of existing habitat, development of side channels, and restoration of streamside vegetation are the management priorities for this system.

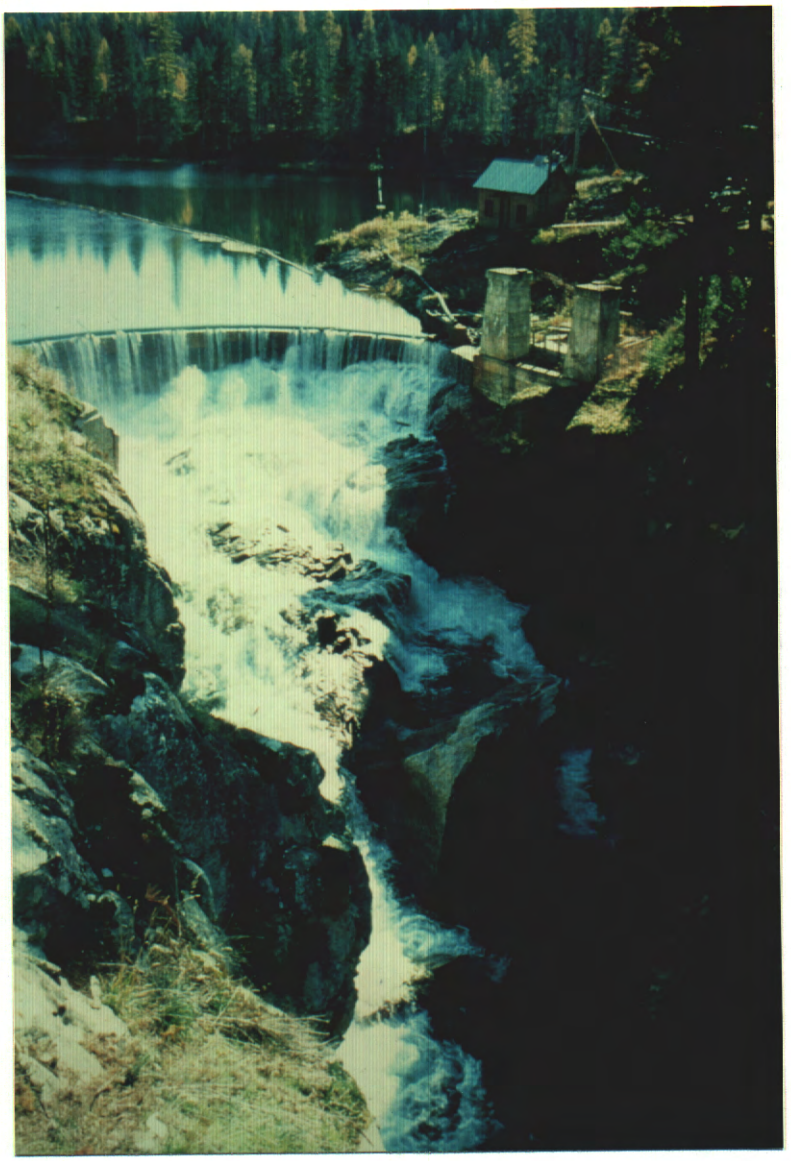


Photo 5.13 Shuswap Falls on Middle Shuswap River. (O. Langer)

Strategies

- Inventory and map riparian zones along the Middle Shuswap River, and develop a management plan (in cooperation with land users) to reestablish a riparian corridor; include revegetation of stream banks and fencing of livestock away from the banks. Educate landowners on the importance of riparian cover to stream ecology. Promote bioengineering techniques to stabilize eroding banks.
- 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.
- Work with B.C. Hydro, MELP and stakeholders to develop a water-use plan for the Shuswap River as part of the provincial review of hydro facilities.
- Continue to work with B.C. 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. (1993).
- Monitor the recreational fishery, and restrict angling during periods of high water temperatures.
- Continue with adult chinook transplants above the Wilsey Dam, and monitor the success of this program.
- Continue exploring the possibility of restoring salmon access upstream of Wilsey Dam through fish bypass facilities or by decommissioning the dam.
- Continue chinook production at the Shuswap River Hatchery. Assess the possibility of supplementing coho production through this hatchery.
- 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).

Ireland Creek

Ireland Creek enters the Middle Shuswap River approximately half way between Bessette Creek and Mabel Lake. Coho and sockeye utilize the Creek, with sockeye generally spawning on the dominant cycle (1994 year). Anadromous fish are restricted to the lower 3.2 km, below a weir and a wooden dam near the Mabel Lake road.

Logging activities are intensive and conducted on the steeper upslope areas where the potential for habitat disturbance is high. Agricultural activities along the valley bottom include cattle ranching, pig farming and crop production; these have resulted in a loss of riparian vegetation and stream bank integrity (Jantz, pers. comm.) Non-point source pollution is also a concern (Sigma Engineering Ltd. 1991). The system is fully subscribed for water licensing, and low instream flows occur in both winter and summer (Rood and Hamilton 1995).

Management Priorities

Restoration of riparian and instream habitat are the management objectives for Ireland Creek.

Strategies

- Reestablish riparian corridor in co-operation with landowners; include revegetation of stream banks and fencing cattle away from the banks.
- Assess stream habitat and ensure fish passage to upstream areas.
- Assess instream flow needs and monitor agricultural water withdrawals during the summer low-flow period.

- Initiate IWAP (to FPC standards) to assess impacts from logging in upslope areas of the drainage and implement restoration activities.

Bessette Creek and Tributaries

Bessette Creek enters the Middle Shuswap River approximately 2 km downstream of the Wilsey Dam. Tributaries include Creighton and Duteau creeks which join the Bessette near the town of Lumby. Above Lumby and Nicklen Creek, Bessette Creek is known as Harris Creek. Flows are regulated by the Vernon Irrigation District (VID), at a dam located in the upper Duteau Creek.

Bessette Creek, and particularly its tributary, the Duteau Creek, are important coho producers in the Shuswap system. Bessette Creek also supports a chinook population. Access in Harris Creek is restricted by a cascade barrier at 18 km. In Creighton Creek which is utilized by spawning and rearing coho salmon, as well as rearing chinook juveniles (DFO 1992b), an irrigation weir located 4.1 km upstream of the creek mouth restricts fish use. In Duteau Creek, chinook and coho distribution is affected by a cascade 10.8 km upstream of the creek mouth, and by the VID dam located 25.6 km upstream of the mouth. Pink and sockeye salmon have also been documented in this system. Resident species include rainbow trout and mountain whitefish.

The Bessette Creek watershed has been impacted heavily by logging activities in the upper sections (particularly in Harris Creek), and by agricultural activities and urbanization along the valley bottom. Intensive upslope logging has contributed sediment from road construction and maintenance, as well as from bank erosion due to slope instability and removal of riparian cover (above Nicklen Creek) (Summit Environmental Consultants Ltd. 1995). Extensive logging in the upper reaches of Creighton Creek, has resulted in loss of riparian cover along 12.5 % of the stream bank (McRae, pers. comm.). Extensive logging in the upper Duteau Creek area has possibly affected hydrologic patterns in tributaries above the reservoir (Rood and Hamilton 1995, Sigma Engineering Ltd. 1991). There is some concern that the Mountain Pine Beetle Control Programs will result in extensive clearing and possible impacts to Harris and Creighton creeks (Kurtz 1988).

Agricultural activity is extensive along the valley floor and includes cattle ranching, pig farming and crop production. Livestock grazing has resulted in trampling of stream banks and removal of streamside vegetation (Photo 5.14). Loss of habitat through bank erosion, channelization (Photo 5.15), low instream flows and increases in summer water temperatures is also observed (Sigma Engineering Ltd. 1991, Jantz, pers. comm., Kurtz, pers. comm.).

Settlement activity is high along Bessette Creek, with rural and residential settlement occurring through much of the creek length, along with a more concentrated population at the Village of Lumby. Land use associated with urbanization has lead to stream channelization and diking by land owners, as well as clearing of land(Photo 5.16).



Photo 5.14 Loss of riparian vegetation and impacts of cattle grazing on Duteau Creek. (G. Kosakoski)



Photo 5.15 Channelization of Harris Creek. (G. Kosakoski)



Photo 5.16 Loss of riparian vegetation and instream habitat on Bessette Creek through rip-rap placement. (O. Langer)



Photo 5.17 Revegetated riparian zone on Duteau Creek 7 years after fencing. (M. Sheng)

High water demand (Rood and Hamilton 1995) has lead to low summer flows. Also low winter flows are observed when the Duteau Creek waters are diverted for domestic and storage transfers into the Okanagan Basin (G. Kosakoski, pers. comm.). User conflicts occur in years of low snowpack and low reservoir inflows when flows into Duteau Creek are curtailed to maintain storage in the reservoirs (Rood 1989). The DFO has conducted minimum flow studies at Duteau Creek, and rule curves have been proposed (Hamilton 1990, Memo unpubl.); however no satisfactory flow agreement presently exists with the Vernon Irrigation District.

Water quality concerns arise from increased nutrient input from agricultural operations (Swain 1991, Townson, pers. comm.), and non-point source pollution from ranching and possibly pesticide use (Swain 1991, Jantz pers. comm., Kosakoski pers. comm.). The problem may be aggravated by reduced water flows and hence reduced stream capacity to dilute non-point pollutants from agricultural activities, landfill wastes - from a sawmill / veneer plant, and leachates - from a landfill operation (Sigma Engineering Ltd. 1991, Kurtz 1988).

Risks to fishery resources due to poor water quality include chlorinated treated effluent from the Village of Lumby wastewater, as well as stormwater runoff, and infiltration basins near the Creek (Sigma 1992, Swain 1991, Jensen, pers. comm., Kosakoski, pers. comm., Kurtz, pers. comm.). The chlorophenate wood-preserving plant located on Bessette Creek upstream of Lumby, is a contaminated site for which specific remediation strategies are being developed. Other industrial activities on Bessette Creek which may impact water quality, include a log refuse yard and an ore concentration mill (Sigma Engineering Ltd. 1991).

In Duteau Creek, a major restoration program has been undertaken by DFO in cooperation with ranchers. The program includes installing fencing to limit cattle access to the Creek (all salmon spawning areas upstream of Lumby have been fenced in 1989), planting riparian vegetation (Photo 5.17) and stabilizing banks where required. One small groundwater feed that enters Duteau Creek was redirected away from a cattle pen to help mitigate nutrient input. This groundwater channel was developed in 1994/95, creating coho offchannel habitat and generating more groundwater flow (Sheng, pers. comm., Townson 1995, pers. comm.). A proposal was made to extend this channel (Sheng, pers. comm.).

