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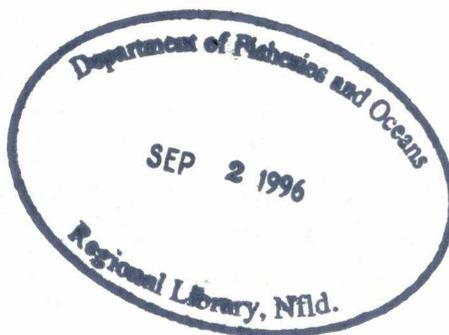
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Hydrology and Water Use for Salmon Streams in the Chilliwack/Lower Fraser Habitat Management Area, British Columbia

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1995

HYDROLOGY AND WATER USE FOR SALMON STREAMS IN
THE CHILLIWACK/LOWER FRASER HABITAT MANAGEMENT AREA,
BRITISH COLUMBIA

by

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ABSTRACT

The Fraser River Action Plan (FRAP) is developing plans for environmentally sustainable salmon production in streams of the Fraser River watershed. This report focuses on the Chilliwack/Lower Fraser Habitat Management Area (HMA). The HMA includes Fraser River tributaries in the eastern Fraser Valley. Hydrology and water use in sixty-five salmon streams are discussed.

North of the Fraser River, streams drain the the Coast Mountains. South of the Fraser, they drain the Cascade Mountains. The main streams cross the Fraser Lowlands to enter the Fraser River. Annual precipitation ranges from 1500 to 2000 mm. About three-quarters of the precipitation falls as rain between October and March. There is some snowfall at higher elevations during winter. North of the Fraser, stream flows are highest during late fall and early winter and lowest during late summer. South of the Fraser, the timing of maximal and minimal flows is more varied. Floods accompany late spring snow melt and rainstorms during winter and summer. Minimum flows occur in late summer or in late winter, under ice.

The hydrologic regimes and the effects of human development on the regimes are emphasized. Ten indices use hydrologic, water use, and land use data to rank habitat sensitivity of the streams. Some indices express the level of human activity. Some express the state of the stream and its ability to resist change. The most useful indices reflect summer water use, compare low and peak flows to mean flow, and indicate the extent of forest harvesting in the watersheds. The most sensitive streams are those that are most affected by human activity and those naturally sensitive to human impact.

Dykes were built on the lower Chilliwack and Vedder Rivers many years ago. Gravel is removed from several streams for flood control. Water withdrawal, riparian vegetation removal, pesticide use near streams, and ditch maintenance are concerns with agricultural activity on the low lands. Many small tributaries in agricultural areas flow through ditches. High water demand during summer is a problem on several streams, where potential water use various purposes accounts for more than 40% of summer low flows. Several streams have low flow problems or dry up completely during summer. Some have low flow problems during winter. Plans to access groundwater may affect flow in groundwater-fed streams. Urbanization affects stream flow in two watersheds, where impervious material covers 10 to 20% of the land. Forest harvesting began seventy years ago and many forests have regrown. However, the lower reaches of many streams are unstable because the coarse sediment deposited years ago continues to move downstream. Fish production seems more affected by stream stability than water use. Forest harvesting affects more than 20% of the area in four watersheds. Poor road construction and maintenance, drainage control, and slope failures in smaller streams also are of concern. Proposed cuts of up to 9% will affect some watersheds.

The report recommends improving stream flow measurement, monitoring and controlling water use, and developing water management plans for the most sensitive streams. Stream flow requirements of fish should be better studied. The impacts of current stormwater management in urbanized areas should be studied and modeled. A formal system should be developed for reporting incidents of erosion. The report also recommends distributing proposed forest harvesting over the various tributary basins, to maintain flow regimes, and organizing five-year harvesting plans by watershed. These measures will allow more accurate prediction of the impacts of harvesting on hydrology.

RÉSUMÉ

Le Plan d'action pour le Fraser (FRAP) vise la production de saumon, dans une perspective de développement durable, dans les cours d'eau du bassin hydrographique du Fraser. Le présent rapport porte sur la zone de gestion de l'habitat (ZGH) Chilliwack/Cours inférieur du Fraser. La ZGH contient les affluents du Fraser de la partie est de la vallée du fleuve. Ce rapport examine l'hydrologie et l'utilisation de l'eau sur soixante-cinq rivières à saumon.

Au nord du Fraser, les cours d'eau drainent la chaîne Côtière; au sud, les monts Cascade. Les principales rivières traversent les basses terres du Fraser pour se jeter dans le fleuve. Les précipitations se situent entre 1 500 et 2 000 mm par an, dont les trois quarts environ tombent d'octobre à mars sous forme de pluie. On observe quelques chutes de neige en altitude pendant l'hiver. Au nord du Fraser, les débits sont au maximum à la fin de l'automne et au début de l'hiver, et au minimum à la fin de l'été. Au sud du Fraser, le calendrier des crues et des étiages est plus varié. Des crues accompagnent la fonte des neiges à la fin du printemps et les orages en hiver et en été. L'étiage se produit à la fin de l'été ou sous la glace à la fin de l'hiver.

Les travaux mettent l'accent sur les régimes hydrologiques et les effets de l'activité humaine sur ces régimes. Dix indices font appel aux données sur l'hydrologie, l'utilisation de l'eau et l'utilisation des terres pour classer les cours d'eau selon la vulnérabilité de leurs habitats. Certains indices expriment le niveau de l'activité humaine; d'autres indiquent l'état du cours d'eau et son aptitude à résister au changement. Les indices les plus utiles reflètent l'utilisation de l'eau en été, comparent les débits minimaux et maximaux au débit moyen, et indiquent l'ampleur de l'exploitation forestière dans les bassins versants. Les cours d'eau les plus vulnérables sont ceux qui sont les plus affectés par l'activité humaine et ceux qui sont naturellement sensibles à l'impact de cette activité.

Des digues ont été construites il y a bien longtemps sur le cours inférieur de la Chilliwack et de la Vedder. On prélève du gravier dans plusieurs cours d'eau pour lutter contre les crues. Les ponctions d'eau, l'enlèvement de la végétation des berges, l'emploi de pesticides près des cours d'eau et l'entretien des fossés occasionnent des problèmes qui sont liés à l'activité agricole sur les basses terres. Dans les zones agricoles, de nombreux petits affluents coulent dans des fossés. La forte demande d'eau pendant l'été pose un problème sur plusieurs rivières, où l'utilisation potentielle de l'eau à diverses fins représente plus de 40 % des niveaux d'étiage. Plusieurs cours d'eau ont des débits trop faibles ou même s'assèchent complètement en été. Certains ont des débits trop faibles en hiver. Des projets d'utilisation des eaux souterraines pourraient nuire au débit des ruisseaux alimentés par des sources. L'urbanisation affecte le débit dans deux bassins, où des matériaux imperméables recouvrent 10 à 20 % du territoire. L'exploitation forestière a commencé il y a 70 ans, et de nombreuses forêts ont repoussé. Toutefois, le cours inférieur de nombreux cours d'eau reste instable du fait que les sédiments grossiers déposés il y a des années continuent à se déplacer vers l'aval. La production de poisson semble plus touchée par l'instabilité des rivières que par l'utilisation de l'eau. L'exploitation forestière touche plus de 20 % de la superficie dans quatre bassins. Les carences de la construction et de l'entretien des routes, l'aménagement des bassins hydrographiques et l'impact des glissements de terrain sur les petits affluents suscitent aussi des inquiétudes. Certains bassins seront touchés par des projets de coupe pouvant atteindre 9 % de la superficie.

Le rapport recommande d'améliorer les mesures du débit, de surveiller et de régir l'utilisation de l'eau, et d'élaborer des plans de gestion de l'eau pour les cours d'eau les plus vulnérables. Il est nécessaire de mieux étudier les besoins du poisson en matière de débit. Il est nécessaire d'étudier et de modéliser les impacts du mode actuel de gestion des eaux pluviales dans les zones urbanisées. Il serait bon d'établir un système officiel pour signaler les cas d'érosion. Le rapport recommande aussi de répartir les projets d'exploitation forestière sur les divers bassins tributaires, de maintenir les débits et d'établir des plans quinquennaux d'exploitation forestière par bassin. Ces mesures permettront de prédire plus précisément les impacts de l'exploitation forestière sur l'hydrologie.

FOREWORD

This report was commissioned by the Fraser River Action Plan (FRAP). It contains hydrology and land use information that will be useful in reviewing salmon habitat quality and assessing habitat sensitivity.

The Hell's Gate landslide in 1913 decimated sockeye and pink stocks from the upper Fraser River. Habitat degradation and marine exploitation rates have affected some salmon stocks as well. Measures to rebuild salmon stocks began several decades ago, and the stocks have been rebuilding slowly. Stock rebuilding became a higher priority after the signing of the 1985 Canada-U.S.A. Pacific Salmon Treaty. Canada's Green Plan recognizes the importance of good habitat quality in rebuilding stocks. The Department of Fisheries and Oceans incorporated habitat considerations in the Fraser River Green Plan initiative in 1990. This program is now called the Fraser River Action Plan. One of its goals is developing and maintaining sustainable fisheries resources in the Fraser River Basin.

Under FRAP, the Department of Fisheries and Oceans is developing an integrated fisheries resource management plan for the entire Fraser River Basin. The plan provides direction to governments and stakeholders for conserving and restoring habitat and rebuilding salmon stocks. The basin was divided into fifteen Habitat Management Areas (HMAs), based on major river systems and salmon stocks. Within each HMA, the status of salmon habitat, stocks, and habitat restoration and protection priorities will be defined. This information will be used to establish a database and the framework for discussing sustainable development, to which Canada is committed.

Sustainable development is based on two principles: maintaining ecological diversity and maximizing the net economic benefits of the resource. Specific goals are incorporated into Habitat Management Plans and associated DFO decisions and activities. These goals are:

- 1) **Avoiding irreversible man-made changes to fish producing habitats.**
Habitat alterations that reduce fish production capacity will be avoided if they cannot be reversed within one human generation.
- 2) **Maintaining the genetic diversity of fish stocks.**
No fish stock will be written off arbitrarily, and small or remnant stocks will be conserved and rebuilt wherever possible.
- 3) **Maintaining the physical and biological diversity of fish habitats.**
Habitat diversity encourages genetic diversity, alternate life history strategies, and the capacity to survive natural variation in environmental conditions.
- 4) **Providing a net gain in the productive capacity by habitat management.**
Natural and self-sustaining methods of increasing productive capacity are preferred to those that require human intervention and maintenance.
- 5) **Maximizing the value of commercial, sport, and aboriginal fisheries.**
Competing uses of the fisheries resources will be quantified by considering tangible and intangible market and extra-market values.

- 6) **Maximizing the non-consumptive values of fishery resources.**
Intangible and cultural values of the fishery resources will be considered when allocating fishery resources.
- 7) **Distributing fishery net benefits in a fair and equitable manner.**
Local communities should help make decisions about habitat conservation and restoration, stock enhancement, distribution of benefits, and cost-sharing arrangements.

This report is intended to contribute to effective land use planning. In turn, this should protect and manage aquatic habitat successfully and result in sustainable development.

1. INTRODUCTION

1.1 Purpose of the Study

The Fraser River Action Plan, of the Department of Fisheries and Oceans, is developing plans for environmentally sustainable salmon production. Planning is based on fifteen sub-basins -- called Habitat Management Areas (HMA) -- of the Fraser River watershed (Figure 1). This report focuses on the Chilliwack/Lower Fraser HMA which includes streams draining to the Fraser River from both the north and south side of the eastern half of the Fraser Valley. On the north side of the Fraser River, the HMA extends east from Mission and includes streams draining to Hatzic and Nicomen Sloughs. On the south side of the Fraser River, it extends from Matsqui to Hope, including the Sumas and Chilliwack River watersheds (Figure 2).

An understanding of hydrologic regime of the salmon streams is one important aspect of habitat management planning and our report describes both the regime in the salmon streams and the effect of human development on that regime. Within the Chilliwack/Lower Fraser HMA, storage and extraction of flows from surface water for agricultural, municipal or industrial purposes, and urban development and forest harvesting impacts on floods and low flows are the main hydrologic issues.