Management Priorities

Rebuilding coho stocks and restoring stream habitat (by planting riparian vegetation, stabilizing banks to reduce erosion, providing adequate instream flows and maintaining water quality) are the management priorities for Bessette, Harris, Creighton and Duteau creeks.

Strategies

- Conduct IWAP (to FPC standards) 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.
- 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.
- Deactivate roads, restore streambank vegetation and stabilize eroding banks caused by logging (through WRP).
- Inventory and map riparian zones along Bessette Creek, and develop a riparian restoration program (in cooperation with land users) that includes protection and revegetation 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 bioengineering techniques for erosion control to maximize benefits to fisheries resources.

- Undertake habitat complexing in previously developed groundwater channels and monitor water temperatures.
- Develop a fish bypass system around the weir in Creighton Creek.
- Explore opportunities to develop offstream groundwater channel from Harris Creek to Duteau Creek, and install Newbury weirs to recreate pool and riffle habitat in Harris Creek.
- Explore the opportunity to augment coho production in the system through the Shuswap River Hatchery, and explore opportunities for offchannel restoration works.
- 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 summer water use downstream of the dam.
- Apply DFO/MELP Land Development Guidelines and Stream Stewardship Guide for urban development to minimize impacts of urban developments.
- Apply DFO/MELP Stream Stewardship Guide for Agriculture and other relevant guidelines to protect riparian zones and control non-point source pollutants.
- Encourage DOE to resolve the issue at the chlorophenate wood-preserving plant through mediation and finalize a site remediation plan.
- Continue monitoring the effectiveness of restoration projects.

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Appendix A-1a. Early summer run sockeye escapements to the South Thompson-Shuswap HMA, 1951-1995. *

Year	Anstey River	Eagle River	Momich/ Cayenne	Scotch Creek	Seymour River	Upper Adams R.	Sub-Total Other Streams **	TOTAL EARLY SUMMER RUN
1951	0	0	0	0	24,344	0	-	24,344
1952	0	0	0	338	6,428	0	-	6,766
1953	0	0	0	1,364	5,947	0	-	7,311
1954	16	0	0	0	24,876	194	-	25,086
1955	11	0	0	0	9,011	0	-	9,022
1956	0	0	0	155	2,562	9	-	2,726
1957	112	31	0	2,230	14,295	291	-	16,959
1958	112	31	0	0	78,578	291	-	79,012
1959	0	0	0	0	52,325	0	-	52,325
1960	0	0	1,000	11	3,047	0	-	4,058
1961	0	0	0	598	5,822	0	-	6,420
1962	77	169	0	7	58,104	79	-	58,436
1963	2	5	0	0	71,690	6	-	71,703
1964	0	0	823	0	2,784	162	-	3,769
1965	0	0	0	1,910	6,954	0	-	8,864
1966	0	288	0	459	28,754	63	-	29,564
1967	0	4	0	0	13,361	0	-	13,365
1968	0	0	617	126	3,957	0	-	4,700
1969	0	18	0	3,395	7,327	0	-	10,740
1970	196	23	0	304	11,991	4	-	12,518
1971	23	9	0	0	19,028	0	-	19,060
1972	0	4	1,003	47	2,889	31	-	3,974
1973	0	11	0	6,235	2,856	0	-	9,102
1974	666	263	0	464	45,189	13	67	46,662
1975	14	9	38	0	37,024	23	13	37,121
1976	0	0	1,998	41	8,489	40	0	10,568
1977	0	65	51	13,586	5,911	0	40	19,653
1978	886	189	0	2,056	62,929	0	355	66,415
1979	41	2	0	0	49,321	0	369	49,733
1980	0	0	3,345	205	8,390	560	0	12,500
1981	0	0	63	18,952	11,529	0	0	30,544
1982	776	1,642	0	4,709	63,306	124	5,049	75,606
1983	382	72	0	239	29,838	0	346	30,877
1984	-	-	5,854	428	17,172	3,502	0	26,956
1985	-	-	56	3,442	6,435	83	0	10,016
1986	7,103	7,152	56	26,624	128,497	567	0	169,999
1987	2,257	879	25	2,097	84,409	2	0	89,669
1988	45	31	5,912	2,093	17,014	7,169	0	32,264
1989	0	175	99	7,236	5,692	11	0	13,213
1990	25,308	4,147	58	83,406	272,157	625	1,992	387,693
1991	5,011	3,677	4	9,954	128,253	67	358	147.324
1992	256	482	2,486	2,281	5,765	2,990	68	14,328
1993	193	11	533	8,528	10,201	47	5	19,518
1994	7,380	45,452	0	73,177	48,743	581	23,115	198,448
1995	3,562	1,890	-	14,816	43,669	90	10,117	74,144

* Data from Fraser River database; (-) indicates no record

** Sub-Total Other Streams (Append. A-1b) - generally minor sockeye streams with incomplete escapement records.

Appendix A-1b. Early summer run sockeye escapements to other streams in the South Thompson-Shuswap HMA, 1974-1995. *

Year	Adams River (Lower)	Bear + Creek	Cayenne Creek	Celista Creek	Gold Creek +	Hunakwa Creek	McNomee Creek	Perry Creek	Salmon River	Yard Creek	Sub-Total **
1974	-	-	-	-	-	67	-	-	-	-	67
1975	-	-	-	-	-	13	-	-	-	-	13
1976	-	-	-	-	-	0	-	-	-	-	0
1977	-	-	40	-	-	0	-	-	-	-	40
1978	-	-	-	-	-	355	-	-	-	-	355
1979	-	-	-	-	-	369	-	-	-	-	369
1980	-	-	-	-	-	0	-	-	-	-	0
1981	-	-	-	-	-	0	-	-	-	-	0
1982	-	-	-	-	-	4,951	-	90	-	8	5,049
1983	-	-	-	-	-	346	-	-	-	-	346
1984	-	-	-	-	-	-	-	-	-	-	0
1985	-	-	-	-	-	-	-	-	-	-	0
1986	-	-	-	-	-	-	-	-	-	-	0
1987	-	-	-	-	-	-	-	-	-	-	0
1988	-	-	-	-	-	-	-	-	-	-	0
1989	-	-	-	-	-	-	-	-	-	-	0
1990	1,980	-	-	-	-	-	-	-	12	-	1,992
1991	0	-	-	358	-	-	-	-	0	-	358
1992	0	-	-	0	-	-	-	68	-	-	68
1993	-	-	-	0	-	-	5	-	-	-	5
1994	3,107	542	92	772	2,383	0	7,871	4,604	4	3,740	23,115
1995	0	0	47	209	0	13	8,059	236	0	1,553	10,117

* Data from Fraser River database; (-) indicates no record.
Adams Channel (not included here) was utilized by 1,024 early summer run sockeye in 1994.

** Sub-Total Other Streams - generally minor sockeye streams with incomplete escapement records.

+ Bear Creek - local name for Hiuihill Creek; Gold Creek (local name for Nikwikwaia Creek)

Appendix A-2a Late run sockeye escapements to the South Thompson-Shuswap HMA,1951-1995. *

Year	Adams Lake	Adams River (Lower)	Anstey River	Eagle River	Hunakwa Creek	Little River	Lower Shuswap River	Middle Shuswap River	Momich River	South Pass Creek	Salmon River	Scotch Creek	Seymour River	Shuswap Lake **	South Thompson River	Sub-Total Other*** Streams	TOTAL LATE RUN
1951	0	134,964	0	0	0	9,690	0	0	0	0	0	0	0	0	450	-	145,104
1952	0	8,692	0	0	0	1,861	0	0	0	0	0	0	0	0	200	-	10,753
1953	0	165,678	0	0	0	37,659	140	0	45	838	0	1,470	0	0	14,533	-	220,363
1954	0	1,740,067	214	0	0	199,004	17,462	61	785	859	0	8,007	93	6,786	57,675	-	2,031,013
1955	0	60,233	0	0	0	4,328	23	0	0	0	0	0	0	0	0	-	64,584
1956	0	3,245	0	0	0	1,255	5	0	0	0	0	0	0	0	0	-	4,505
1957	0	253,573	0	490	0	34,964	490	0	0	1,463	0	1,543	55	0	14,645	-	307,223
1958	0	1,730,600 +	967	1,049	0	409,480	9,387	499	369	403	0	9,047	0	14,300	123,864	-	3,306,151 +
1959	0	113,257	0	0	0	21,080	281	0	0	0	0	0	0	0	472	-	135,090
1960	0	1,848	0	0	0	66	0	0	0	0	0	0	0	0	0	-	1,914
1961	0	56,988	0	7	0	8,253	342	0	0	13	0	0	0	0	254	-	65,857
1962	0	991,728	992	9,194	0	67,398	31,205	457	218	940	45	4,518	4	29,916	14,441	86	1,151,142
1963	0	154,086	0	0	0	2,436	2,014	0	0	0	0	0	0	0	45	-	158,581
1964	0	716	0	0	0	0	0	0	0	0	0	0	0	0	0	-	716
1965	0	55,041	41	398	0	3,274	583	0	0	0	0	0	0	0	192	-	59,529
1966	0	1,197,336	1,352	9,810	0	55,952	24,629	1,872	0	344	0	4,770	0	22,102	4,313	-	1,322,480
1967	0	755,238	164	61	0	74,490	5,951	58	0	0	0	9,461	0	237	270	-	845,930
1968	0	3,983	0	0	0	0	0	0	0	0	0	15	0	0	0	-	3,998
1969	0	45,908	0	128	22	6,842	1,703	0	0	86	0	0	0	0	630	-	55,319
1970	0	1,297,990	387	9,614	625	168,881	29,074	4,559	360	507	0	3,076	50	35,770	5,931	-	1,556,824
1971	0	280,176	0	320	0	2,821	6,117	284	0	2	0	313	0	250	10	-	290,293
1972	0	4,325	0	2	0	81	290	0	0	0	0	0	0	0	0	-	4,698
1973	0	33,312	0	0	0	6,689	7,452	0	0	0	0	0	0	0	545	-	47,998
1974	0	889,613	1,152	4,507	382	122,112	86,396	3,064	0	171	92	4,613	149	30,816	14,466	-	1,157,533
1975	0	148,187	0	455	0	7,268	11,652	227	0	2	0	164	0	594	16	-	168,565
1976	0	5,013	0	0	0	175	400	0	0	0	0	0	0	0	0	-	5,588
1977	0	57,964	0	0	0	8,684	14,695	0	0	0	0	0	0	0	432	-	81,775
1978	749	1,493,473	441	8,025	935	81,055	187,167	10,690	65	547	434	5,994	149	100,493	9,986	-	1,900,403
1979	0	275,616	18	238	41	10,443	10,092	578	0	4	0	313	66	2,140	144	-	299,713
1980	0	2,560	-	2	0	32	81	0	0	0	0	0	0	0	0	-	2,675
1981	0	31,097	-	0	0	8,169	7,358	0	0	101	0	0	0	0	182	-	46,907
1982	1,840	2,068,979	981	32,350	2,342	239,278	513,925	40,302	112	2,725	1,602	4,849	90	72,974	73,603	7,176	3,063,128
1983	0	201,669	0	508	0	0	7,308	27	0	5	50	43	0	1,814	0	-	211,424
1984	-	4,183		17	-	49	79	-	-	-	-	-	-	-	11	-	4,339
1985	-	10,715		263	-	972	3,123	180	-	-	-	-	-	-	0	-	15,253
1986	2,965	1,334,590	3,168	25,719	299	227,919	600,495	80,529	315	585	1,465	4,232	1,145	39,670	30,730	2,438	2,356,264
1987	47	568,060	436	1,532	0	18,000	10,343	787	0	14	0	317	43	3,566	18	-	603,163
1988	0	4,630	0	6	0	225	194	0	0	0	0	0	0	0	4	-	5,059
1989	0	7,778	0	621	15	167	3,017	0	0	30	0	0	7	0	18	-	11,653
1990	6,532	2,073,212	5,099	56,200	1,177	360,000	983,554	96,451	454	1,779	1,288	28,800	374	58,213	32,400	8,608	3,714,341
1991	419	1,201,180	733	2,760	65		15,678	581	25	29	41	10,544	40	4,150	61	16,236	1,252,542
1992	0	12,287	0	54	0	83	355	180	-	0	0	20	0	149		-	13,128
1993	-	8,149	0	95	0	229	2,736	47	0	0	11	29	0	-	70	-	11,366
1994	428	674,786	1,836	27,699	646	198,108	368,385	31,806	76	495	78	3,694	488	27,807	25,079	1,673	1,363,006
1995	119	378,903	94	857	28	9,128	12,330	155	2	38	8	2,707	0	4,589	270	1,093	410,321