The main objective of the report is to express the habitat sensitivity of the salmon streams through various indices that are calculated from the hydrologic, water use and land use data collected for the streams. In this report, we use "sensitivity", in a very broad sense, to refer to the state of those aspects of the hydrologic regime that affect habitat and are altered by human activities. The indices are used to rank the streams within the HMA. The most sensitive streams are those that are most affected by human activities and those that, because of their geomorphic or hydrologic regime, have the least ability to resist human impact.

1.2 Scope of the Study

Our study examines 65 known and presently utilized salmon streams within the Chilliwack/Lower Fraser HMA that are listed in SSIS (the Stream Information Summary System; Table 1). Some salmon streams that are included in the HMA (Matsqui Slough, Clayburn and Willband Creeks) were discussed previously (Rood and Hamilton 1994) and are not included in this report. Note that there are differences between the Water Rights Maps, NTS Topographic Maps and the SISS regarding proper names and the location of the various streams. Our analysis is based on information compiled by the Water Survey of Canada, the Ministry of Environment, Lands and Parks, the Department of Fisheries and Oceans and various municipalities as well as interviews with staff of various government departments and agencies. Information available prior to 1994 has been summarized in this report. The following tasks were completed during our study:

1. Summarize and describe those aspects of the climate, physiography, surficial geology and soils that affect the hydrology of the salmon streams;
2. Describe the local hydrologic regime and prepare estimates of mean annual flows, mean annual floods, mean monthly flows and seasonal 7 day low flows for each of the salmon streams from Water Survey of Canada records, Water Management Branch records or from regional analysis for ungauged streams;

3. Use Water Rights Branch records to calculate potential licensed demand on surface waters in each of the salmon streams;
4. Review the impact of forest harvesting on hydrology and determine the portion of the watersheds of the salmon streams that are harvested;
5. Review the impact of urbanization on hydrology and use Zoning Maps, Land Use Maps, and air photographs to measure areas of various land uses in the watersheds of the salmon streams;
6. Use the hydrologic, water use and land use data to calculate sensitivity indices and rank, or prioritize the various salmon streams according to water withdrawals, high flows, low flows and logging.
7. Summarize the main issues for the salmon streams and discuss technical or management alternatives based on interviews and discussions with government personnel.

The main task was calculating flow characteristics for the 65 salmon streams. The quality of information varied greatly from stream to stream and our method estimated flow characteristics so that streams within the study area could be compared and ranked. The estimated flows are not necessarily the best estimate for any individual stream and should not be used for design of structures or evaluation of projects without further, detailed study of that particular stream.

1.3 Organization of the Report

The report describes each task separately and presents the overall results of the study in the final chapter. Chapter 2 describes the characteristics of the study area; Chapter 3, the methods used to estimate flow characteristics; Chapters 4 and 5, the effect of land use on hydrology and the measurement of the effects of harvesting and development; and Chapter 6, the calculation of licensed demand for surface flows. Table 7 summarizes the data for these investigations for each of the salmon streams.

The sensitivity indices are described in Chapter 7. Table 10 presents the calculated indices that express the sensitivity of each of the salmon streams and Table 11 summarizes the most sensitive streams. Chapter 7 discusses the individual streams in detail and Chapter 8 describes technical and management recommendations for the Habitat Management Area.

1.4 Acknowledgements

Funding for this study was provided by the federal Department of Fisheries and Oceans through the Fraser River Action Plan, a Green Plan Initiative. A number of individuals provided an overall perspective on land and water use and hydrology, as well as information on the salmon streams. We would like to thank Robert Edwards, Neil Peters, Peter Caverhill and Bruce Usher of the Surrey Office of the Ministry of Environment, Lands and Parks; and Konrad Johannsen, Lee Dutta, Marissa Bryne, Bruce Reid, Karen Hutton, John Patterson and Herb Klassen of the Department of Fisheries and Oceans. Final preparation of the report for publication was made by Karen Munro.

2. THE CHILLIWACK/LOWER FRASER HABITAT MANAGEMENT AREA

Physiography and geology act to influence the behaviour of soil and water within the study area and, consequently, the hydrologic characteristics of the salmon streams. Terrain and surficial deposits help determine storm runoff characteristics, infiltration rates, and the susceptibility of stream channels to erosion. Subsurface geologic materials influence the recharge, movement and re-emergence of ground water.

Climate, in combination with physiography and geology, can be used to define broad regions of similar hydrologic behaviour. As is discussed in the following sections, the salmon streams of the Chilliwack/Lower Fraser HMA lie within two physiographic regions and also within two ecoregions and two ecosections (Table 2). The ecosections and physiographic regions correspond fairly well, and the following discussion of physiography and climate is based on the physiographic regions, which provide the best regionalization of hydrologic characteristics.

2.1 Physiography

The Chilliwack/Lower Fraser HMA includes the streams draining to Hatzic Prairie and Nicomen Slough on the north side of the Fraser and as well as streams on the south side of the Fraser River lying east of Sumas Prairie, including the Chilliwack River watershed. On the north side of the Fraser River, the watershed of Norrish Creek lies mostly within the southern Fiord Ranges of Coast Mountains (Matthews 1986), though the lower reaches of this stream and most of the watersheds of the smaller streams lie in the Fraser Lowland. The lowland is traditionally separated from the Coast Mountains along the generalized 2,000 foot (600 m) contour (Holland, 1976) though this elevation has no particular hydrologic or geologic significance. On the south side of the river, the tributaries of the upper Chilliwack and those streams lying east of Rosedale lie mostly within the Cascade Mountains, while the other streams lie almost entirely on the Fraser Lowland, though Elk Creek lies partly in both physiographic units.

The Fraser Lowland is a triangular-shaped depositional feature that extends eastward from Point Grey to Laidlaw and southward to near Bellingham and lies between the Coast and Cascade Mountains (Armstrong 1984). The main feature of the Lowland is the Fraser River, which bisects the region in a 5 km wide valley that is cut up to 200 m deep into the surrounding terrain.

On the north side of the Fraser River, flat-lying floodplain deposits in the Fraser River Valley meet the southern edge of the Coast Mountains, where maximum elevations are about 1,200 m in most of the small and moderate-sized watersheds. Most of the streams have built a fan of coarse sediment where they discharge onto the Fraser Floodplain. There are glaciomarine, till and outwash deposits along the larger valleys such as the lower Norrish Creek and, particularly, Hatzic Valley and Lagace Creek.

On the south side of the Fraser River, the Fraser Lowlands is a low flat-lying area, though Sumas and Chilliwack Mountains are outliers of the Coast Mountains that project above the lowland surface to elevations of about 800 and 300 m. The Sumas Prairie, which lies between Sumas Mountain and the Cascade Mountains, was an arm of the sea during much of the Quaternary (Armstrong 1983) and it is filled with 300 m or more of marine deposits topped with less than 5 m of post-glacial lacustrine deposits left by Sumas Lake. Sumas Lake formed behind the fan of the Chilliwack River, which lies to the east of the Prairie, and was drained in the mid-1920's.

The Skagit Ranges of the Cascade Mountains lie within the HMA and form the watersheds of the Chilliwack River and other salmon streams lying east of Rosedale. The eastern portion of the Ranges are mostly granodiorite while west of the Centre Creek, they are mostly composed of sandstone, limestone and conglomerates. The highest peaks are Mount Cheam, Silver Peak and Welch Peak which are near 2,100 m and the peaks and high ridges are serrate and show the effects of alpine glaciation (Holland 1976). Below 1,800 m peaks are rounded from overtopping by ice and cirque basins occur on the north and northeast faces of the mountains, though there are now no active glaciers in the Canadian portion of the Ranges. About 50% of the Chilliwack River watershed is over 1,100 m elevation (McLean 1980).

The Chilliwack River valley is U-shaped, which is particularly noticeable in the reaches immediately downstream of Chilliwack Lake where there is a broad valley flat. Much of the valley is filled with thick glacial deposits. The upper deposit consists of 50 m or so of recessional sand and gravel laid down during the Sumas stade (Armstrong 1959). Downstream of Chipmunk Creek, the Chilliwack River has downcut into these deposits leaving benches up to 80 m above the valley bottom.

The Chilliwack River has deposited a large fan downstream of Vedder Crossing since the end of the Pleistocene glaciation. The fan is triangular, occupies about 70 km², and extends roughly from Sumas to Chilliwack Mountain. Many of the small streams and sloughs on the fan surface flow in old channels of the Chilliwack River and receive part of their inflow from a water table aquifer.

2.2 Surficial Geology

Armstrong (1956; 1957; 1960a; 1960b) mapped the surficial geology of the Fraser Lowland and then summarized his work in two publications (Armstrong 1983; 1984). Armstrong (1984; his Figure 3) generalizes the surficial geology of the Fraser Lowland and the major tributary valleys. The main elements of the surficial geology were described in the previous section.

2.3 Climate

2.3.1 Climate of the HMA

The climate of the Chilliwack/Lower Fraser HMA ranges from a modified maritime to a cordilleran climate that is affected by both continental and modified maritime conditions. Hydrologic regimes in the two climate types are different, primarily as a result of snow accumulation and winter rainfall in the cordilleran (Cascade Mountains) zone and winter rainfall and minimal snow accumulation in the Fraser Lowlands. Precipitation increases from south to north within the HMA and also increases with elevation.

Table 4 describes the hydrologic regions associated with the various ecoregions and ecosections. Examination of Tables 3 and 4 (and regional hydrology studies: Rood 1988) suggests that there are two distinct hydrologic regions in the HMA: the Fraser Lowland and Cascade Mountains regions. These are discussed below:

Fraser Lowland: Mean annual temperature is around 10°C in the valley of the Fraser River at Mission and Chilliwack. January is the coldest month with mean temperatures of 1 to 2°C and

extreme minimum temperatures of around -20°C. July is the warmest month with mean temperatures of 18°C and extreme maximum temperatures of around 40°C.

The Fraser Lowland lies partly in the rainshadow of the Olympic Mountains and Vancouver Island and has a modified maritime climate. Annual precipitation is lowest at Vancouver Airport (1000 mm) and increases to the north and, to a lesser extent, to the east as result of approach effects which produce enhanced precipitation prior to uplift over the Coast and Cascade Mountains. Annual precipitation is around 1,500 mm on the southern side of the Fraser River and increases to about 2,000 mm at lower elevations along the north side of the river. Precipitation increases rapidly with elevation and distance into the Coast Mountains. Table 3 lists climate normals at a number of stations within the Fraser Lowland.

Mean annual runoff in the salmon streams is about 700 to 1,000 mm, accounting for most of the total precipitation of about 1,500 mm. Subtracting mean annual runoff from normal precipitation indicates that annual evapotranspiration and losses to groundwater amount to about 500 or more mm.

Rain falls throughout the year and from late September or October until March a continual procession of Pacific westerlies cross the coast, occasionally broken by the formation of high pressure ridges. About three-quarters of the annual precipitation falls in this period, almost all as rain. During summer, a high pressure zone dominates off the coast and only about 25% of the annual precipitation falls between May and September (Table 3). Drought, or periods without rain, which usually occur in July and August, can extend from a few weeks to 50 days or more and annual low flows occur during or at the end of these dry periods. Summer storms are usually brief and intense though large storms occasionally disrupt the high pressure zone. These infrequent large storms often produce extreme flooding (Evans and Lister 1974; Schaefer 1973). Daily flows vary greatly over the year and maximum daily flows are often 500 times greater than minimum daily flows. In the winter, the hydrograph consists of a succession of storm peaks, corresponding to the passage of rainstorms, superimposed on a high base flow (Appendix B).

July and August also have the greatest evapotranspiration demand and little of the rainfall replenishes groundwater or contributes to streamflow. Soil moisture deficiencies are typically expected in July and August and amount to about 200 mm (UMA Engineering Ltd 1988).

Cascade Mountains: The climate stations along the bottom of the Chilliwack Valley do not report temperature, but it is expected to be somewhat cooler than in the Fraser Lowland (Table 3).

Annual normal precipitation at the valley bottomstations is similar to that on the lowlands, at around 1,600 mm. Precipitation must increase greatly with elevation and distance inland as annual runoff from Slesse Creek and the upper Chilliwack River is around 1,800 mm and evapotranspiration amounts to several hundred mm, suggesting that 2,500 mm or so must fall at upper elevations in order to produce the observed runoff. Annual runoff is reasonably constant along the upper Chilliwack River suggesting that there is little north to south variation of precipitation. Most of the precipitation falls from October through March and July receives the least precipitation. As in the Fraser Lowland, only about 20% of the annual precipitation falls from May through September (Table 3).

Annual normal snowfall is less than 10% of the total precipitation along the valley bottom of the Chilliwack River. Nearby snowcourses indicate that there is little accumulation at elevations

below 500 m or so though accumulation increases with elevation. The Sumallo River snow course, 3D01, at an elevation of 880 m has a normal April 1 accumulation of 314 mm and at elevations over 1,200 m normal maximum water equivalents are around 300 to 400 mm on April 1 (Lightning Lake, 3D02, and Klesilkwa, 3D03A) with significant snowpack remaining into May. Melt of this snowpack provides a spring freshet on the Chilliwack River and its tributaries.

Rain falls throughout the year at low and mid-elevations and accumulation and melt of shallow snowpacks contributes to winter flooding. While the annual flood often results from snowmelt and occurs in May or June, the largest floods result from fall rainstorms and rain on snow when Pacific storms are forced over the Cascade Mountains. June is the month with the average maximum discharge.

Annual minimum flows typically occur in the late summer and early fall and sometimes occur in winter during a cold, dry period (and may possibly occur under an ice cover).

2.3.2 Temporal Variation in Climate

Long-term climate records are available at several stations near the Chilliwack/Lower Fraser HMA (Figure 4). Moore (1991) reviewed records at Agassiz, one of the few stations with good quality, long term records and concluded that annual precipitation had remained roughly constant but that a lower portion of the precipitation had fallen as snow since the mid-1970's. (Note that snowfall is only a very small part of the total precipitation at this station.) He also observed an increase in temperature at these stations since the mid-1970's.

Moore's analysis also indicates a distinct decline in runoff during 1977-1988, when compared to 1960-1976. This decline in runoff seems to be connected to a reduced winter snowpack resulting from warmer temperatures. Moore does not include a formal analysis of snow survey stations in the Chilliwack/Lower Fraser HMA but snow course data at Klesilkwa (1,130 m; Station 3D03A), shows below-normal accumulation throughout most of the 1980's (Ministry of Environment 1992) and a general trend to declining maximum accumulation since the early 1960's.

2.3.3 Global Warming and Climate Change

Levy (1992) discusses potential climate changes resulting from global warming and the potential impacts on hydrologic regimes and salmon production in the Fraser Watershed. The general circulation models used to predict climate changes provide different results and are not intended for regional evaluation of climate change. If global warming occurs, higher winter streamflows may result from an increase in winter precipitation and a decrease in the portion of this precipitation falling as snow. The snowmelt freshet that occurs in some of the larger streams may also occur earlier and summer flows may be lower.

Increased precipitation in summer is not expected to contribute to increased discharge as much of this precipitation will be evaporated or transpired. Decreasing snowpack in the large streams, coupled with increased summer temperatures, are expected to produce somewhat lower flows in late summer in the salmon streams originating in the southern Fiord Ranges. In the Fraser Lowlands the combination of increased precipitation and temperature may maintain summer low flows, which are the critical low flows, at near their present values.

Air temperatures are also predicted to increase during global warming. Average stream and groundwater temperatures will increase, following the general pattern for air temperature increases. Increased air temperatures will increase potential evapotranspiration and soil water deficits. While there may only be a small effect on stream discharges from warmer temperatures, increased water demand may be a major factor affecting summer flows.

2.4 Groundwater Resources

Halstead (1986) summarizes the hydrologic and hydrogeologic character of the surficial deposits in part of the Chilliwack/Lower Fraser HMA. The marine and glaciomarine sediments that are at, or near, the surface throughout most of the study area are commonly less than 30 m thick and are of moderate to low permeability. The deltaic sands and gravels are highly permeable, up to 40 m thick and generally have a flat or gently sloping surface. Most rain that falls on these sediments percolates to groundwater rather than leaving as surface runoff. The glacial tills are of varying grain size and compactness and consequently have varying permeabilities. The tills exposed at higher elevations are often ablation tills, which overlie lodgement tills, and are not compact.

Halstead (1986) briefly summarizes the groundwater resources along the north side of the Fraser River. The northern half of the Hatzic Valley is underlain by thick glaciomarine stoney silts and successful wells have been drilled at depths of 50 to 60 m. The southern half of the Hatzic Valley is underlain by floodplain sands and gravels and successful wells are drilled to about 25 to 30 m depth. These wells are recharged from upland areas and do not affect flows in the salmon streams. Atwater et al (1994) identify a major aquifer on the Norrish Fan, with significant recharge from Norrish Creek.

On the south side of the Fraser River, groundwater development on the Sumas Prairie is mostly in the shallow beach sand left around the margin of Sumas Lake. These small deposits provide water supply to much of the Sumas Prairie (Willis Cunliffe and Tait 1982). There has been no success in locating groundwater resources on Sumas Mountain.

The Columbia Valley, at the north end of Cultus Lake, is filled with poorly sorted gravel and sand with till lenses. Wells drilled in these sediments provide an ample water supply. Static levels are up to 30 m below ground level and the groundwater likely drains to Cultus Lake.

Atwater *et al* (1994) identify three major aquifers on the south side of the river: the upper Chilliwack, Vedder Crossing and Rosedale. Groundwater wells operate on Elk Creek (Chilliwack water supply) and there are a few wells along the Chilliwack River valley at the Canadian Forces base in Chilliwack and at the Chilliwack River Fish Hatchery (flowing artesian well). The Ministry of Environment (no date) identifies ground water potential in Rosedale/Greendale where floodplain deposits may be exploited, Sardis and Vedder Crossing where there appears to be a 10 m thick aquifer, at Lindell Beach (at the south end of Cultus Lake) and in Chilliwack where a groundwater aquifer already provides good yields.

Groundwater reservoirs (or aquifers) recharge during fall and winter rains when vegetation is dormant and evapotranspiration is at a minimum. They discharge during the summer when recharge is small, because precipitation is at a minimum and evapotranspiration consumes much of the rainfall.

It is likely that low flows in many small tributaries are maintained by groundwater discharge during the late summer and early fall and that glacio-fluvial deposits, marine deltas and Holocene channel and fan deposits, particularly those in the bottom of major valleys, may be important source of groundwater. However, this possibility has not been studied in detail.

2.5 Main Stream Pattern

Chilliwack Lake is dammed by landslide debris. Downstream of the lake, the Chilliwack River flows across a broad valley in a stable boulder bed channel that is downcut slightly into the valley floor. Downstream of Chipmunk Creek, the river has degraded into its valley deposits leaving terraces up to 50 m above the river level. The slope break at Chipmunk Creek seems to result from bedrock exposed in the valley bottom at this point (McLean 1980).

The Chilliwack flows in an irregular pattern to Slesse Creek, which is a major source of coarse sediment to the upper river and the river widens noticeably below this creek. There is a steep rapid just upstream of Tamahi Creek, composed of large, angular boulders which appear to be debris from a landslide. The river is wandering or braided downstream of Ryder Creek.

Vedder Crossing is the head of the Chilliwack River fan. There are old terraces upstream of Vedder Crossing, which are about 12 m above the river, which suggest that the fan was graded to a much higher elevation at one time and that it has been downcutting. Important sources of sediment to the upper Chilliwack River include Slesse Creek, and Nesakwatch, Tamahi and Liumchen Creeks which are less important, and large failures on terraces along the river which contribute sand and gravel to the stream.

The original works to control flooding on the Chilliwack and Vedder Rivers was a dyke along the left bank that was constructed to protect Yarrow as part of the original Sumas dyking and drainage project in 1924. Over the next 50 years, a large number of projects were completed on the river system with most of the effort going to prevent the river from re-occupying its abandoned channels, particularly Luck-a-Kuck channel. McLean (1980) describes some of these works, which included private gravel removal operations in the mid-1960's. The overall effect of these works was to cut off side channels and sloughs, straighten the river and reduce its width.

After the 1975 flood a three phase program was initiated to manage the lower river consisting of bank protection and training works, gravel extractions and, finally, setback dykes. Gravel are removed on an almost annual basis and the removals are now managed by the Vedder River Management Committee based on surveys and flood capacity calculations.

2.6 Stream Stability

From the point of view of habitat management, a stable channel is one that maintains its physical characteristics: it is not eroding, incising (downcutting), widening, straightening, narrowing or aggrading. Stream channels become unstable for a variety of reasons, some of which are due to human activity. For instance, forest harvesting or urbanization may increase flood flows in streams which, in turn, may cause downcutting, widening and bank and valley wall erosion. Channels may also become unstable because of natural events, such as extreme rainstorms, or on-going channel adjustments related to slope or sediment load.

The stream response to these external factors is affected by channel slope, the size of bed material, the nature of material underlying the channel and channel pattern. In some instances, there may be no immediate response, while in other case, it may be immediate and dramatic. Consequently, it is often difficult to ascertain the exact cause for a particular channel response or instability.

The typical salmon stream in the Cascade Mountains starts in an upland area where thin deposits of glacial sediment or colluvium overlie bedrock. Here, the channel is steep and often contained in a gully or narrow valley. Sediment is provided to the channel by snow avalanches, and debris slides and flows from valley walls, and stream erosion of valley walls and channel banks. Logging road failures often aggravate sediment supply to streams. In the Fraser Lowland streams, it is debris slides and stream erosion that are important sources of sediment in undisturbed watersheds. Channel widening and downcutting are the most likely channel responses to disturbance in these reaches though in bedrock-floored canyons little channel adjustment may occur.

Lower reaches of salmon streams often cross thick accumulation of glacial or recent sediments or flow onto their fan. Many salmon streams wander in these reaches frequently resulting in bank erosion and channel instability, particularly where there is supply of coarse debris from upstream reaches as occurs on the north side of the Fraser River and in the Cascade Mountains. These reaches are often steep and floored with large bed material. Channel reaches immediately downstream of lakes are often very stable as floods are regulated by lake storage, sediment supply is lacking, and bed materials are winnowed to a stable pavement.

Table 5 summarizes reported channel instability and the kinds of human modifications to the channels which are discussed in Sections 8 and 9. Channel response includes channel pattern change (avulsions or channel shifts), bank and valley wall erosion, incision or downcutting, aggradation or channel filling, and bed material changes such as sedimentation and scour. Human modifications include dyking (for flood control), river training (including bank protection, diversions, revetments, spurs or other structures), channel encroachment (by land filling or by narrow dykes), gravel removal (dredging, bar scalping or deepening of the main channel), removal of riparian vegetation and removal of large organic debris. In the Chilliwack/Lower Fraser most human interference is in the lower reaches of the streams.

The table is not comprehensive because some channel responses, such as slow downcutting, cannot be identified without detailed measurements. Also, the assessments which are based on interviews, reports and limited field visits, may be inaccurate, out-of-date or may reflect only a site-specific situation.

3. CALCULATING FLOW CHARACTERISTICS FOR THE SALMON STREAMS

The following average flow characteristics were estimated for the mouth of each salmon stream (see Table 6 for definitions):

- **Mean Annual Flow**, expresses the total yield of water from the drainage basin and is useful for reservoir design;
- **Mean Annual Flood**, when combined with channel slope, is related to the potential for scour of gravel in the stream during incubation and the potential for channel erosion and enlargement. Peak flows at greater return periods are used for design of instream structures;
- **Mean Monthly flow** for August and September express the average flow of water available during the driest portion of the summer rearing season and during the peak removals for summer irrigation. Low flows in these months reduce rearing habitat, strand juveniles and are associated with high temperatures that reduce habitat quality. Mean monthly flows in February express the average flow of water available during the driest portion of the incubation period. Low flows in this month affect incubating eggs through freezing in de-watered or exposed redds;
- **Seasonal 7 day low flows** for the summer express the minimum flows during the summer rearing season and are used for fish habitat evaluations, calculating water allocations and water quality prescriptions. The 7 day low flows for the winter express the average minimum flow experienced during the winter and are associated with de-watering of redds.