* Data from Fraser River database; (-) indicates no record

** Shuswap Lake sockeye spawners were observed in all lake Arms (Anstey, Main, Salmon, Seymour), with highest numbers in the Main Arm and lowest in the Seymour Arm.

*** Sub-Total Other Streams (Append A-2b) - generally minor sockeye streams with incomplete escapement records.

\+ In 1958, an additional 1,006,177 sockeye were diverted from Lower Adams R (Farwell et al 1987) to prevent overspawning; these poor quality, late arrivals died or spawned in adjacent areas below; they are included only with the Total.

Appendix A-2b. Late run sockeye escapements to the other streams in the South Thompson-Shuswap HMA, 1962-1995. *

Year	Bear Cr.++	Bush Creek	Canoe Creek	Celista Creek	Five Mile Creek	Gold Cr.++	Mc-Nomee Creek	Noisy Creek	Onyx Creek	Perry Creek	Reien-ecker Creek	Ross Creek	Tappen Creek	Tsulus Creek	Wap Creek	Sub-Total***
1962	-	-	-	-	86	-	-	-	-	-	-	-	-	-	-	86
1981	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1982	1,840	-	83	-	-	1,834	-	353	-	-	214	1,477	563	126	686	7,176
1983	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	104	41	-	-	83	-	122	-	-	-	-	1,006	13	1,069	2,438
1987	-	0	0	-	-	0	-	0	-	-	-	-	0	0	0	-
1988	-	0	0	-	-	0	-	0	-	-	-	-	0	0	0	-
1989	-	0	0	-	-	0	-	0	-	-	-	-	0	0	0	-
1990	2,925	76	128	42	-	2,365	12	0	110	0	-	0	1,417	-	1,733	8,808
1991	616	0	0	0	-	2,095	13,500	-	0	25	-	-	-	-	-	16,236
1992	0	0	0	-	-	0	0	-	0	0	-	0	0	-	-	-
1993	-	0		-	-	-	-	-	0	0	-	-	-	-	-	-
1994	194	0	49	13	-	272	0	-	0	29	-	-	322	169	625	1,673
1995	425	0	2	0	-	666	-	-	0	0	-	0	0	0	0	1,093

* Data from Fraser River database; (-) indicates no record.
Adams Channel (not included here) was utilized by about 14,000 late run sockeye during 1990-1995.

*** Sub-Total Other Streams (Append. A-2b) - generally minor sockeye streams with incomplete escapement records.

++ Bear Creek - local name for Hiuihill Creek; Gold Creek - local name for Nikwikwaia Creek.

Appendix A-3. Total sockeye escapements (early summer and late runs) to the South Thompson-Shuswap HMA, 1951-1995. *

Year	Early Summer	Late	TOTAL RUN	% Late of Total
1951	24,344	145,104	169,448	85.6
1952	6,766	10,753	17,519	61.4
1953	7,311	220,363	227,674	96.8
1954	25,086	2,031,013	2,056,099	98.8
1955	9,022	64,584	73,606	87.7
1956	2,726	4,505	7,231	62.3
1957	16,959	307,223	324,182	94.8
1958	79,012	3,306,151	3,385,163	97.7
1959	52,325	135,090	187,415	72.1
1960	4,058	1,914	5,972	32.0
1961	6,420	65,857	72,277	91.1
1962	58,436	1,151,142	1,209,578	95.2
1963	71,703	158,581	230,284	68.9
1964	3,769	716	4,485	16.0
1965	8,864	59,529	68,393	87.0
1966	29,564	1,322,480	1,352,044	97.8
1967	13,365	845,930	859,295	98.4
1968	4,700	3,998	8,698	46.0
1969	10,740	55,319	66,059	83.7
1970	12,518	1,556,824	1,569,342	99.2
1971	19,060	290,293	309,353	93.8
1972	3,974	4,698	8,672	54.2
1973	9,102	47,998	57,100	84.1
1974	46,662	1,157,533	1,204,195	96.1
1975	37,121	168,565	205,686	82.0
1976	10,568	5,588	16,156	34.6
1977	19,653	81,775	101,428	80.6
1978	66,415	1,900,403	1,966,818	96.6
1979	49,733	299,713	349,446	85.8
1980	12,500	2,675	15,175	17.6
1981	30,544	46,907	77,451	60.6
1982	75,606	3,063,128	3,138,734	97.6
1983	30,877	211,424	242,301	87.3
1984	26,956	4,339	31,295	13.9
1985	10,016	15,253	25,269	60.4
1986	169,999	2,356,264	2,526,263	93.3
1987	89,669	603,163	692,832	87.1
1988	32,264	5,059	37,323	13.6
1989	13,213	11,653	24,866	46.9
1990	387,693	3,714,341	4,102,034	90.5
1991	147,324	1,252,542	1,399,866	89.5
1992	14,328	13,128	27,456	47.8
1993	19,518	11,366	30,884	36.8
1994	198,448	1,363,006	1,561,454	87.3
1995	74,144	410,321	484,465	84.7
Average				
1951-60	22,761	622,670	645,431	96.5
1961-70	22,008	522,038	544,046	96.0
1971-80	27,479	395,924	423,403	93.5
1981-90	86,684	1,003,153	1,089,837	92.0
1991-95	90,752	610,073	700,825	87.1
1986-95	114,660	974,084	1,088,744	89.5

* Data from Append. A-1 and A-2.

Appendix A-4. Chinook escapements to the South Thompson-Shuswap HMA, 1951-1995. *

Year	Adams River	Adams River, Upper	Bessette Creek	Eagle River	Little River	Salmon River	Scotch Creek	Seymour River	Shuswap River, Lower	Shuswap River, Middle	Thompson River, South	TOTAL
1951	750	n/r	n/r	750	75	750	n/r	n/r	750	750	3,500	7,325
1952	3,500	n/r	n/r	3,500	400	1,500	n/r	n/r	3,500	1,500	3,500	17,400
1953	3,500	n/r	n/r	3,500	750	750	n/r	n/r	7,500	750	7,500	24,250
1954	1,500	n/r	n/r	1,500	750	n/r	n/r	400	1,500	n/r	n/r	5,650
1955	1,500	n/r	n/r	400	75	200	n/r	n/r	3,500	1,500	25	7,200
1956	1,500	n/r	n/r	750	400	200	n/r	n/r	3,500	1,500	400	8,250
1957	3,500	n/r	n/r	1,500	750	25	n/r	n/r	3,500	1,500	1,500	12,275
1958	1,500	n/r	n/r	1,500	1,500	200	n/r	400	7,500	750	3,500	16,850
1959	1,500	n/r	n/r	750	200	200	n/r	75	1,500	750	1,500	6,475
1960	1,500	n/r	n/r	1,500	200	200	n/r	n/r	3,500	750	3,500	11,150
1961	1,500	n/r	n/r	750	750	25	n/r	n/r	3,500	1,500	3,500	11,525
1962	1,500	n/r	25	3,500	750	400	n/r	400	3,500	750	3,500	14,325
1963	1,500	n/r	25	1,500	400	200	n/r	200	3,500	750	1,500	9,575
1964	400	25	25	400	750	75	n/r	n/r	3,500	750	7,500	13,425
1965	1,500	n/r	n/o	750	200	200	n/r	75	1,500	400	3,500	8,125
1966	3,500	n/r	n/o	750	400	200	n/r	25	3,500	400	2,000	10,775
1967	1,500	n/r	25	750	400	200	25	75	15,000	1,500	3,500	22,975
1968	3,500	n/r	n/o	200	400	200	25	n/o	7,500	400	3,500	15,725
1969	5,000	n/r	n/o	400	200	200	n/r	25	7,500	500	7,500	21,325
1970	1,500	n/r	25	300	750	200	n/r	n/o	7,500	750	7,500	18,525
1971	900	n/r	25	750	200	400	n/r	n/o	7,500	750	2,100	12,625
1972	1,900	n/r	25	300	125	200	n/r	n/r	4,500	300	5,000	12,350
1973	1,700	n/r	n/o	350	200	150	n/r	n/r	9,000	400	5,000	16,800
1974	1,700	n/r	25	350	300	250	n/r	n/r	10,000	600	4,500	17,725
1975	1,300	n/r	25	300	400	200	n/r	n/r	17,500	600	7,000	27,325
1976	400	n/r	n/o	250	100	150	n/r	n/r	2,500	400	1,500	5,300
1977	1,750	n/r	15	756	600	300	n/r	25	9,500	550	7,000	20,496
1978	2,200	n/r	20	400	100	350	n/r	n/o	10,400	350	3,500	17,320
1979	1,000	n/r	50	300	700	300	n/r	10	10,000	500	6,000	18,860
1980	350	n/r	50	250	400	360	n/r	n/r	4,000	500	3,000	8,910
1981	700	n/o	40	250	400	300	n/o	n/o	5,500	500	6,000	13,690
1982	500	n/r	10	400	100	700	n/o	20	2,200 b	500 b	3,500	7,930
1983	250	n/r	10	250	100	300	n/o	n/o	5,800 c	300	3,000	10,010
1984	650	n/r	100	775 a	250	850 a	n/r	15	7,892 d	700	6,000	17,232
1985	750	n/r	200	1,250 a	400	1,670 a	n/r	n/r	11,125 d	900	7,000	23,295
1986	2,500	n/r	230	1,000 a	350	1,000 a	n/r	n/r	12,000	1,000	6,500	24,580
1987	2,000	n/r	n/o	840 a	200	641 a	n/r	n/r	10,000	1,700	8,500	23,881
1988	1,500	n/r	50	1,000 a	400	1,100 a	n/r	n/r	14,000	1,600	12,000	31,650
1989	1,250	n/r	190	821 a	400	1,638 a	n/r	n/r	11,000	1,500	10,000	26,799
1990	2,000	n/r	200	1,200 a	400	1,100 a	n/r	n/r	13,000	4,000	6,000	27,900
1991	3,000	12	180	835 a	250	616 a	n/r	50	10,000	5,000	8,000	27,943
1992	1,300	n/r	80	1,271 a	600	300 a	n/r	n/r	13,300	5,000	12,000	33,851
1993	800	150	250	1,100 a	n/r	1,850 a	n/r	3	6,000	2,500	4,000	16,653
1994	1,800	n/r	200	1,200	500	800	n/r	n/r	16,150	4,000	2,800	27,450
1995	1,900	n/r	280	550	150	700	n/r	n/r	10,000	3,000	5,500	22,080
Average												
1951-60	2,025	n/r	n/r	1,565	510	447	n/r	292	3,625	1,083	2,769	11,683
1961-70	2,140	25	25	930	500	190	25	133	5,650	770	4,350	14,630
1971-80	1,320	n/r	29	401	313	266	n/r	18	8,490	495	4,460	15,771
1981-90	1,210	n/r	103	779	300	930	n/r	18	9,252	1,270	6,850	20,697
1991-95	1,760	81	198	991	375	853	n/r	27	11,090	3,900	6,460	25,595
1986-95	1,805	81	184	982	361	975	n/r	27	11,545	2,930	7,530	26,279

* Data from Fraser River Division database. Additional minor escapements (not included here) observed in some years for Anstey River and Hunakwa, Duteau and Wap creeks

a Fence count (unpublished)

b Systematic survey (unpublished)

c Mark recapture study (Pearce MS 1983)

d Mark recapture study (Rice et al. MS 1987)

Appendix A-5. Coho escapements to the South Thompson-Shuswap HMA, 1951-1995 a,b

	Adams River System						Bessette Creek System					Eagle River System		
Year	Adams River	Adams River, Upper	Cay-enne Creek	Mo-mich River	Sin-max Creek	Anstey River	Bes-sette Creek	Creigh-ton Creek	Du-teau Creek	Harris Creek	Canoe Creek	Eagle River	South Pass Creek	Hunak-wa Creek
1951	750	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	750	n/r	n/r
1952	3,500	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	7,500	n/r	n/r
1953	3,500	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	1,500	n/r	n/r
1954	750	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	3,500	n/r	n/r
1955	3,500	3,500	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	1,500	n/r	n/r
1956	750	1,000	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	3,500	n/r	n/r
1957	750	750	n/r	n/r	75	n/r	n/r	n/r	n/r	n/r	n/r	3,500	n/r	n/r
1958	400	3,500	n/r	400	750	750	n/r	n/r	n/r	n/r	n/r	1,500	n/r	n/r
1959	750	1,500	n/r	400	750	n/o	n/r	n/r	n/r	n/r	n/r	1,500	n/r	n/r
1960	1,500	750	n/r	400	200	25	n/r	n/r	n/r	n/r	n/r	1,500	n/r	n/r
1961	200	3,500	n/r	400	200	750	n/r	n/r	n/r	n/r	n/r	3,500	n/r	n/r
1962	750	500	n/r	750	750	75	200	n/r	n/r	n/r	n/r	3,500	n/r	n/r
1963	750	750	n/r	200	200	25	75	n/r	n/r	n/r	n/r	750	n/r	n/r
1964	400	1,500	n/r	200	75	75	1,500	n/r	n/r	n/r	25	1,500	n/r	n/r
1965	750	n/o	n/r	n/o	400	25	2,500	n/r	n/r	n/r	n/r	3,500	n/r	75
1966	400	n/r	n/r	n/o	200	n/o	1,150	n/r	n/r	n/r	25	1,500	n/r	25
1967	200	n/o	n/r	n/o	75	25	25	n/r	n/r	n/r	n/r	750	n/r	n/r
1968	400	n/o	n/r	75	400	25	1,650	n/r	n/r	n/r	25	1,500	n/r	25
1969	750	n/r	n/r	200	200	25	1,750	n/r	n/r	n/r	n/o	750	n/r	75
1970	400	n/r	n/r	n/o	200	25	750	n/r	n/r	n/r	25	1,500	n/r	25
1971	300	n/r	n/r	75	213	n/o	750	n/r	n/r	n/r	25	1,500	n/r	25
1972	200	200	n/r	25	104	25	1,850	n/r	n/r	n/r	25	1,500	n/r	25
1973	300	n/r	n/r	25	165	25	5	50	500	200	10	1,800	30	40
1974	150	200	n/r	25	130	25	1,300	25	500	n/r	25	2,200	n/r	100
1975	100	60	n/r	25	60	25	150	25	550	100	30	1,400	25	30
1976	10	n/r	n/r	n/o	25	25	5	40	325	105	10	1,100	20	25
1977	338	150	n/r	20	40	n/r	70	2	94	n/r	n/o	2,694	40	n/o
1978	150	100	n/r	40	55	75	n/r	30	400	150	100	2,000	50	200
1979	100	475	n/r	150	140	n/o	50	30	300	150	75	2,500	60	75
1980	200	75	n/r	n/o	30	10	60	10	350	60	60	1,500	20	42
1981	100	100	n/r	40	60	50	10	20	250	65	30	850	20	25
1982	100	200	n/r	225	15	25	15	20	200	85	80	1,000	50	50
1983	100	300	50	30	10	20	20	20	500	70	20	1,200 c	10	50
1984	500	200	35	20	40	50	50	100	750	100	30	7,100 c	25	125
1985	500	500	n/r	n/r	75	n/r	50	50	600	200	100	3,500 c	50	n/r
1986	150	1,100	100	50	80	50	60	60	750	250	30	4,500 c	50	n/r
1987	150	500	75	80	120	50	60	100	750	40	100	11,015 c	n/o	100
1988	350	700	50	10	80	50	50	150	650	200	50	10,300 c	75	150
1989	350	1,100	n/o	n/o	40	n/r	40	150	700	300	100	5,900 c	50	120
1990	100	n/r	n/r	n/r	n/o	n/r	50	25	350	50	50	4,396 c	50	30
1991	100	100	n/r	n/r	n/o	30	n/o	25	n/o	25	30	2,000 c	25	75
1992	250	n/o	n/r	n/r	n/o	80	100	150	500	200	20	3,312 c	85	120
1993	20	n/r	n/r	n/r	n/r	n/r	n/r	12	12	20	25	1,040 c	n/r	n/r
1994	70	100	n/r	n/r	n/r	N I	100	N I	UNK	UNK	6	1,500 c	2	N I
1995	75	n/r	n/r	n/r	n/r	N I.	150	50	200	75	10	800 c	258	60
Average														
1951-60	1,615	1,833	n/r	400	444	388	n/r	n/r	n/r	n/r	n/r	2,625	n/r	n/r
1961-70	500	1,563	n/r	304	270	117	1,067	n/r	n/r	n/r	25	1,875	n/r	45
1971-80	185	180	n/r	48	96	30	471	27	377	128	40	1,819	35	62
1981-90	240	522	62	65	58	42	41	70	550	136	59	4,976	42	81
1991-95	103	100	n/r	n/r	n/r	55	117	59	237	80	18	1,730	93	85
1986-95	162	600	75	47	80	52	76	80	489	129	42	4,476	74	94

(cont'd)

Appendix A-5 (cont'd)