The quality and availability of flow records ranges widely for the salmon streams in the Chilliwack/Lower Fraser HMA. A few streams have long-term gauging records at stations that continue to operate, some streams have short-term or seasonal records of moderate quality from the 1950's or 1960's, while most streams have no information available. The average flow characteristics in the above list, as well as other characteristics, can be reliably estimated for salmon streams with long-term discharge records. Less reliable estimates can be prepared for streams with limited records and the least reliable estimates are for streams with no records.

3.1 Reference Point for Flow Characteristics

All flow characteristics, as well as water licence summaries, were prepared for the mouth of each stream as this was a representative and easily-identified point. Flows at the mouth are representative of the length of the lower reaches of the stream downstream of any major tributaries. If a major tributary enters near the mouth the calculated flow characteristics only represent a limited reach of the lower stream, downstream of its entrance.

The Water Survey of Canada report their data for a specific point on the stream which may be near the mouth of the stream, or a considerable distance upstream. The sites are generally selected for accessibility and for their suitability as gauging sites, rather than other criteria. When the gauging site is near the mouth of the stream we have assumed that the recorded flows also describe flows at the mouth. However, if a major tributary enters between the gauge and the mouth, or if the gauge is well upstream of the mouth, the flows recorded at the gauge were

adjusted to obtain flow characteristics at the mouth either by adding measured tributary flows or by increasing flows based on the ratio of drainage areas at the mouth and at the gauge (Appendix A).

On ungauged streams, flow characteristics were calculated for the drainage area to the mouth of the stream.

3.2 Period of Record for Calculating Flow Characteristics

In much of British Columbia, there is a consistent pattern of declining annual flows in the late 1940's and 1950's, above average annual flows in the 1960's and 1970's (Barrett 1979) and below average annual flows during the 1980's (Figure 5). Consequently, it is important when comparing records at different stations to limit or adjust flow data to a common period, so that variation between gauges reflects the character of the particular station rather than differences in the period of record.

We have adopted the most recent decade, 1981-90 (inclusive), as our standard period for analysis. This decade included unusually large floods in November 1989 and 1990, as well as droughts in 1985 and 1987.

3.3 Hydrometric Data in the Chilliwack/Lower Fraser HMA

The Water Survey of Canada is the prime agency collecting and reporting flow data in British Columbia. Gauging stations in the Chilliwack/Lower Fraser HMA are described in *Surface Water Data Reference Index: Canada 1991*, published by Environment Canada. A number of these stations are on the salmon streams (Table 1; Figure 3) and 21 of the salmon streams have had at least one operating gauging station. However, only three salmon streams (Norrish Creek, Chilliwack River and Slesse Creek) have nearly complete gauging records from 1981 to 1990 at stations near their mouths. It is on these streams that flow characteristics may be calculated directly from Water Survey of Canada records. These calculations are discussed in Section 3.5.

The other salmon streams typically have either: 1) partial records between 1981 and 1990, 2) partial or complete records from earlier decades, such as the 1950's or 1960's, or 3) no records from the Water Survey of Canada (Table 1). Procedures for estimating flows on these streams are discussed in Section 3.6 and Appendix A.

There are also gauging stations on streams that are not within the boundaries of the study area or are not salmon streams. Where these stations provide useful information on the hydrologic characteristics of watersheds in the Chilliwack/Lower Fraser HMA they are used in estimating flow characteristics (Appendix A).

3.4 Other Sources of Hydrometric Data

The Water Management Branch (WMB) of the Ministry of Environment, Lands and Parks operates some gauging stations whose data are reported by the Water Survey of Canada. The WMB also collects miscellaneous measurements to establish flows for approving licensed extractions, and carries out occasional (regional) data collection programs during droughts. Only

Lonzo Creek was examined during the drought measurement programs (Richards 1977; Nyhof 1985; Nyhof 1987).

3.5 Gauged Salmon Streams

The gauged salmon streams are those whose flow characteristics can be calculated directly from Water Survey of Canada records. (Gauges on the salmon streams are included in Table 7.) Table 6 provides definitions of the flow characteristics used in this report and more detailed descriptions follow in Sections 3.5.1 and 3.5.2.

The gauging stations on the salmon streams either measure natural flows or regulated flows, where regulated flows are those affected by upstream storage or water extractions. **Natural flows** – those that occur in the absence of all regulation or extraction -- are best-suited for the sensitivity indices so that licensed extractions can be expressed as a percentage of the total available flow, rather than the measured flow.

3.5.1 Water Extractions and Flow Characteristics

For streams whose regulation consists of water extractions, the flow characteristics calculated from records were adjusted to represent the natural regime in the stream by adding potential water extractions, as calculated from summaries of water licences, to the flow recorded at the gauge (Figure 6). We have referred to these adjusted flows as **naturalized flows** to distinguish them from measurements of the natural regime.

This approach provides a reasonable estimate of the natural flows in the Chilliwack/Lower Fraser HMA because there is little developed storage in most watersheds, because total storage is small in comparison to irrigation requirements and because licensed demand is often low in comparison to flows. In these circumstances, it is reasonable to ignore the contribution of storage to low flows, and naturalized flows may be assumed to represent the natural regime. The naturalized flows are close to the natural flows, but are expected to over-estimate these flows, because of differences between actual and licensed water use upstream of the gauge, flow enhancement by releases from small storage projects and return flows from irrigation diversions. The degree of over-estimation is small for the gauged streams and can be evaluated by comparing storage volumes to irrigation demand and to typical flows in August and September on the salmon streams. Note also that well extractions, which are not licensed, may reduce low flows in some streams.

3.5.2 Storage and Flow Characteristics

A small storage reservoir operates on Dickson Lake in Norrish Creek and is used by the Dewdney-Alouette Regional District as a balancing reservoir for their downstream water intake. B.C. Hydro operates the Wahleach Dam which diverts water to their powerhouse on the Fraser River. Most other storage projects are very small.

3.5.3 Annual Flow Characteristics

The historic period for the **mean annual flow** is 1981 to 1990, inclusive (see Table 6 for definitions). No adjustments were applied for the effect of regulation. The historic period for the **mean annual flood** is 1981 to 1990, inclusive. No adjustments were applied for the effect of regulation, based on the negligible effects of storage contribution (Section 3.5.1).

3.5.4 Seasonal Flow Characteristics

The water year was divided into two seasons: summer (May 1 to October 31) and winter (November 1 to April 30). This division was selected to include all irrigation within one season and to separate low flows into two distinct seasons corresponding to different parts of the salmon life cycle. Summer low flows are affected by storage and release of water, irrigation diversion and domestic and waterworks withdrawals. Low flows in the summer reduce rearing habitat, strand juveniles and are associated with high water temperatures.

Winter low flows are only affected by storage and release of water (in a few circumstances) and domestic and waterworks withdrawals. Low flows in the winter affect incubating eggs by de-watering redds and freezing or desiccating eggs.

Table 7 reports mean August and September flows for the gauged streams. Measured flows were adjusted to naturalized flows by adding potential licensed demands for each month, following the procedures discussed above.

Summer and winter 7 day low flows were extracted from Water Survey of Canada records, covering 1981 to 1990, and mean seasonal seven-day low flows calculated as an average of all observations. The mean low flows do not necessarily correspond with the two-year return seven-day low flows. This is because the mean low flow is affected by extreme seven-day low flows occurring within the period of record.

Where necessary, summer 7 day low flows were naturalized by adding the calculated potential demand for September, as these flows typically occur in September. This is a crude adjustment as low flows may occur during periods of limited or no irrigation and the adjustment will over-estimate the natural flows that would occur. Winter 7 day low flows were also naturalized when necessary.

3.6 Gauging Records on the Stream Summary Sheets

The flows recorded at gauging stations on the salmon streams are of interest for more than establishing average flow characteristics at their mouths. The gauging records permit calculation of detailed flow characteristics such as mean annual hydrographs, monthly distributions of annual 7 day low flows, and 7 day low flow frequency curves. These flow characteristics are based on all available, complete years of data at the gauge site, rather than 1981-90 -- in order to best estimate the flow characteristics at the gauge -- and are not naturalized because of the difficulty of adjusting each year's flow.

All data are included on the Stream Summary sheets attached as Appendix B. The mean annual hydrographs are calculated from all available complete, continuous years of record at the gauge. All years were used because these gave the best representation of the annual pattern of flow.

The distribution, by month, of the annual 7 day low flows, is based on all complete years of record at the gauge. 7 day low flow frequency curves for these records are also included on the Summary Sheets.

Floods with various return periods were calculated from the annual daily maximum flows with the CFA-88 program, prepared by the Water Survey of Canada, as adapted for micro-computers. Floods of 2, 10, 20, 50 and 100 year return periods are reported in Appendix B.

3.7 Ungauged Salmon Streams

The ungauged salmon streams include all those streams where average flow characteristics for 1981 to 1990 must be estimated rather than calculated from Water Survey of Canada records. A variety of techniques were used to estimate the flows and these are discussed in Appendix A.

Flows were estimated for the ungauged streams by transferring measured flows from nearby, similar streams, by adjusting incomplete records on the individual stream or by regional equations that relate flows to basin characteristics. Mean annual flows, mean annual floods, mean monthly flows and mean summer and winter 7 day low flows are estimates of values appropriate for 1981 to 1990.

4. FOREST HARVESTING

The natural hydrologic regime of the salmon streams in the Chilliwack/Lower Fraser HMA has been altered, to some extent, by land use. Urbanization, agriculture and forest harvesting all have the potential to alter the hydrologic regime. Agriculture affects the hydrologic regime by extracting surface and ground water for stock watering, domestic use and irrigation and, in this HMA, it also causes a minor increase in flood discharge in a few salmon streams, through conversion of forest lands. Urbanization affects the hydrologic regime through extractions for waterworks. In the Chilliwack/Lower Fraser HMA, urbanization has had a significant effect on flood discharges in some of the salmon streams (Chapter 5). Agriculture often occupies only a small part of the lower elevations of the watersheds and does not greatly affect hydrology except through surface water extractions. These are discussed in Section 6, "Water Licences".

The removal of timber during forest harvesting (or agricultural land clearing) alters transpiration and the distribution of snow and may often increase rates of melt. These changes in the watershed, coupled with road construction and soil modifications tend to increase water yield (mean annual flow), mean annual floods and summer base flows.

There are secondary effects on stream channels associated with increased flood flows. In suitable materials, channels often enlarge through bank erosion and channel incision. These processes, along with sediment released from harvesting activities, may greatly increase the quantity of sediment transported through the stream.

This section describes the measurement of impact of forest harvesting on the hydrology of the salmon streams through estimation of the rate of cut, or estimation of the equivalent clearcut area (ECA) within the watersheds; and further discusses the changes in hydrological and sedimentological regimes typically associated with forest harvesting.

4.1 Forest Harvesting

Maps and databases maintained by the Ministry of Forests were used to determine harvested areas in the watersheds of the salmon streams. History Record Reports lists activities in all openings (areas where forest cover has been removed) created prior to 1987 and continue with Small Business Forestry Enterprise Program (SBFEP) openings to 1993. Each opening is described by the region and compartment (the compartment boundaries follow watershed boundaries), a location tag, date of last activity and size of the opening. The openings are listed by compartment and the salmon streams within that compartment are determined. If the compartment includes only one watershed, then all cut blocks are split into 10 year age groups and added to the harvesting in that watershed. Note that Vacant Crown Land (VCL: fire or infestation-related openings) is not included in the total harvest. If two or more watersheds are included in the compartment the location tags (which are usually a watershed or sub-drainage name) are used to allocate the blocks to a particular stream. A few openings have obscure or unidentifiable location tags: these were assigned to the same watershed as the previous opening on the list. The opening are listed in a geographic grouping, so this procedure provides only a small source of error.

The QMF-100 Report describes openings created by major licensees since 1987. Each opening is referenced to a 1:20,000 Map sheet, and has a date of harvest, a size of opening and a licensee. In large watersheds, where the sheet falls entirely within the watershed, all harvested

cutblocks are added to the harvest in that watershed. Where the sheet includes two or more watersheds, the total harvest on the map sheet is calculated, and then harvested areas assigned to each watershed depending on the portion of the 1:20,000 sheet that they occupy. This procedure was sometimes modified to improve the quality of these estimates. If a watershed had no prior and no proposed logging then no cut was assigned to it from the QMF-100 Report. Also the licensee tag was used to re-distribute the logging. If the proposed logging indicated that only one licensee worked within a watershed then the total cut, on the map sheet, by this licensee was added to that one watershed. Errors from this approach affect recent harvesting totals and are expected to be greatest in small watersheds (less than 50 km² or so) and minor in moderate and large watersheds.

Proposed harvesting was measured on Five-year Plans available at Ministry of Forests District Offices. The plans typically list block sizes which were totalled for each salmon stream watershed. Only amendments to the proposed logging introduce error into the proposed harvest.

Harvested areas in each watershed are described on Table 7 as:

- **Oldest, Older and Old Harvested Area:** Includes those blocks cut prior to 1964, or between 1964 and 1973 or 1974 and 1983. History Record Reports were used to determine the total harvest by period.
- **Recently Harvested Area:** Includes those harvested areas that are less than 10 years old as identified from the History Record and QMF-100 Reports and includes major licences and the Small Business Enterprise Forestry Program.
- **Proposed Harvest:** Identified from five-year plans current to 1993. The data was extracted from the comprehensive plan, prepared by the various Forest Districts, that incorporates all five-year plans submitted by the various logging companies. Salvage logging for beetle-kill or blowdown is additional to the five-year plans but is also incorporated in the proposed harvest.

4.2 The Effect of Logging on Hydrology

Haul and skidder road construction compact the surface and increases runoff from the road surface and increases the rapidity of runoff. Ditching along roads concentrates water, generally into fewer channels, and intercepts subsurface flow, increasing the speed of flow to drainage channels. The removal of trees severely reduces or eliminates transpiration, in the short-term. Tree removal also increases air movement and changes soil temperature which tend to increase evaporation from the soil surface, but the overall effect is to reduce evapotranspiration from the soil. In British Columbia, tree harvesting also affects the distribution of snow and the timing of its melt.

4.2.1 Forest Harvesting and Streamflow Quantities

Well-designed experiments generally show increased water yield as a response to forest removal, and the increase is generally proportional to the amount of canopy removed (Bosch and Hewlett 1982). The increased flow of water results from increased storage of water in the soil as the result of reduced transpiration following the removal of forest cover. Increases are

observed during the summer low flow season and also during the wet, or high flow season, particularly early in the season when soil storage differences are greatest between the forested and clearcut areas.

In snowmelt-dominated watersheds, clearcut logging produces increases in water yield. In Camp Creek near Penticton, B.C., clearcut logging following Pine Beetle infestation, increased both annual and March to November monthly water yields, with the greatest increases recorded in the months of August and September (Cheng 1990). There was no consistent evidence of increased streamflow in the winter months. Clearcut logging in rainfall-dominated systems also produces increases in water yields. Studies in Camation Creek indicate increases in annual and summer low flows in a small completely-harvested watershed for at least the first few years after logging (Hetherington 1987).

4.2.2 Forest Harvesting and Flood Flows

Many studies have demonstrated increased storm volumes and peak flows following forest removal, though there are few results appropriate to the parts of British Columbia where snowmelt is the dominant mechanism for flood generation. Cheng (1990) found increased, and earlier, peak flows in Camp Creek after clearcutting of 30% of the basin area. His finding of a 20% greater, and two weeks earlier, flood peak are roughly comparable with studies in other snowmelt-dominated systems. King (1989) examining streamflow responses in northern Idaho, found increases of 15 to 35% in maximum instantaneous discharges.

Forest harvesting also affects flood flows in rainfall-dominated systems though results are sometimes ambiguous. In Camation Creek, roads seem to have increased peak flows in a small intensely-harvested tributary though there has no reported effect on flood flows from the overall watershed which is about 40% harvested (Hetherington 1987). Studies in other areas indicate that clearcutting increases small flood peaks but has little effect on the larger peaks flows that occur when soils are thoroughly wet (Wright et al 1990).

Forest harvesting also affects flood flows generated by rain on snow, as shown through studies in the transient snow zone of the Pacific Coast. Generally, greater melt rates of shallow, warm snowpacks are expected following forest harvesting because of greater transfer of convective energy from increased wind speeds and turbulence. However, a number of variables, such as antecedent snow conditions, storm characteristics and climate affect the results and few studies have demonstrated increased peak flows (Harr 1986). Beaudry (1981), based on studies in Jamieson Creek in the Seymour watershed, shows that air temperature and the presence of snow in the canopy in the forest affect the relative melt rates and runoff from clearcut and forested sites.

The British Columbia Forest Practices Code and The Southern Interior Watershed Assessment Procedure propose to manage hydrologic impacts through controlling the rate of cut in watersheds to minimize changes to the annual hydrograph. In the Southern Interior, this is accomplished by distributing the cut over a range of elevations and aspects and by controlling the equivalent clearcut area (ECA) within the watershed. The ECA is calculated from the product of the total cut area and a regeneration recovery factor, which reflects the fact that there is near zero hydrologic recovery for regeneration of 3 m regeneration and nearly complete recovery for 9 m regeneration on the block. Intermediate regeneration reduces the hydrologic effect of the clearcut. Maximum allowable equivalent clearcut areas will vary with basin type and the history of past disturbance, but may range from 20% to 35%.

4.2.3 Forest Harvesting and Sedimentation

Watershed disturbance during forest harvesting often causes increased fine (suspended) and coarse (bedload) sediment delivery to streams, through erosion of roads and cut-banks, soil disturbance (log skidding, prescribed burning, or scarification), mass soil failures, or increased bank erosion from deposition of debris, increased flood flows or bank instability from the removal of riparian vegetation. Elevated suspended and bed sediment loads and deposition of this material on fans or in low-gradient sections of streams may have greater impact than changes in the hydrologic regime resulting from logging.

The relative importance of various erosion processes, and the various forestry activities, to the total sediment budget of a disturbed watershed depend on the precipitation regime, character of the watershed, and soils and logging practices. Details may only be resolved after extremely detailed study. However, a general appreciation of the nature of sediment sources and sediment delivery processes may be obtained from aerial photographs and reconnaissance studies.

4.3 Physiography

Drainage areas upstream of stream gauging-sites were extracted from Water Survey of Canada publications. Drainage areas above the mouths of salmon streams were extracted from WSC publications or measured on 1:50,000 maps. These maps do not provide sufficient detail to accurately establish the drainage areas of small streams whose basins mostly lie in flat-lying parts of the HMA and watersheds are approximate for those streams with watersheds less than few km².

As well, ten of the salmon streams extend into the United States and these are indicated on the tables by a letter in brackets that follows the stream name. Tables 1 through 8 quote the total drainage area of these streams but water demands, logged areas and urban development were not measured for the part of the stream in the United States. The following list indicates the area of the watershed that does **not** lie in Canada:

- (a) Sumas River: 146 km²
- (b) Chilliwack River (lower): 485 km²
- (c) Chilliwack River (upper): 227 km²
- (d) Sweltzer River: 55.1 km²
- (e) Liumchen Creek: 24.1 km²
- (f) Tamih Creek: 72.2 km²
- (g) Slesse Creek: 106 km²
- (h) Nesakwatch Creek: 12.5 km²
- (i) Center Creek: 1.3 km²
- (j) Depot Creek: 34.8 km²

The Sumas River basin includes only the watershed of the Sumas River and does not include that of the Chilliwack/Vedder River.

5. URBAN LAND USE

Urbanization alters the hydrologic regime in several ways. Development of waterworks, either from groundwater or surface water, may reduce mean annual flows, mean annual floods and seasonal 7 day low flows. However, the main impact of development is the creation of impervious surfaces that are directly connected to watercourses. These impervious surfaces change the runoff processes -- rapid flow over impervious surfaces and through pipes is substituted for less rapid interflow (lateral flow through soils) -- speeding the delivery of water to streams and increasing both the volume of rainfall runoff and the maximum discharges reached during a storm.

There are secondary effects associated with the increased flows. Channels often enlarge through bank erosion and, in suitable materials, incision or downcutting may result. These processes, along with sediment released from construction activities, often increase the quantity of sediment transported through the stream.

This section describes the measurement of impact of urbanization on the salmon streams through estimation of effective impervious area (EIA) within the watersheds and further discusses the changes in hydrological and sedimentological regimes typically associated with urbanization.

5.1 Measurement of Effective Impervious Area (EIA)

The effective impervious area in a drainage basin provides a quantitative measure of the potential alteration of the hydrologic regime imposed by urbanization. It is a measure of the total area where water does not infiltrate into the soil and that is connected directly to the drainage network. The noneffective impervious area includes those impervious areas that drain to pervious terrain where stormwater infiltrates -- an example is a roof whose gutters discharge to a lawn rather than a stormwater drainage system.

Alley and Veenhuis (1983) and Dinicola (1990) describe how they estimated EIA from land use in Denver and King County, Washington. This approach was used to estimate EIA for the Chilliwack/Lower Fraser HMA. First, 1:50,000 maps were used to identify those salmon streams where impervious area may account for more than a few percent of the watershed. For these streams, the watershed area covered by low density, medium density and high density single family housing, multi-family developments and commercial, industrial, and transportation facilities was measured from Zoning Plans made available by the various municipalities and the actual use confirmed on recent air photographs. Once the total area of each different land use was measured then the total impervious area within each type was estimated from typical percentages quoted in Alley and Veenhuis (1983). The effective impervious area for each land use type was then estimated as a percentage of the total impervious area for each land use type and these were summed to calculate the EIA within each watershed (Table 8). The conversion to EIA assumes that not all impervious surfaces, particularly rooftops, are directly connected to the drainage network.

5.2 The Effect of Urbanization on Hydrology

Urban development is accompanied by changes in the watershed that affect its hydrologic response. Roads and drains are constructed which collect and concentrate surface and shallow subsurface runoff; vegetation is cleared, soil is compacted and partly stripped which reduces or eliminates transpiration and increases the potential for surface flow; the ground surface is re-graded and depressions are filled, eliminating ground surface water storage; and subsurface utilities and drainage trenches intercept deeper subsurface flow and pipe it to surface drainage. Buildings create additional impervious area, reduce infiltration, and accelerate surface runoff to streams.

Booth (1990) discusses three effects of urbanization on hydrology and drainage:

- Concentration of storm runoff into surface channels. In regions where subsurface runoff dominates under natural conditions, this may erode surface soils and create gulying;
- The total volume of surface (storm) runoff increases, increasing the mean annual discharge from the watershed;
- Peak discharges increase at the outlet of the developed area. Booth (1990) shows consistent increases of the ratio of the (simulated) development flood to the pre-development flood with EIA for small basins. With effective impervious areas exceeding 20%, the 100-year discharge is doubled and the 1.5 year flood discharge is increased about 2.5 times.

5.2.1 Urbanization and Streamflow Quantities

A common result of urbanization is an increase of the overall mean annual runoff. The increase results from increased stormflow, as a result of reduced infiltration, and reduced evapotranspiration. Booth (1990) describes increases of mean annual runoff amounting to several hundred mm in King County, Washington. Similar results might be expected in the Chilliwack/Lower Fraser HMA, as surficial geology and climate are similar, but there are no studies in the Lower Mainland to confirm these values.

It is often assumed that reduced infiltration and increased storm runoff reduces soil and ground water recharge, ultimately leading to reduced base flows during the late summer. However, removal of vegetation tends to counteract this effect as decreased transpiration usually leads to increased low flow in late summer. There are no studies in the Lower Mainland that demonstrate the effect of urbanization on summer low flows.