		Salmon R. System				Lower Shuswap River System										
Year	Noi-sey Creek	Salmon River	Bolean Creek	Sco-tch Creek	Sey-mour River	Lower Shuswap River	Blur-ton Creek	King-fisher Creek	Ire-land Creek	John-son Creek	Tri-nity Creek	Middle Shuswap River	Tap-pen Creek	Wap Creek	TOTAL	
1951	n/r	750	n/r	750	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	400	n/r	3,400	
1952	n/r	3,500	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	400	n/r	14,900	
1953	n/r	400	n/r	200	n/r	3,500	n/r	n/r	n/r	n/r	n/r	1,500	400	n/r	11,000	
1954	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	n/r	750	n/r	n/r	5,000	
1955	n/r	7,500	n/r	n/r	n/r	3,500	n/r	n/r	n/r	n/r	n/r	3,500	750	n/r	23,750	
1956	n/r	400	n/r	n/r	n/r	1,500	n/r	n/r	n/r	n/r	n/r	750	300	n/r	8,200	
1957	n/r	1,500	n/r	n/r	n/r	750	n/r	n/r	n/r	n/r	n/r	400	25	n/r	7,750	
1958	n/r	3,500	n/r	n/r	n/r	3,500	n/r	n/r	n/r	n/r	n/r	1,500	25	n/r	15,825	
1959	n/r	750	n/r	n/r	n/r	1,500	n/r	n/r	n/r	n/r	n/r	750	200	n/r	8,100	
1960	n/r	1,500	n/r	25	n/r	1,500	n/r	n/r	n/r	n/r	n/r	3,500	25	n/r	10,925	
1961	n/r	1,500	n/r	n/r	n/r	750	n/r	n/r	n/r	n/r	n/r	3,500	25	n/r	14,325	
1962	n/r	750	n/r	n/r	n/r	750	n/r	n/r	n/r	n/r	n/r	1,500	200	n/r	9,725	
1963	n/r	1,500	n/r	n/r	n/r	750	n/r	n/r	n/r	n/r	n/r	1,500	25	n/r	6,525	
1964	n/r	750	n/r	n/r	n/r	3,500	n/r	n/r	n/r	n/r	n/r	750	25	n/r	10,300	
1965	n/r	3,500	n/r	n/r	25	200	n/r	n/r	n/r	n/r	n/r	400	25	n/r	11,400	
1966	n/r	400	n/r	n/r	n/r	400	n/r	n/r	n/r	n/r	n/r	400	n/o	n/r	4,500	
1967	n/r	200	n/r	25	n/r	200	n/r	n/r	n/r	n/r	n/r	200	n/o	n/r	1,700	
1968	n/r	1,000	n/r	25	n/r	400	n/r	n/r	n/r	n/r	n/r	400	25	25	6,050	d
1969	n/r	1,500	n/r	n/r	n/r	750	n/r	n/r	n/r	n/r	n/r	750	25	n/r	6,775	
1970	n/r	750	n/r	200	n/r	400	n/r	n/r	n/r	n/r	n/r	400	25	400	5,100	
1971	n/r	1,500	n/r	25	n/r	75	n/r	n/r	n/r	n/r	n/r	400	25	25	4.938	
1972	n/r	2,000	n/r	25	n/r	300	n/r	n/r	n/r	n/r	n/r	400	25	200	6,904	
1973	n/r	600	n/r	10	n/r	250	n/r	10	n/r	n/r	n/r	500	4	250	4,774	
1974	n/r	1,800	n/r	25	n/r	100	n/r	25	n/r	n/r	n/r	500	n/o	25	7,155	
1975	n/r	900	n/r	30	n/r	100	n/r	30	n/r	n/r	n/r	250	25	175	4,090	
1976	n/r	900	50	5	1	40	25	10	n/r	n/r	n/r	60	1	20	2,802	
1977	n/r	1,588	n/r	n/r	25	100	40	62	n/r	n/r	n/r	594	12	516	6,385	
1978	n/r	1,500	50	n/r	n/r	300	10	10	15	4	4	350	2	300	5.895	
1979	n/r	2,000	50	n/r	40	300	25	25	45	n/r	45	500	3	400	7,538	
1980	n/r	1,300	20	n/r	6	350	16	n/r	32	n/r	10	550	n/o	250	4,951	
1981	n/r	500	55	n/r	11	250	15	25	30	n/r	10	250	15	100	2,881	
1982	n/r	800	100	20	n/r	300	n/o	100	30	40	35	350	5	225	4,070	
1983	n/r	1,000	50	25	n/r	200	n/o	75	30	n/o	10	250	n/o	80	4.120	
1984	n/r	1,550 c	10	n/r	50	300	50	25	20	100	30	250	20	150	11,680	
1985	n/r	3,800 c	100	n/r	n/r	500	50	25	30	75	20	1,200	30	250	12,155	e
1986	25	2,700 c	50	50	n/r	250	50	80	25	50	60	650	30	200	11,450	f
1987	15	2,479 c	n/o	30	n/r	350	50	120	25	50	20	500	30	450	17,259	g
1988	25	4,943 c	75	100	n/r	450	30	150	50	75	75	1,200	30	250	20,318	
1989	n/r	3,641 c	35	50	50	250	35	50	30	50	50	500	35	250	13,876	
1990	n/r	1,221 c	35	50	50	200	50	n/r	n/o	50	50	200	15	200	7,222	
1991	n/r	308 c	n/o	40	n/r	200	n/o	n/o	n/o	30	10	300	n/o	75	3,373	
1992	25	2,250 c	n/o	50	n/r	250	50	45	30	50	50	800	15	300	8,732	
1993	n/r	500 c	n/r	10	n/r	20	30	60	n/r	24	6	20	n/r	n/r	1,799	
1994	N I	376 c	n/o	10	N I	100	8	32	N I	6	N I	300	n/o	180	2,790	
1995	0	900 c	20	20	0	25	0	25	25	25	0	50	10	50	2,828	
Average																
1951-60	n/r	2,200	n/r	325	n/r	2,250	n/r	n/r	n/r	n/r	n/r	1,581	281	n/r	10,885	
1961-70	n/r	1,185	n/r	83	25	810	n/r	n/r	n/r	n/r	n/r	980	47	213	7,640	
1971-80	n/r	1,409	43	20	18	192	23	25	31	4	20	410	12	216	5.543	
1981-90	22	2,263	57	46	40	305	41	72	30	61	36	535	23	216	10,503	
1991-95	13	867	20	26	0	119	22	41	28	27	17	294	13	151	3,904	
1986-95	18	1,932	43	41	33	210	34	70	31	41	36	452	24	217	8,965	

(cont'd)

Footnotes to Appendix A-5.

a. Data from Fraser River Division (1994 and 1995 data from B. Rosenberger, pers. comm.). Escapements include river spawners only (some streams had no escapement estimates in some years).
Abbreviations used: n/r or n/o - no numerical estimate available, N.I. - not inspected, UNK - unknown.

b. Coho spawner presence noted in some years for the following streams: Blurton Creek, Little River, Olwhead Creek, Onyx Creek, Reinecker Creek, South Thompon River and Tsuius Creek (available escapements for these streams included with the Total).

c. For each of Eagle and Salmon rivers, total escapements consist of fence counts (available for respective rivers from 1983 and 1984), below fence estimates and fish removed for broodstock.

d. Total for 1968 includes South Thompson River coho (75 fish).

e. Total for 1985 includes Little River coho (450 fish).

f. Total for 1986 includes Onyx Creek coho (20 fish).

g. Total for 1987 includes Tsuius Creek coho (10 fish).

Appendix A-6. Pink escapements to the South Thompson-Shuswap HMA, 1957 - 1991. *

Year	Adams River	Little River	Lower Shuswap River	South Thompson River	TOTAL
1957	n/o	n/o	n/o	n/r	n/r
1959	n/o	n/o	n/o	n/r	n/r
1961	n/o	n/o	n/o	n/r	n/r
1963	n/o	n/o	n/o	n/r	n/r
1965	53	n/o	n/o	n/r	53
1967	n/o	n/o	n/o	n/r	n/r
1969	n/o	n/o	n/o	n/r	n/r
1971	815	n/o	n/o	n/r	815
1973	119	n/o	n/o	n/r	119
1975	2,447	244	15	n/r	2,706
1977	1,165	2,730	3	1,336	5,234
1979	3,951	738	5	260	4,954
1981	1,122	865	8	1,560	3,555
1983	3,450	198	13	829	4,490
1985	243	n/o	n/o	n/o	243
1987	1,310	117	0	123	1,550
1989	1,300	36	5	0	1,341
1991	2,153	39	n/r	0	2,192
Average					
1957-59	n/o	n/o	n/o	n/r	n/r
1961-69	53	n/o	n/o	n/r	53
1971-79	1,699	1,237	8	798	3,742
1981-91	1,596	251	7	502	2,356

* Data from Fraser River Division database;
estimates for individual streams not available after 1991.
Abbreviations used: n/r and n/o - no numerical estimate available.

Appendix B. Hydrology of the salmon streams in the South Thompson-Shuswap HMA. (source: Rood and Hamilton 1995)

Stream Name	WSC Gauge No.	Basin Area (mouth) (km^2)	Logged Area Recent (km^2)	Logged Area Older (km^2)	Improved Farmland (1990) (km^2)	Total Water Licenses Domestic (g/day)	Irrigation (ac-ft)	Waterworks (g/day)	Industrial (g/day)	Conservation (cfs)	Licensed Demand (L/s) Aug	Sept	Feb	Naturalized Flows in the Salmon Streams (m^3/s) Mean Annual	Mean Flood	Mean Monthly Aug	Mean Monthly Sept	Mean 7-day Flow Summer	Mean 7-day Flow Winter
S. Thompson River (lower mainstem)	08LE031	17311	1644.5	2830.4	-	-	-	-	-	-	-	-	-	311	930	397	242	-	62.2
Chase Ck		297	17.8	41.6	3.84	22,100	2,559	6,000	716,298	0	339	219	39	1.4	13.5	0.72	0.54	0.30	0.10
S. Thompson River (upper mainstem)		15209	1455.5	2428.8	299.55	-	-	-	-	-	-	-	-	17.8	71.3				
Adams R	08LD001	3323	205	397.1	6.53	48,000	3,553	52,000	1,449,209	2	497	331	81	74.1	230	110	74.0	46.2	22.6
- Hiuihill Ck		110	11	21.9	0.97	3,500	1,068	0	936,209	0	174	124	49	1.4	11.1	0.35	0.25	0.15	0.10
- Nikwikwaia Ck		97	11.7	22.3	0	-	-	-	-	-	0	0	0	1.2	9.8	0.25	0.16	0.13	0.08
Adams R above Adams Lake		3087	179	343.8	5.51														
- Sinmax Ck		191	28.6	38.2	5.51	8,000	1,897	0	47,500	0	225	136	3	0.8	3.0	0.63	0.40	0.30	0.20
- Momich R		477	27.3	61.9	0	-	-	-	-	-	0	0	0	21.1	152	5.30	4.50	3.58	1.90
- Cayenne Ck		368	22.1	51.5	0	-	-	-	-	-	0	0	0	16.3	117	4.10	3.50	2.74	1.52
Scotch Ck		611	61	183.2	0.54	1,500	203	0	0	0	24	14	0	7.7	61.7	5.40	4.40	3.59	1.94
Onyx Ck		57	5.7	17.3	2.15	6,000	543	0	0	0	64	38	0	1.0	9.6	0.27	0.18	0.13	0.09
Ross Ck		106	10.6	31.7	0	0	535	0	0	0	83	38	0	1.9	17.8	0.60	0.51	0.24	0.15
Seymour R	08LE027	807	40.3	96.8	0.27	5,000	26	0	0	0	3	2	0	35.7	257	32.50	25.60	11.70	6.70
- McNomee Ck		68	3.4	23.7	0	-	-	-	-	-	0	0	0	3.0	21.7	0.83	0.76	0.38	0.21
Hunakwa Ck		35	0	8.8	0	-	-	-	-	-	0	0	0	0.9	7.0	0.21	0.18	0.08	0.07
Anstey R		238	23.8	59.4	0	0	0	0	0	0	0	0	0	10.5	75.9	3.26	2.81	1.76	0.74

1. Gauge numbers indicate that flow characteristics were calculated from WSC gauging records.
2. Logged areas, improved farmland, mean annual flows and mean annual flood from Sigma (1991).
3. Total water licences for each salmon stream expressed in imperial units, as provided by Water Management Branch.
4. Reference for all data in table is the mouth of the salmon stream.
5. Licenced demands (L/s) calculated from total water licences as described in body of report.
6. Naturalized flows are estimates of those that would occur in the absence of all upstream water extractions.

Appendix B (cont'd)

Stream Name	WSC Gauge No.	Basin Area (mouth) (km^2)	Logged Area		Improved Farmland (1990) (km^2)	Total Water Licenses					Licensed Demand (L/s)			Naturalized Flows in the Salmon Streams (m^3/s)					
			Recent (km^2)	Older (km^2)		Domestic (g/day)	Irrigation (ac-ft)	Waterworks (g/day)	Industrial (g/day)	Conservation (cfs)	Aug	Sept	Feb	Mean Annual	Mean Flood	Mean Monthly Aug	Mean Monthly Sept	Mean 7-day Flow Summer	Mean 7-day Flow Winter
Eagle R	08LE024	1246	158.1	154.6	10.8	42,000	2,306	18,500	5,543,685	10	565	457	295	37.7	236	31.06	24.16	18.52	10.34
- Owlhead Ck		24	0.5	3	0.65	2,000	62	0	0	0	7	4	0	1.0	6.0	0.27	0.26	0.11	0.07
- Perry R		438	43.8	65.7	0	0	0	0	0	0	0	0	0	19.4	140	8.15	7.07	4.85	1.68
- South Pass Ck		31	1.6	9.2	0	0	0	0	0	0	0	0	0	1.3	9.0	0.60	0.60	0.26	0.14
Reienecker Ck		53	2.6	15.8	0	0	0	0	0	0	0	0	0	1.0	9.6	0.30	0.25	0.13	0.09
Tappen Ck		131	6	36.2	5.98	49,000	1,002	0	306,428	10	136	89	19	0.3	0.8	0.45	0.34	0.20	0.15
Salmon R	08LE021	1501	161.4	439.1	68.1	132,750	19,562	40,000	40,879	0	2300	1385	11	4.6	28.6	3.91	3.16	2.59	1.50
- Bolean Ck	08LE094	221	33.2	55.4	2.16	8,000	705	0	0	0	83	50	0	1.1	7.9	0.39	0.46	0.17	0.11
Canoe Ck		80	1.6	18.3	12.07	17,500	296	2,233,000	4,446	0	153	139	119	0.2	1.0	0.13	0.09	0.04	0.05
Shuswap R	08LC002	5415	674.6	770.5	?	313,350	49,100	12,011,402	2,951,682	1.38	6549	4251	804	101	420	79.1	57.2	46.49	37.91
Shuswap R (Mabel Lake to Mara Lake)	08LC018	1372	115.5	203.4	116.28	-	-	-	-	-	-	-	-	18.6	93.2	65.3	50.1		-
- Johnson Ck		22	1.1	3.2	0.32	3,500	171	0	0	0	20	12	0	0.9	6.4	0.28	0.27	0.11	0.07
- Blurton Ck		24	1.2	7.2	0.27	8,500	270	0	5,000	0	32	20	1	1.0	7.0	0.25	0.23	0.10	0.07
- Fortune Ck		151	3	12.1	60.98	13,250	799	2,544,000	29,403	0	230	192	136	1.2	10.0	0.38	0.32	0.25	0.10
- Trinity Ck		195	13.7	15.6	2.72	7,000	1,632	0	3,000	0	192	115	1	2.0	8.5	0.41	0.34	0.26	0.10
Kingfisher Ck		192	17.7	49.4	0	500	38	0	53,855	0	7	5	3	8.1	55.7	1.42	1.15	0.72	0.39
- Danforth Ck		29	1.5	8.8	0	-	-	-	-	-	0	0	0	1.2	8.4	0.15	0.13	0.06	0.05
Shuswap River	08LC019	4029	556	565.3	56.83	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Noisy Ck		59	5.8	17.6	0	0	0	0	0	0	0	0	0	2.5	17.1	0.64	0.58	0.29	0.17
- Wap Ck		354	35.4	53.1	0	0	0	0	0	0	0	0	0	14.9	103	6.11	5.31	3.52	1.28
- Tsuius Ck		210	20.9	31.5	0	-	-	-	-	-	0	0	0	8.8	60.9	2.34	1.98	1.23	0.57
- Ireland Ck		104	8.3	12.5	0.8	2,500	680	0	2,500	0	80	48	0	4.4	30.2	0.50	0.40	0.23	0.16
- Bessette Ck	08LC039	795	109.5	78.5	39.24	49,600	30,939	2,537,901	148,164	1.38	3764	2316	144	4.5	34.3	5.69	4.53	3.43	0.95
- Creighton Ck		154	15.4	23.1	10.96	12,000	1,733	0	1,000	0	204	122	1	0.9	7.8	0.59	0.45	0.28	0.20
- Duteau Ck	08LC006	217	54.3	21.7	11.73	9,000	18,329	2,537,901	40,164	1.38	2281	1423	136	1.2	11.0	0.69	0.41	0.30	0.23
- Harris Ck		212	21.2	10.6	0	0	8,000	0	2,000	0	936	562	0	1.2	10.7	1.39	1.11	0.71	0.39

1. Gauge numbers indicate that flow characteristics were calculated from WSC gauging records.
2. Logged areas, improved farmland, mean annual flows and mean annual flood from Sigma (1991).
3. Total water licences for each salmon stream expressed in imperial units, as provided by Water Management Branch.
4. Reference for all data in table is the mouth of the salmon stream.
5. Licenced demands (L/s) calculated from total water licences as described in body of report.
6. Naturalized flows are estimates of those that would occur in the absence of all upstream regulation and water extractions.

Appendix C. Sensitivity indices -- South Thompson-Shuswap HMA. ((source: Rood and Hamilton 1995)

		SUMMER WATER USE				LOW FLOWS		PEAK FLOW	LOGGING	
Stream Name	*Status*	*Index 1 Aug Use/ Sum Q7L2*	*Index 2 Sept Use/ Sum Q7L2*	*Index 3 Aug Use/ mean Aug*	*Index 4 Sept Use/ mean Sept*	*Index 5 Sum Q7L2/ QAA*	*Index 6 Win Q7L2/ QAA*	*Index 7 Q2/ QAA*	*Index 8 Recent/ Basin*	*Index 9 Total/ Basin*
S. Thompson River		-	-	-	-	-	-	3	9%	26%
(lower mainstem)										
Chase Ck	RES	113%	73%	47%	41%	6%	4%	10	6%	20%
S. Thompson River		-	-	-	-	-	-	4	10%	26%
(upper mainstem)										
Adams R	RES	1%	1%	0%	0%	62%	30%	3	6%	18%
- Hiuihill Ck	RES	116%	83%	50%	49%	2%	4%	8	10%	30%
- Nikwikwaia Ck		0%	0%	0%	0%	11%	7%	8	12%	35%
Adams R above Adams	RES								6%	17%
- Sinmax Ck	FR	75%	45%	35%	34%	20%	25%	4	15%	35%
- Momich R		0%	0%	0%	0%	17%	9%	7	6%	19%
- Cayenne Ck		0%	0%	0%	0%	17%	9%	7	6%	20%
Scotch Ck		1%	0%	0%	0%	46%	25%	8	10%	40%
Onyx Ck		49%	30%	24%	22%	9%	9%	9	10%	40%
Ross Ck		26%	16%	10%	7%	10%	8%	9	10%	40%
Seymour R		0%	0%	0%	0%	33%	19%	7	5%	17%
- McNomee Ck		0%	0%	0%	0%	13%	7%	7	5%	40%
Hunakwa Ck		0%	0%	0%	0%	9%	8%	8	0%	25%
Anstey R		0%	0%	0%	0%	17%	7%	7	10%	35%

- Status refers to restrictions noted by the Water Management Branch: FR, fully recorded with exceptions for storage; RES, reserved, no licencing; PWS, possible water shortages, RNW, refused, no water.
- Aug and Sept Use are total demands in these months; Sum and Win Q7L2 are summer and winter mean 7 day low flows; mean Aug and and Sept are mean August and September monthly flows; QAA is mean annual flow; Q2 is the mean annual flood; Recent and Total are recent and total logging areas in the basin; Basin is basin area above the mouth.
- Indices expressed as percentages except 7, which is a direct ratio.

Appendix C (cont'd)

		SUMMER WATER USE				LOW FLOWS		PEAK FLOW	LOGGING	
Stream Name	*Status*	*Index 1 Aug Use/ Sum Q7L2*	*Index 2 Sept Use/ Sum Q7L2*	*Index 3 Aug Use/ mean Aug*	*Index 4 Sept Use/ mean Sept*	*Index 5 Sum Q7L2/ QAA*	*Index 6 Win Q7L2/ QAA*	*Index 7 Q2/ QAA*	*Index 8 Recent/ Basin*	*Index 9 Total/ Basin*
Eagle R		3%	2%	2%	2%	48%	27%	6	13%	25%
- Owlhead Ck		7%	4%	3%	2%	10%	7%	6	2%	15%
- Perry R		0%	0%	0%	0%	25%	9%	7	10%	25%
- South Pass Ck		0%	0%	0%	0%	20%	11%	7	5%	35%
Reienecker Ck		0%	0%	0%	0%	13%	9%	10	5%	35%
Tappen Ck		68%	45%	30%	26%	37%	44%	3	5%	32%
Salmon R	RES	89%	54%	59%	44%	26%	33%	6	11%	40%
- Bolean Ck	RES	49%	29%	21%	11%	11%	10%	7	15%	40%
Canoe Ck	RES	393%	358%	118%	155%	0%	0%	5	2%	25%
Shuswap R		14%	9%	8%	7%	42%	37%	4	12%	27%
Shuswap R (Mabel Lake to Mara Lake)								5	8%	23%
- Johnson Ck		18%	11%	7%	5%	11%	8%	7	5%	20%
- Blurton Ck		33%	20%	13%	9%	8%	7%	7	5%	35%
- Fortune Ck		91%	76%	60%	60%	5%	0%	8	2%	10%
- Trinity Ck		75%	45%	47%	34%	7%	5%	4	7%	15%
Kingfisher Ck		1%	1%	1%	0%	9%	5%	7	9%	35%
- Danforth Ck		0%	0%	0%	0%	5%	4%	7	5%	36%
Shuswap River									14%	28%
- Noisy Ck		0%	0%	0%	0%	12%	7%	7	10%	40%
- Wap Ck		0%	0%	0%	0%	24%	9%	7	10%	25%
- Tsuius Ck		0%	0%	0%	0%	14%	6%	7	10%	25%
- Ireland Ck		35%	21%	16%	12%	4%	4%	7	8%	20%
- Bessette Ck		110%	68%	66%	51%	25%	18%	8	14%	24%
- Creighton Ck		74%	44%	35%	27%	18%	23%	9	10%	25%
- Duteau Ck		760%	474%	331%	347%	15%	8%	9	25%	35%
- Harris Ck		132%	79%	67%	51%	12%	33%	9	10%	15%

- Status refers to restrictions noted by the Water Management Branch: FR, fully recorded with exceptions for storage; RES, reserved, no licencing; PWS, possible water shortages, RNW, refused, no water.
- Aug and Sept Use are total demands in these months; Sum and Win Q7L2 are summer and winter mean 7 day low flows; mean Aug and and Sept are mean August and September monthly flows; QAA is mean annual flow; Q2 is the mean annual flood; Recent and Total are recent and total logging areas in the basin; Basin is basin area above the mouth.
- Indices expressed as percentages except 7, which is a direct ratio.