In King County, the effect of urbanization on low flows has not been studied extensively. Leytham (personal communication) indicates that effects are expected to be site-specific and at least partly dependent on surficial materials. In small basins in relatively impervious surficial materials (tills, glaciomarine sediments) flows tend to be near-zero or zero between rain storms. In these circumstances on-site detention stores water and releases it gradually and acts to improve base flows. For low density developments on permeable sediments (i.e., glaciofluvial sands and gravels) sufficient recharge may reach the groundwater table to maintain the low flow regime experienced under pre-development conditions.

Low flows are a critical aspect of habitat in the Chilliwack/Lower Fraser HMA and the uncertainty of the effect of urbanization on their regime makes it difficult to manage these streams.

5.2.2 Urbanization and Flood Flows

Studies elsewhere have demonstrated increased storm volumes and peak flows following urbanization; however these results have not been confirmed by studies in the Lower Mainland. In King County, Booth (1990) indicates a consistent increase of the ratio of post- to pre-development storm peaks with increasing EIA for small basins. Based on simulation, the increase of the 100-year discharge averages about 2 times and that of the 1.5-year flood about 2.5 times for an EIA of 20%, and these values increase with increasing EIA.

The ratios of post- to pre-development flood discharges varies widely in individual basins, partly as a result of variable terrain and surficial sediments. Detention or retention structures or other stormwater control measures in the urban environment also reduce the simulated post- to pre-development ratios.

Studies from King County do not indicate a "threshold" level of EIA needed for impact on the hydrologic or geomorphic regime. However, studies by Morisawa and Laflure (1979) indicate a threshold level, where more than 25% of watershed needs to be covered by housing with at least 5% impermeable area (an EIA of about 5%), prior to detectable channel enlargement. Major channel enlargement appeared to begin at an EIA of about 10%. These results cannot be directly applied to the Chilliwack/Lower Fraser HMA because of different materials in channel banks and beds.

5.2.3 Urbanization and Sedimentation

Urban development generally results in increased fine (suspended) and coarse (bedload) sediment delivery to streams through erosion of roads and cut-banks, and other types of disturbance. Of more general concern are the channel changes that may be initiated by changes in peak flows following urbanization. In erodible materials, the channel is expected to respond to increased peak discharges by enlarging its channel cross section, with this eroded material contributing to the suspended and bed load of the stream. Channels also respond by lowering gradient or degrading their channel bed, and this eroded material will also contribute to the bed and suspended load, and coarsening their bed sediments. These changes, and the elevated sediment supply regime, may persist over many years, depending on the local surficial material, the degree of urbanization, the history of storm events and the transport capacity of the stream channel.

6. WATER LICENCES

The Water Rights Branch of the Ministry of Environment maintains a computerized data base of water licences in British Columbia. Summaries (by type) were produced for all salmon streams, as well as streams with long-term Water Survey of Canada gauging stations. The database includes existing licences as well as applications. The applications are included in Table 7 because most of them are eventually approved though the quantities requested in the applications may be adjusted.

6.1 Classification of Water Licences

Figure 7 reproduces the water licence classification system used by the Water Management Branch. They are classified into consumptive and non-consumptive uses and further classified by the type of user. Computer-generated summaries, obtained from the Water Rights Branch, Victoria, utilize the main classification on Figure 6, as well as providing more detail on the type of user, producing a total of 73 sub-categories (including non-consumptive uses).

6.1.1 Consumptive Licences

The computer-generated classification provides more detail than is required so we have reported consumptive licensed extractions from the salmon streams under the categories of Domestic, Waterworks, Irrigation and Industrial. Table 7 reports the sum of all licences, including applications, of each type, above the mouth of the salmon stream.

6.1.2 Non-Consumptive Licences

Non-consumptive water use includes power generation, storage (nonpower and power) and conservation. Conservation licences are totalled and summarized on Table 7. Nearly all the storage licences are non-power licences.

The total non-power storage licences in each salmon stream are listed on Table 9. The total includes all storage for domestic, waterworks, irrigation, and industrial licences; though, in most streams, the majority of these licences store water for irrigation. Table 9 also compares the irrigation licences to the non-power storage in each salmon stream. Storage affects flow by being accumulated during the spring freshet and released during low flows, or during the irrigation season. In many watersheds, licensed storage volumes are matched to some irrigation licences, and the net reduction in low flows resulting from diversion for irrigation is, theoretically, less than the total licensed irrigation diversion. This does not work in practice as the upstream storage facilities trap incoming flows during low flows as well as high flows -- reducing downstream flows in addition to extractions -- and leaky dams and evaporative and transmission losses reduce the storage quantity available to compensate for licensed extractions.

6.2 Licensed Versus Actual Water Use

6.2.1 Domestic, Waterworks and Industrial Licences

Domestic use is only partly consumptive. In summer, although a large portion of the domestic use is for watering of lawns and gardens, some of this water re-enters the stream as return flow.

Waterworks are also only partly consumptive; but in organized areas, water may be diverted out of the basin with return flows ending up in a different stream, producing a true loss to streamflow. Typically, waterworks are licensed for amounts well in excess of actual extractions. Because licence-holders for large waterworks projects pay a fee based on actual water use, rather than the licensed amount, records are available of the annual volumes of water extracted from streams. We have not obtained these records because waterworks and domestic extractions in salmon streams in the Chilliwack/Lower Fraser HMA are insignificant when compared to irrigation use or to streamflow.

Land improvement licences are used to provide water for ponds, which may be used for landscaping or to raise fish. On older licences, removal rates were set from an evaporation of one-eighth inch per day (doubled to one-quarter inch for a factor of safety), multiplied by the pond surface area, and converted to gallons/day. On newer licences, the licensee is permitted to divert whatever quantity is required to maintain water levels in his pond. The Land Improvement licences are consumptive as most water is lost to evaporation though some may enter groundwater and re-appear as return flow. Most withdrawals will be during hot, dry weather when evaporation is greatest and streamflow is least. Much smaller withdrawals are expected during winter or rainy, cold weather.

6.2.2 Irrigation Licences

A certain percentage of the water diverted for irrigation reenters the stream as return flow. When flood irrigation (by ditches and flumes) was prevalent it was assumed that roughly 30% of the diverted volume returned to the stream. Sprinkler and drip/trickle irrigation are expected to produce considerably less return flow and these are now the dominant methods of irrigating.

Water applied to the land on a particular day will cause return flow some days, weeks or months later. In the Okanagan (Reksten 1976) it is assumed that 12% of the annual return flow occurs in September and 9% in October; and that a small percentage (about 4% per month) occurs through the winter months. Return flow in August and September may reduce the impact of irrigation diversions in those months if the flow is returning to a reach of the stream supporting fish.

Actual irrigation demand can be estimated from the area of irrigated land and a calculated or estimated water duty. The duty -- the water needed for the irrigation season expressed as a depth which is assumed to be about 20 cm (8 inches) in the Lower Mainland (UMA Engineering 1988) -- is used to calculate the total amount of water needed for irrigation. The theoretical duty and the actual amount applied can be very different, as a result of farming practices and, as well, the duty varies with location and elevation and from year to year. Year-to-year variations are significant in many areas: for example, from 1975 to 1988, duty in the Vernon Irrigation District varied from 31 to 48 cm (Rood 1989), with the greatest amount required during low flow, dry years; and in dry years the actual extraction approaches the licensed volume.

Irrigation demand can be estimated following the above procedure; however, we prefer to use the water licence summaries for several reasons. First, areas of cultivated farmland do not always correspond with the total irrigation licences and some basins with cultivated land have no licensed irrigation withdrawals. This may result from non-use of licences, diversion of water to farms out of the basin, or inaccuracies in estimating improved farmland. Second, the irrigated portion of improved farmland is only roughly known for the individual salmon streams and, third, duty is only known for a few basins with detailed studies. Finally, the water licences represent, as discussed in the next section, a potential maximum demand on the salmon streams and provide a comparable standard of comparison from stream to stream.

6.3 Calculation of Licensed Demand

Calculation of licensed demand has the advantage of providing a consistent measure of demand from each stream and, in many instances, the licensed amount may be close to actual use; extractions are greatest in dry years and overuse of some licences may compensate for licences that are only partly used, or not used at all.

The demand calculated from all licences is the maximum potential demand that may be exerted on the stream, if all licences were fully utilized. For streams that are fully recorded, the calculated demand may not increase; on other streams additional licences will likely be issued.

The water licences summarized on Table 7 are expressed in various units, ranging from acre-feet for irrigation and industrial licences, to gallons/day for waterworks, industrial, and domestic licences and ft³/s for industrial and conservation licences. Licensed amounts expressed as a discharge were converted to litres per second (L/s) using appropriate conversion factors: 1 L/s is equivalent (approximately) to 19,000 imperial gallons/day; 1 L/s is equivalent (approximately) to .035 ft³/s.

Licensed amounts expressed as a volume (ac-ft) were converted to cubic decameters (dam³), where 1 dam³ is equivalent (approximately) to 0.81 ac-ft. In any time period, the total demand is calculated by adding the demand from waterworks, domestic and industrial licences, which are assumed to be constant throughout the year, to the irrigation demand. Irrigation volumes are assumed to be distributed as follows: May (10%), June (15%), July (30%), August (30%) and September (15%). (These percentages are quoted by UMA Engineering Ltd (1988) in their study of Matsqui Prairie and reflect the main moisture deficiency which occurs in July and August.) These percentages represent the average distribution of water and may not be appropriate in any particular year, as a result of weather and cropping practices. Monthly irrigation volumes (in dam³) were converted to discharges (L/s) by multiplying by 10⁶, and dividing by the number of seconds in the month.

The total demand varies from month to month as a result of irrigation extractions. Table 7 presents calculated licensed total demand, in L/s, for August, September and February. These months were selected because August and September are months when low flows commonly occur during the irrigation season and February is a typical winter month.

7. SENSITIVITY INDICES FOR THE SALMON STREAMS

We have expressed the habitat sensitivity of the salmon streams through various indices that are calculated from the hydrologic, water use and land use data collected for the streams. The sensitivity indices used here indicate the level of concern for those aspects of the hydrologic regime that affect habitat and which can be altered by human activities. The indices are of two general types:

- Indices that express the level of human activity in the watersheds of the salmon. These include expressions of the proportion of the basin of the salmon streams that have been developed and the degree of utilization of water for irrigation, industrial and waterworks; and
- Indices that express the state of the particular stream and its ability to resist further change. These indices express peak flows and low flows as a ratio or percentage of the mean annual flow. Extreme values indicate stressed systems with a limited ability to withstand further hydrologic alteration.

The most useful indices for assessing habitat sensitivity indicate the magnitude of water use during low flows in summer, compare the magnitude of low flows to mean flows, compare peak flows to mean flows and indicate the extent of development in the watershed.

The indices are expressed as percentages of mean annual flow, except for peak flows, which are expressed as a ratio of the mean annual flow. The use of percentages and ratios permits easy comparison of streams of different watershed areas and allows ranking of the streams. The most sensitive streams were defined as those with the most extreme indices or those whose indices exceeded some critical value. On Table 10 these streams are shaded: the rationale for selecting the most sensitive streams is discussed separately for each index in the following sections. The following table summarizes the indices:

Index	Definition	Interpretation
1	potential demand in August as a percent of the mean summer 7 day low flow	expresses the maximum portion of flow during the rearing season that is used for water demand
2	as above for September	as above
3	potential demand in August as a percent of mean August flow	expresses the typical portion of flow during the rearing season that is used for water demand
4	as above for September	as above
5	actual summer 7 day average low flow as a percent of mean annual flow	expresses the ability of the system to resist water removals; low values indicate streams with low natural 7 day low flows
6	as above for winter 7 day lows	as above
7	mean annual flood as a ratio of mean annual flow	expresses the peakiness of the stream hydrograph and the potential for scour and erosion
8	recent logged area as a percent of total basin area	roughly expresses the equivalent clearcut area and indicates the extent of hydrograph changes from logging; values exceeding 20% indicate potential changes
9	total logged area as a percent of total basin area	as above
10	recent and proposed logging as a percent of total basin area	as above

7.1 Summer Water Demand

Indices 1, 2, 3 and 4 express potential demand in August and September as percentages of various measures of low flow and indicate the total portion of the natural low flows devoted to irrigation and other water uses. Indices 1 and 2 compare potential water demand to mean 7 day summer low flows, which typically occur in August or September. The 7 day low flows used in calculating the indices are "naturalized"; that is, they are estimates of the natural low flow and, consequently, the indices indicate the percentage of the available low flow that could, potentially, be required to meet water demand. Indices 1 and 2 represent *extreme* demands that may occur during the irrigation season. Indices 3 and 4 compare potential demand in August and September to *average* flows in these months and are a measure of the typical portion of flows devoted to irrigation during the late summer.