Appendix D. Forest inventory of South Thompson-Shuswap HMA salmon streams. (source: Sigma Engineering Ltd. 1991)

Gazetted Name	Watershed Code	Total Area (km2)	Non-forested (km2) (% total)	Potentially Forested (km2) (% total)	Recently Logged (km2) (% total)	Older Logging (km2) (% total)	Total Logged (km2) (% total)	Forest Remaining (km2) (% total)
South Thompson R	03	17311.00	3266.60	14044.40	1644.50	2830.40	4474.90	9569.50
			18.87	81.13	9.50	16.35	25.85	55.28
South Thompson R (Lower)	03-0000-000-000-000-000-991	1961.20	687.40	1273.80	184.40	374.60	559.00	714.80
			35.05	64.95	9.40	19.10	28.50	36.45
Watershed exterior to tributary of interest		1664.30	665.70	998.60	166.40	332.90	499.30	499.30
			40.00	60.00	10.00	20.00	30.00	30.00
Chase C	03-1500	296.90	20.80	276.10	17.80	41.60	59.40	216.70
			7.00	93.00	6.00	14.00	20.00	73.00
South Thompson R (Middle)	03-0000-000-000-000-000-992	141.00	28.20	112.80	7.10	28.20	35.20	77.60
			20.00	80.00	5.00	20.00	25.00	55.00
South Thompson R (Upper)	03-0000-000-000-000-000-993	15208.80	2559.60	12649.20	1455.50	2428.80	3884.30	8764.90
			16.83	83.17	9.57	15.97	25.54	57.63
Adams R	03-1800	3323.10	523.70	2799.33	205.00	397.10	602.10	2197.23
			15.76	84.24	6.17	11.95	18.12	66.12
Adams R (below Adams Lake)	03-1800-000-000-000-000-991	234.40	5.40	229.00	24.90	50.10	75.00	154.00
			2.29	97.71	10.62	21.38	32.00	65.71
Hiuihill C	03-1800-010	109.60	2.20	107.40	11.00	21.90	32.90	74.50
			2.00	98.00	10.00	20.00	30.00	68.00
Nikwikwaia C	03-1800-020	97.10	1.90	95.20	11.70	22.30	34.00	61.20
			2.00	98.00	12.00	23.00	35.00	63.00
Adams R (Upper Adams R)	03-1800-000-000-000-000-992	3086.60	522.90	2563.70	179.00	343.80	522.80	2040.90
			16.94	83.06	5.80	11.14	16.94	66.12
Watershed exterior to tributaries of interest		2418.50	483.70	1934.80	120.90	241.80	362.80	1572.00
			20.00	80.00	5.00	10.00	15.00	65.00
Sinmax C	03-1800-070	191.00	19.10	171.90	28.60	38.20	66.80	105.10
			10.00	90.00	15.00	20.00	35.00	55.00
Momich R	03-1800-150	477.10	20.50	456.60	27.30	61.90	89.20	367.40
			4.29	95.71	5.72	12.98	18.70	77.01
Watershed exterior to tributary of interest		109.40	2.20	107.20	5.50	10.90	16.40	90.80
			2.00	98.00	5.00	10.00	15.00	83.00
Cayenne C	03-1800-150-500	367.70	18.40	349.40	22.10	51.50	73.60	275.80
			5.00	95.00	6.00	14.00	20.00	75.00
Scotch C	03-2000	610.50	48.80	561.70	61.00	183.20	244.20	317.50
			8.00	92.00	10.00	30.00	40.00	52.00
Onyx C	03-2500	57.40	1.10	56.30	5.70	17.30	23.00	33.30
			2.00	98.00	10.00	30.00	40.00	58.00

Appendix D (cont'd)

Gazetted Name	Watershed Code	Total Area (km2)	Non-forested (km2) (% total)	Potentially Forested (km2) (% total)	Recently Logged (km2) (% total)	Older Logging (km2) (% total)	Total Logged (km2) (% total)	Forest Remaining (km2) (% total)
Ross C	03-2600	105.80	2.10	103.70	10.60	31.70	42.30	61.40
			2.00	98.00	10.00	30.00	40.00	58.00
Seymour R	03-3300	806.60	188.70	617.80	40.30	96.80	137.10	480.70
			23.40	76.60	5.00	12.00	17.00	59.60
Watershed exterior to tributary of interest		738.80	184.70	554.10	36.90	73.90	110.80	443.30
			25.00	75.00	5.00	10.00	15.00	60.00
McNomee C	03-3300-010	67.80	3.40	64.40	3.40	23.70	27.10	37.30
			5.00	95.00	5.00	35.00	40.00	55.00
Hunakwa C	03-3690	35.30	4.90	30.40	0.00	8.80	8.80	21.60
			14.00	86.00	0.00	25.00	25.00	61.00
Anstey R	03-3700	237.70	47.50	190.20	23.80	59.40	83.20	107.00
			20.00	80.00	10.00	25.00	35.00	45.00
Eagle R	03-4300	1245.90	195.00	1050.90	158.10	154.60	312.70	738.20
			15.65	84.35	12.69	12.41	25.10	59.25
Watershed exterior to tributaries of interest		753.70	37.70	716.00	113.00	75.40	188.40	527.60
			5.00	95.00	15.00	10.00	25.00	70.00
Owlhead C	03-4300-010	23.50	1.20	22.30	0.50	3.00	3.50	18.80
			5.00	95.00	2.00	13.00	15.00	80.00
Perry R	03-4300-050	437.90	153.30	284.60	43.80	65.70	109.40	175.20
			35.00	65.00	10.00	15.00	25.00	40.00
South Pass C	03-4300-090	30.80	3.10	27.70	1.60	9.20	10.80	16.90
			10.00	90.00	5.00	30.00	35.00	55.00
Reienecker C	03-4700	52.60	1.00	51.60	2.60	15.80	18.40	33.20
			2.00	98.00	5.00	30.00	35.00	63.00
Tappen C	03-5000	120.60	8.40	112.20	6.00	36.20	42.20	70.00
			7.00	93.00	5.00	30.00	35.00	58.00
Salmon R	03-5200	1501.20	134.40	1366.80	161.40	439.10	600.50	766.30
			8.95	91.05	10.75	29.25	40.00	51.05
Watershed exterior to tributary of interest		1279.80	128.00	1151.80	128.00	383.90	511.90	639.90
			10.00	90.00	10.00	30.00	40.00	50.00
Bolean C	03-5200-170	221.40	6.60	214.80	33.20	55.40	88.60	126.20
			3.00	97.00	15.00	25.00	40.00	57.00
Canoe C	03-5300	79.60	27.90	51.70	1.60	18.30	19.90	31.80
			35.00	65.00	2.00	23.00	25.00	40.00
Shuswap R	03-5400	5414.50	754.20	4660.30	674.60	770.50	1445.10	3215.20
			13.93	86.07	12.46	14.23	26.69	59.38
Shuswap R (Mabel L to Mara L)	03-5400-000-000-000-000-991	1371.50	195.40	1176.10	115.50	203.40	318.90	857.20

Appendix D (cont'd)

Gazetted Name	Watershed Code	Total Area (km2)	Non-forested (km2) (% total)	Potentially Forested (km2) (% total)	Recently Logged (km2) (% total)	Older Logging (km2) (% total)	Total Logged (km2) (% total)	Forest Remaining (km2) (% total)
			14.25	85.75	8.42	14.83	23.25	62.50
Watershed exterior to tributaries of interest		787.70	118.20	669.50	78.80	118.10	196.90	472.60
			15.00	85.00	10.00	15.00	25.00	60.00
Johnson C	03-5400-050	21.60	0.40	21.20	1.10	3.20	4.30	16.90
			2.00	98.00	5.00	15.00	20.00	78.00
Blurton C	03-5400-060	24.10	0.50	23.60	1.20	7.20	8.40	15.20
			2.00	98.00	5.00	30.00	35.00	63.00
Fortune C	03-5400-120	151.30	60.50	90.80	3.00	12.10	15.10	75.70
			40.00	60.00	2.00	8.00	10.00	50.00
Trinity C	03-5400-160	195.10	7.80	187.30	13.70	15.60	29.30	158.00
			4.00	96.00	7.00	8.00	15.00	81.00
Kingfisher C	03-5400-210	191.70	9.00	182.70	17.70	49.40	67.10	115.60
			4.70	95.30	9.25	25.75	35.00	60.30
Watershed exterior to tributary of interest		162.30	8.10	154.20	16.20	40.60	56.80	97.40
			5.00	95.00	10.00	25.00	35.00	60.00
Danforth C	03-5400-210-030	29.40	0.90	28.50	1.50	8.80	10.30	18.20
			3.00	97.00	5.00	30.00	35.00	62.00
Shuswap R (Sugar L to Mabel L)	03-5400-000-000-000-000-992	4029.00	557.20	3471.80	556.00	565.30	1121.30	2350.50
			13.83	86.17	13.80	14.03	27.83	58.34
Watershed exterior to tributaries of interest		2507.50	376.10	2131.40	376.10	376.10	752.20	1379.20
			15.00	85.00	15.00	15.00	30.00	55.00
Noisy C	03-5400-230	58.60	5.90	52.70	5.80	17.60	23.40	29.30
			10.00	90.00	10.00	30.00	40.00	50.00
Wap C	03-5400-240	354.20	24.80	329.40	35.40	53.10	88.50	240.90
			7.00	93.00	10.00	15.00	25.00	68.00
Tsuius C	03-5400-260	209.70	31.50	178.20	20.90	31.50	52.40	125.80
			15.00	85.00	10.00	15.00	25.00	60.00
Ireland C	03-5400-320	104.20	3.10	101.10	8.30	12.50	20.80	80.30
			3.00	97.00	8.00	12.00	20.00	77.00
Bessette C	03-5400-350	794.80	117.50	677.30	109.50	78.50	188.00	489.40
			14.78	85.22	13.78	9.87	23.65	61.57
Watershed exterior to tributaries of interest		212.10	27.60	184.50	14.80	17.00	31.80	152.70
			13.00	87.00	7.00	8.00	15.00	72.00
Creighton C	03-5400-350-030	153.80	16.90	136.90	15.40	23.10	38.50	98.40
			11.00	89.00	10.00	15.00	25.00	64.00
Duteau C	03-5400-350-040	217.20	65.20	152.00	54.30	21.70	76.00	76.00
			30.00	70.00	25.00	10.00	35.00	35.00

Appendix D (cont'd)

Gazetted Name	Watershed Code	Total Area (km2)	Non-forested (km2) (% total)	Potentially Forested (km2) (% total)	Recently Logged (km2) (% total)	Older Logging (km2) (% total)	Total Logged (km2) (% total)	Forest Remaining (km2) (% total)
Harris C	03-5400-350-060	211.70	8.50 4.00	203.20 96.00	21.20 10.00	10.60 5.00	31.76 15.00	171.50 81.00

Appendix E. Agricultural inventory of the South Thompson-Shuswap HMA streams. (source: Sigma Engineering Ltd. 1991)

Gazetted Name	Watershed Code	Total Area (km2)	1976 Improved Farmland (km2) (% total)	est.1990 Improved Farmland (km2) (% total)	max.2010 Improved Farmland (km2) (% total)	est.1990 Animal Units (AUs) (AUs/km2)	max.2010 Animal Units (AUs) (AUs/km2)	Census Code (CCSD)	1976-86 % Change, Farmland (%)	AUs/km2, 1986 Farmland (AUs/km2)
South Thompson R (Shuswap L to Humamilt L)	03	17311.0	349.63	372.54	414.57	41044	44984	na	na	na
Shuswap L, Humamilt L			2.02%	2.15%	2.39%	2.37	2.60			
South Thompson R (Lower)	03-0000-000-000-000-000-991	1961.2	74.14	69.47	92.15	5071	6727	TNE	-4.5%	73
(Below Little Shuswap Lake)			3.78%	3.54%	4.70%	2.59	3.43			
Chase C	03-1500	296.9	3.89	3.64	5.33	266	389	TNE	-4.5%	73
Pillar Lake			1.31%	1.23%	1.80%	0.90	1.31			
South Thompson R (Middle)	03-0000-000-000-000-000-992	141.0	3.76	3.52	4.89	257	357	TNE	-4.5%	73
(Between Shuswap Lake and Little Shuswap Lake)			2.67%	2.50%	3.47%	1.82	2.53			
South Thompson R (Upper)	03-0000-000-000-000-000-993	15208.8	271.73	299.55	317.53	35716	37900	na	na	na
Little Shuswap Lake			1.79%	1.97%	2.09%	2.35	2.49			
Adams R	03-1800	3323.1	6.97	6.53	8.24	866	1124	na	na	na
			0.21%	0.20%	0.25%	0.26	0.34			
Adams R (below Adams Lake)	03-1800-000-000-000-000-991	234.4	1.32	1.02	1.98	172	336	CSC	14.9%	126
(from outlet of Adams L to Shuswap L)			0.56%	0.43%	0.84%	0.73	1.43			
Hiuihill C	03-1800-010	109.6	1.28	0.97	1.92	166	328	TNB	-17.3%	171
			1.17%	0.88%	1.75%	1.51	3.00			
Nikwikwaia C	03-1800-020	97.1	0.00	0.00	0.00	0	0	TNA	-1.8%	126
			0.00%	0.00%	0.00%	0.00	0.00			
Adams R (Upper Adams R)	03-1800-000-000-000-000-992	3086.6	5.65	5.51	6.26	694	788	TNA	-1.8%	126
Adams Lake, Tumtum Lake			0.18%	0.18%	0.20%	0.22	0.26			
Sinmax C	03-1800-070	191.0	5.65	5.51	6.26	694	788	TNA	-1.8%	126
Forest Lake, Johnson L			2.96%	2.88%	3.27%	3.63	4.13			
Momich R	03-1800-150	477.1	0.00	0.00	0.00	0	0	TNA	-1.8%	126
Momich Lake, Third Momich Lake			0.00%	0.00%	0.00%	0.00	0.00			
Little Momich Lake										
Cayenne C	03-1800-150-500	367.7	0.00	0.00	0.00	0	0	TNA	-1.8%	126
Stukemapten L			0.00%	0.00%	0.00%	0.00	0.00			
Scotch C	03-2000	610.5	0.45	0.54	0.68	69	85	CSC	14.9%	126
			0.07%	0.09%	0.11%	0.11	0.14			
Onyx C	03-2500	57.4	1.79	2.15	2.15	271	271	CSC	14.9%	126
			3.12%	3.74%	3.74%	4.72	4.72			
Ross C	03-2600	105.8	0.00	0.00	0.00	0	0	CSC	14.9%	126
			0.00%	0.00%	0.00%	0.00	0.00			
Seymour R	03-3300	806.6	0.22	0.27	0.33	34	42	CSC	14.9%	126
Humamilt L			0.03%	0.03%	0.04%	0.04	0.05			
McNamee C	03-3300-010	67.8	0.00	0.00	0.00	0	0	CSC	14.9%	126
			0.00%	0.00%	0.00%	0.00	0.00			
Hunakwa C	03-3690	35.3	0.00	0.00	0.00	0	0	CSC	14.9%	126
Hunakwa Lake			0.00%	0.00%	0.00%	0.00	0.00			
Anstey R	03-3700	237.7	0.00	0.00	0.00	0	0	CSC	14.9%	126
			0.00%	0.00%	0.00%	0.00	0.00			
Eagle R	03-4300	1245.9	9.05	10.80	10.80	1361	1361	CSC	14.9%	126
Griffin Lake, Three Valley Lake			0.73%	0.87%	0.87%	1.09	1.09			
Owlhead C	03-4300-010	23.5	0.59	0.65	0.65	82	82	CSC	14.9%	126
			2.51%	2.76%	2.76%	3.48	3.48			
Perry R	03-4300-050	437.9	0.00	0.00	0.00	0	0	CSC	14.9%	126
			0.00%	0.00%	0.00%	0.00	0.00			
South Pass C	03-4300-090	30.8	0.00	0.00	0.00	0	0	CSC	14.9%	126
			0.00%	0.00%	0.00%	0.00	0.00			
Retenecker C	03-4700	52.6	0.00	0.00	0.00	0	0	CSC	14.9%	126
			0.00%	0.00%	0.00%	0.00	0.00			
Tappen C	03-5000	120.6	4.95	5.98	6.74	754	850	CSC	14.9%	126
			4.10%	4.96%	5.59%	6.25	7.05			

Appendix E (cont'd)

Gazetted Name	Watershed Code	Total Area (km2)	1976.00 Improved Farmland (km2) (% total)	est.1990 Improved Farmland (km2) (% total)	max.2010 Improved Farmland (km2) (% total)	est.1990 Animal Units (AUs) (AUs/km2)	max.2010 Animal Units (AUs) (AUs/km2)	Census Code (CCSD)	1976-86 % Change, Farmland (%)	AUs/km2, 1986 Farmland (AUs/km2)
Salmon R	03-5200	1501.2	73.07 4.87%	88.10 5.87%	90.13 6.00%	11101 7.39	11356 7.56	CSC	14.9%	126
Salmon Lake Bolean C	03-5200-170	221.4	1.96 0.89%	2.16 0.97%	2.16 0.97%	272 1.23	272 1.23	CSC	14.9%	126
Bolean Lake Canoe C	03-5300	79.6	9.99 12.55%	12.07 15.17%	12.99 16.32%	1521 19.11	1636 20.56	CSC	14.9%	126
Shuswap R	03-5400	5414.5	165.24 3.05%	173.11 3.20%	185.48 3.43%	19740 3.65	21176 3.91	na	na	na
Shuswap R (Mabel L to Mara L)	03-5400-000-000-000-000-991	1371.5	107.44 7.83%	116.28 8.48%	117.02 8.53%	13148 9.59	13234 9.65	na	na	na
Mara Lake Johnson C	03-5400-050	21.6	0.29 1.34%	0.32 1.48%	0.32 1.48%	45 2.10	45 2.10	NOA	19.5%	142
Blurton C	03-5400-060	24.1	0.21 0.87%	0.27 1.11%	0.27 1.13%	38 1.58	39 1.61	NOA	19.5%	142
Fortune C	03-5400-120	151.3	57.58 38.06%	60.98 40.30%	60.98 40.30%	5366 35.47	5366 35.47	NOS	26.8%	88
Trinity C	03-5400-160	195.1	2.77 1.42%	2.72 1.40%	3.46 1.77%	316 1.62	401 2.06	NOB	-1.2%	116
Kingfisher C	03-5400-210	191.7	0.00 0.00%	0.00 0.00%	0.00 0.00%	0 0.00	0 0.00	NOA	19.5%	142
Danforth C	03-5400-210-030	29.4	0.00 0.00%	0.00 0.00%	0.00 0.00%	0 0.00	0 0.00	NOA	19.5%	142
Shuswap R (Sugar L to Mabel L)	03-5400-000-000-000-000-992	4029.0	57.80 1.43%	56.83 1.41%	68.46 1.70%	6592 1.64	7942 1.97	na	na	na
Mabel Lake, Sugar Lake, Greenbush L Noisy C	03-5400-230	58.6	0.00 0.00%	0.00 0.00%	0.00 0.00%	0 0.00	0 0.00	NOA	19.5%	142
Wap C	03-5400-240	354.2	0.00 0.00%	0.00 0.00%	0.00 0.00%	0 0.00	0 0.00	NOA	19.5%	142
Wap Lake Tsuius C	03-5400-260	209.7	0.00 0.00%	0.00 0.00%	0.00 0.00%	0 0.00	0 0.00	NOA	19.5%	142
Ireland C	03-5400-320	104.2	0.81 0.78%	0.80 0.76%	1.05 1.01%	92 0.89	122 1.17	NOB	-1.2%	116
Bessette C	03-5400-350	794.8	39.91 5.02%	39.24 4.94%	44.44 5.59%	4552 5.73	5155 6.49	NOB	-1.2%	116
Creighton C	03-5400-350-030	153.8	11.15 7.25%	10.96 7.13%	11.81 7.68%	1272 8.27	1370 8.91	NOB	-1.2%	116
Duteau C	03-5400-350-040	217.2	11.93 5.49%	11.73 5.40%	12.94 5.96%	1361 6.26	1501 6.91	NOB	-1.2%	116
Harris C	03-5400-350-060	211.7	0.00 0.00%	0.00 0.00%	0.00 0.00%	0 0.00	0 0.00	NOB	-1.2%	116