Demand results from diversion for irrigation, industry and waterworks. Large values of Indices 1 through 4 indicate streams with great potential demand on summer low flows. A number of

the salmon streams have large water demands and on Table 10 only the top 25% of the demands are shaded, which includes streams whose demands exceed 40% of summer low flows.

The potential water demand is calculated from the total licences and probably over-estimates the actual water use. The indices also do not account for storage and release in the watershed. Also, small errors in measurement or calculation of 7 day low flows, particularly for groundwater influent streams, can make large differences in the value of the indices.

7.2 Summer and Winter 7 day Low Flows

Indices 5 and 6 compare seasonal 7 day low flows to mean annual flow, expressing the 7 day low flows as a percentage of mean flow and indicate the ability of the stream to accept water extractions. Low values of the index indicate streams where 7 day low flows are small and where further reductions may significantly affect habitat.

Actual 7 day low flows, as opposed to naturalized flows, were used in the indices so that the indices reflected current conditions in streams with licensed demand and those without licensed demand. The 7 day low flows used in calculating the indices are the recorded low flows on gauged streams, prior to adjustment to reflect upstream storage and diversion of waters. On ungauged streams, with licensed demand, the predicted natural flows were adjusted to actual flows by subtracting the (September) potential water demand. Low values of the indices indicate streams with large water demand or steep recession curves during summer drought.

On Table 10, those salmon streams with low summer 7 day flows, relative to mean flow, are shaded. They are mostly those streams with large demands. Those streams with low winter 7 day low flows, relative to mean flow, include tributaries to the upper Chilliwack River in the Cascade Mountains and salmon streams with large industrial and waterworks demand.

7.3 Peak Flows

Index 7 compares the mean annual flood to mean annual flow, expressing the mean annual flood as a ratio of the mean annual flow. Higher values of the index indicate streams with a greater range of flow and also those that potentially have lower channel stability, though channel slope and bed materials also affect stability. Typically, the ratio of mean annual flood to drainage area increases with decreasing drainage area. This occurs because smaller basins are often completely covered by individual storms, whereas not all of the larger basins are exposed and, as a result, have lower mean annual floods per unit area.

Extreme floods also affect channel stability. Appendix B provides a table showing floods of various return periods for gauged salmon streams in the Chilliwack/Lower Fraser HMA.

7.4 Logging

Indices 8, 9 and 10 express the area of logging as a percentage of total basin area. Index 9 is the total percentage of the watershed that has been logged (all cutblocks including those blocks with some hydrologic recovery); Index 8 is the percentage of recent logging (less than 10 years

old based on silvicultural records). Index 10 expresses the area of recent and proposed logging as a percentage of total basin area and reflects the area of clearcut with little or no hydrologic recovery expected by the end of the five-year plan. The "old logging" includes cutblocks in varying stages of hydrologic recovery, ranging from those with limited or no hydrologic recovery that were recently harvested to some blocks that may be near 9 m regeneration which is often accepted to represent full hydrologic recovery. The percentage that have not recovered and the equivalent clearcut areas (ECA; Section 4.2) of the older logged areas are not known.

It is expected that the Ministry of Forests will ultimately use limits of 25% and 20% (in community watersheds) ECA to control rate-of-cut under their Watershed Assessment Procedure. This degree of clearcutting is expected to produce some changes in the hydrologic regime (Section 4.2). Index 9 is not an ECA values because it is not adjusted for hydrologic recovery of cutblocks and, as a result, may over-estimate the equivalent clearcut area of total harvesting. However, when most of the cutblocks have been harvested in the last few decades, Index 9 may not over estimate the equivalent clearcut area by very much. Indices 8 and 10 represent equivalent clearcut areas.

We have selected total or recent harvesting covering more than 20% of the watershed, which may correspond to an ECA of up to 20%, to indicate that management concern should be raised for fish habitat. A cut of 20% represent the point where effects on the hydrologic regime often become apparent and where changes in the sediment regime of the stream may result. We have also selected a low value so that those streams where changes in the hydrologic regime may be anticipated with further cutting are identified and management options may be considered. Those streams with Indices 8, 9 or 10 greater than 20% are shaded on Table 10. Only logged areas in Canada are included in Table 7 and for some watersheds (Section 4.3) logging in the United States may increase the values of Indices 8, 9 and 10.

Total basin area was used rather than forested area for several reasons. The effect on the hydrologic regime depends on the portion of the total basin whose hydrologic response is altered. Often if the forested area is only a small portion of the basin area, clearing a large percentage of the forest will have an undetectable influence on the hydrologic regime. However, if flood flows are mostly generated from the forested area, cutting may alter downstream hydrology greatly. Also, the Ministry of Forests uses total basin area in calculating these indices and we have followed their practice.

7.5 Urbanization

The effective impervious area expressed as a percentage of the watershed area was used as an index of urbanization. It indicates the potential increase in peak flows that might result from urbanization, though the actual increase will depend on detention storage constructed to manage stormwater, soils and underlying materials and the physiography and geometry of the watershed.

There is no critical level for this index that indicates detectable changes in the hydrologic regime (Section 5.2.2). However, we have selected 10% to indicate potential changes in hydrologic regime. Those watersheds exceeding this value are listed on Table 11.

8. DISCUSSION OF THE SALMON STREAMS

As part of our study we reviewed available reports and studies and discussed the salmon streams with Provincial and Federal government personnel. This section summarizes the stream sensitivity analysis and describes hydrologic constraints, anticipated future conflicts, and opportunities for restoration or enhancement on the individual salmon streams. Our acknowledgements provide a summary of individuals contacted during the study.

8.1 Sensitive Streams

Table 11 identifies the most sensitive salmon streams in the Chilliwack/Lower Fraser Habitat Management Area. The greatest water demands for irrigation, waterworks and industrial use are on salmon streams in the Hatzic Slough, Norrish and Brousseau Creeks along Nicomen Slough, and the streams crossing the Fraser Lowlands at Chilliwack and Rosedale. These streams have more than 40% of their low flows potentially diverted to meet water demands and many appear to be over-subscribed, with water demands exceeding low flows. However, low flows are only approximately known, particularly in groundwater effluent streams.

In the Cascade Mountains flows are greatest during snowmelt in May and June, decline over the summer, and often reach a minimum from January through April, under ice-cover. These tributaries to the Chilliwack River have the lowest winter 7 day low flows in relation to mean flows. The lowest summer 7 day low flows, in relation to mean flow, are on the small tributaries to Hatzic Lake and Nicomen Slough and on stream affected by waterworks withdrawals, such as Elk, Dunville and Nevin Creeks and other creeks near Rosedale and Chilliwack.

Forest harvesting affects the hydrologic regime of some salmon streams. Chilqua Creek, Little Tamihi Creek, Borden Creek and Paleface Creek have over 20% of their watershed area cut. Urbanization is affecting the hydrologic regime of Luckakuck Creek and, possibly, of Draper Creek near Mission. Ten percent of these watersheds are equivalent impervious area which is expected to cause significantly increased flood flows. Other salmon streams have less than 5% EIA and most have close to 0%.

8.2 Discussion by Stream

Our discussions summarize previous studies or personal communications from knowledgeable individuals familiar with the streams and describe hydrologic constraints, anticipated future conflicts, and opportunities for restoration or enhancement. For some streams we have further distilled the available information into recommendations for management of individual streams and general recommendations for management within the Chilliwack/Lower Fraser Habitat Management Area (Section 9). We recommend further study and investigation of all the sensitive salmon streams identified on Table 11.

Hatzic Slough: Hatzic Prairie is an agricultural area where the main impact on aquatic productivity results from ditching of streams, subsequent clearing and maintenance, removal of riparian vegetation and use of herbicides and pesticides to the stream edge. Little riparian vegetation remains along most of the streams. Ditching, stream diversion and use of local names have created some confusion regarding the names of the various tributaries.

Draper Creek drains from the west side of the valley; its upper reaches are in Mission and are urbanizing. Mission does not have a requirement for on-site detention for suburban developments consequently storm drainage may eventually cause problems in this stream. There are debris fan problems on most of the streams along the east side of the Hatzic Valley. Scorey Creek has a large fan and gravel has been excavated from the stream. Woods (1983), after a debris flow initiated in a gully above Stave Lake Road, identified a number of potentially hazardous gullies and fans between Kenworthy and Bouchier Creeks.

Chilqua Creek is a groundwater-fed tributary of Chilqua Slough which drains towards Hatzic Prairie from the east. Much of the drainage area is farmland and the north branch of the creek flows in a drainage ditch for most of its 1.5 km length (Schubert 1980). Schubert (1980) and The Stream Summary Catalogue (Mission) recommends excavation of pools, bank stabilization and gravel placement. B.C. Environment is concerned that Norrish Creek could shift channels and travel down this slough to Hatzic Prairie.

The main issue on Lagace Creek is sediment deposition from Patterson Creek, a tributary that enters from the east. Two very large failures initiated in an area of Patterson Creek that was harvested in the mid-1960's. Severe rainstorms produced large debris torrents and their sediments deposited in Patterson Creek and were then re-worked and moved downstream to Lagace Creek. Associated Engineering Services Ltd (1993) recommended several alternatives to manage sediment from Patterson Creek, including construction of settling basins, though none of these have been constructed to date. Sediment accumulation in Lagace Creek has led to dredging, widening of the creek bottom and construction of low dykes from the dredge spoil. Sediment accumulation and channel widening also results in subsurface flow in the upper channel during low discharges.

Norrish Creek: Gravel has accumulated in the channel of Norrish Creek for a number of years. Cleugh et al (1979) note removal of gravel and dyke construction near the CP Rail bridge in the early 1950's and river works and gravel removal through the 1960's. There is an emergency dyke along the right (west) bank of Norrish Creek. It is not a standard dyke and mostly consists of a stockpile of gravel cleared from the channel upstream of the CPR bridge.

The Dewdney-Alouette Regional District (DARD) operates a water intake on Norrish Creek, about 500 m upstream of Rose Creek. Their licensed diversion is 8.5 mgd (million gallons per day) or about 450 L/s. Dickson Lake has about 20 feet of developed storage and is used as a balancing reservoir: water is released to maintain flows at the diversion during low discharges on Norrish Creek. The Dewdney-Alouette Regional District has applied to increase their licensed diversion to 20 mgd with expanded storage for low flow months.

Accumulation of gravel, bed instability and bank erosion have been continual problems on the fan of Norrish Creek. Part of the problem has resulted from numerous failures from clearcut slopes in tributaries of Norrish Creek. Howes (1987) mapped the failures but there has been no further studies to examine whether sediment supply has reduced or increased in subsequent years. During low discharges, water flows sub-gravel downstream from the Bailey bridge across the river (which is upstream of the lower Water Survey of Canada station). Measurements indicate that as much as 1,000 L/s of water are lost to sub-gravel flow and groundwater on the alluvial fan. The channel is very wide on its fan and moves considerable quantities of bedload.

TRS Contractors currently remove gravel from Norrish Creek upstream of the CPR bridge and place it behind the emergency dyke where it is stored for road construction. Gravel is removed from dry portions of the channel to help establish a low flow channel.

An Integrated Watershed Management Plan (1988) has been prepared for the watershed to manage low flows, reservoir releases, and resource development. An inventory of inactive roads has been recommended. Timber harvesting is now regulated and is thought to have few negative impacts. The DARD (1984) visited and described erosion problems along all the tributaries in the Norrish Creek watershed though it is not clear if any remedial action has been taken.

Inches Creek: The Fisheries and Marine Service (1979) describe Inches Creek as about 6 m wide with high banks, and a low gradient. Prior to 1965, flows in Inches Creek were derived from groundwater in the Norrish Creek fan and occasional flood inflows from Norrish Creek. Inches Creek is also inundated by high water levels in Nicomen Slough. Works on Norrish Creek prevented flood flows from entering the creek and apparently also diverted and reduced groundwater inflows.

The Fisheries and Marine Service (1979) describe initial groundwater development for the Inches Creek hatchery and spawning channel. Maximum pumping capacity for the well field is about 190 L/s (Atwater et al 1994) and discharge from the hatchery maintains flow in the lower creek.

Worth Creek: Worth Creek is similar to Inches Creek in that it was once a channel of Norrish Creek and flows are now maintained by groundwater inflows. The Salmon Enhancement Program (SEP) added a drop structure to improve depths and placed gravel in a spawning channel. Lister et al (1980) described and assessed the enhancement work.

Hawkins Creek: The Stream Summary Catalogue (Mission) reports that this creek is often dry and suffers from extremely low flows that prevent access by salmon.

Railway Creek: Also a former channel of Norrish Creek, it is primarily supplied by groundwater with some surface contribution during heavy rainfall.

Deroche Creek: The creek transports large quantities of gravel on its fan and is reported to have a very flashy regime. The Stream Summary Catalogue (Mission) reports that spawning grounds are disrupted by regular gravel removals.

Deroche Creek could potentially leave its existing channel upstream of the CN Rail bridge. The Dewdney-Alouette Regional District intends to undertake a study of Deroche Creek and its fan that would lead to control of development on the fan and provide structural solutions to sediment accumulation, such as a debris basin near the head of the fan.

Pye Creek: Anadromous salmon cannot pass the culvert at the Lougheed Highway but the upstream habitat is very limited. Downstream of the Lougheed Highway, there is good habitat when there is water in the stream. It is reported to often be dry, though water may flow through the streambed gravels. The farmland downstream of the railway is regularly flooded and the owner would like to dyke the stream.

Pye is a small creek with a flashy hydrologic regime. It moves large quantities of coarse sediment and CP Rail often has to clear their culvert. The source of the coarse sediment is not known.

Barnes Creek: Suburban development is proceeding in the upper reaches of Barnes Creek. Most lots are large and leave strips have been used to protect the stream.

Riparian vegetation has also been left along the lower reaches of the stream. The lower reaches are stable and, unlike Pye and Siddle Creeks, sediment does not accumulate in the channel. The stream is reported to often be dry in the late summer.

Siddle (Bell) Creek: A narrow culvert at the CP Rail line blocks coarse sediment which helps reduce downstream accumulation and aggradation. CP Rail regularly removes gravel from upstream of their culvert and would like to construct a debris basin to simplify their removal program. The Stream Summary Catalogue (Mission) blames logging in the headwaters for increasing the supply of coarse sediment.

Despite removals by CP Rail, gravel still accumulates in the lower reaches of the creek, building bars up to the height of the banks. The aggradation has created the potential for a channel avulsion across its fan. Siddle Creek was dredged a few years ago and the sediment was left as a berm along one side of the stream. The stream bed is unstable and subjected to both scour and sedimentation. As enhancement opportunities, Schubert (1980) recommended creating pools and providing cover along the creek downstream of the CP Rail line and improving access to the west branch of the channel.

The farmer along the lower reach of the stream would like to subdivide his land, leaving a 15 m wide greenbelt along the creek.

Sumas River: The Sumas is a slow-moving river with very little shade, high temperatures and low dissolved oxygen. Narrow dykes contain the river. Riparian vegetation is removed as part of dyke maintenance.

Many of the tributaries, such as Lonzo and Marshall Creeks, flow through road ditches for part of their courses. The timing of cleaning and maintenance of these streams, and of agricultural drainage ditches in fields, is a major concern. Tributaries such as Lonzo Creek are recognized as streams by the Water Management Division and work in and around them currently requires a permit under Section 7 of the Water Act, whereas field drainage ditches do not.

The local Indian Band would like to dredge gravel from the Sumas River to use in a golf course development.

Lower Chilliwack River: The Vedder Management Committee manages the lower river: the committee's main concerns are bed aggradation and gravel removals. Regular surveys are used in conjunction with water profile modelling to assess the channel capacity. When capacity is no longer adequate to pass the 200-year instantaneous discharge bars are scalped to increase the size of the channel. Local municipalities would like to dredge the main channel and bars are often removed to below the waterline. The Yarrow Water Works intake is affected by sediment accumulation and gravels are regularly removed from its vicinity.

Setback dykes, river training and bank revetments have cut off or blocked secondary channels and this has led to the establishment of a single channel. Large organic debris (LOD) along the

channel has also been lost. SEP has excavated channels into the alluvial gravels to create groundwater spawning channels along Peach and Street Creeks and Hopedale slough.

Salwein Creek: Salwein Creek crosses under the Southern B.C. Railway line. This section was washed out during the November 1990 flood and the railway is rebuilding the crossing and re-establishing the stream. Salwein Creek flows primarily in drainage ditches through farmland in its upper 3 km. Downstream of the large pond on the Department of National Defence Lands, Salwein Creek meanders across the Chilliwack River floodplain (Schubert 1984). Agriculture is the main activity in the upper reaches of Salwein Creek. Channel maintenance is required most years to prevent flooding of fields: DFO has refused to approve further gravel removal permits until the creek is fenced.

Siltation from agriculture has affected spawning gravels in the east branch of Salwein Creek. The Stream Summary Catalogue (Chilliwack) reports that the west branch is spring-fed and stable.

Street Creek: A stable, spring-fed, low gradient stream that flows into a groundwater spawning channel constructed in a side channel of the Chilliwack River by SEP.

Barrett Creek: Barrett Creek joins the Chilliwack River near Lickman Road. As part of an enhancement project, SEP dredged the stream, placed spawning gravels and joined it to Peach Creek.

Peach Creek: Peach Creek is an artificial stream occupying what used to be a secondary channel of the Chilliwack River. The Stream Summary Catalogue (Chilliwack) reports that the channel goes dry at its lower end and freezes to the bed during cold winters.

Sweltzer River: Sweltzer River flows out of Cultus Lake and through the Soowahlie Reserve, where the Band has completed some habitat improvements. Sweltzer River is mostly unaffected by development, though summer flows are reduced to maintain water levels in Cultus Lake suitable for recreation. The stream has stable winter flows and its flood discharges are moderated by storage in Cultus Lake.

Liumchen Creek: The District of Chilliwack has applied for a water licence for waterworks on this stream and on Foley Creek. Both streams have good quality water supplies with low to moderate turbidity levels. Water from Liumchen Creek is viewed as a "short-term" solution to water supply in the District of Chilliwack. Liumchen, together with Foley Creek and storage on Upper or Lower Foley Lake is viewed as a "long-term" solution to water supply (Dayton and Knight Ltd 1982).

Ryder Creek: Urban development of the Ryder Uplands by the District of Chilliwack is the major threat to this creek. Long-term plans call for five developed areas, 1,500 ha of developed land and a population of about 60,000. The District of Chilliwack currently has no requirement for stormwater detention or retention on developments. Urban-generated stormwater is likely to end up in Ryder and Semmihault Creeks, greatly increasing flood flows and potentially altering their stream channels.

The Stream Summary Catalogue (Chilliwack) reports low flow problems along Ryder Creek and notes that DFO recommends no further withdrawals to ensure fisheries maintenance flows.

Flood flows erode banks and scour gravels. Siltation of the stream bed is reported to reduce egg-to-fry survival (Stream Summary Catalogue: Chilliwack).

Tamihi Creek: The Stream Summary Catalogue (Chilliwack) reports that glaciers in the United States help maintain unusually high flows during the late summer in this creek.

Thurston Creek: Thurston Creek is a groundwater-fed channel that maintains a reasonably constant flow.

Slesse Creek: Slesse Creek is an unstable, active stream. It is the major gravel source to the upper Chilliwack River, partly as a result of large failures which contribute gravel to the river. These failures mostly are a result of road construction and clearcutting in the watershed. A moratorium has been placed on further logging.

Several options have been discussed to reduce gravel supply to the Chilliwack River; they include construction of a berm or a debris basin.

Fourteen Mile Creek: Fourteen Mile Creek flows in a former side channel of the Chilliwack River and its flows are sustained by groundwater inflow. During floods, the Chilliwack River deposits fine sediment in the stream, burying spawning gravels. Summer and winter low flows may also limit habitat in this stream.

Fifteen Mile Creek: The Stream Summary Catalogue (Chilliwack) reports siltation and lack of flow as constraints on this system.

Lonzo (Marshall) Creek: The easterly discharge from the Abbotsford aquifer was formerly through a series of springs that flowed into Lonzo Creek. The "Lonzo Creek near Abbotsford, 08MH080" gauge, which operated in the early 1960's, recorded very high flows, given the small drainage area apparent on 1:50,000 NTS maps. Wells for the Fraser Valley Trout Hatchery and the District of Abbotsford now withdraw water from this part of the aquifer, affecting discharge to Lonzo Creek.

Industrial and residential development along this creek have added effective impervious area to the watershed, which now amounts to about 6% of the watershed area, and further development may begin to alter the hydrologic regime. Landfilling and encroachment on the floodplain have narrowed the stream.

Kilgard Creek: Kilgard Creek flows from Sumas Mountain through an Indian Reserve. The lack of detention or retention structures on urban development on Sumas Mountain has affected some of the tributaries draining the Mountain. Siltation along the lower reaches of Kilgard Creek is a concern.

DFO reports riparian plantings are being used along the stream to improve habitat.

Chilliwack/Luckakuck Creeks: Luckakuck Creek is spring-fed. Most of the substrate is silt except near culvert outflows and areas of upwelling where gravels are found. Aquatic vegetation grows throughout the creek (Schubert 1980).

Commercial, industrial and residential development in Luckakuck Creek watershed affect its surface water hydrology. About 21% of the watershed is now effective impervious area. Both

industrial and residential developments encroach on the streams. Riparian vegetation has been removed in the residential section except in a few reaches.

Both Chilliwack Creek and Luckakuck Slough are old channels of the Chilliwack/Vedder River and their flows partly result from groundwater inflow and seepage. Chilliwack Creek has been enhanced upstream of Knight Road. About 2 km of channels were excavated where previously there were only standing pools. Agricultural water use affects flows in these streams.

Atchelitz Creek: The Stream Summary Catalogue (Chilliwack) reports low flow problems along this creek and notes that DFO opposes further water withdrawals. Siltation from erosion of agricultural lands is reported to have affected much of the creek.

Calkins and Marblehill Creeks: Critical low flows are reported in both these creeks and the Stream Summary Catalogue (Chilliwack) notes that DFO opposes further water removals. Urban development on Marblehill Road has no provision for detention or retention storage.

A licence for industrial use (fish culture) on Marblehill Creek is being converted to bottling of water for export. The licence has been reduced from 3 cfs to 150,000 gallons per day and has a rider regarding future use.

Hope and Camp Sloughs: As properties along Hope Slough extend to the middle of the slough, owners often "beautify" them by removing riparian vegetation and growing lawn to the edge of the slough. De Leuw and Stewart (1981) examined land and water use along both these sloughs and concluded that there was low potential for enhancement because of habitat degradation through clearing and dyking. The Department of Fisheries and Oceans hopes that an education program for landowners will lead to restoration of riparian vegetation.

Elk Creek: The watershed of Elk Creek faces north and drains Mount Thurston. Unlike most other Fraser Lowland streams, Elk Creek often has a spring snowmelt freshet as a result of snow persisting at high elevation until late April or May. A spring peak may also occur in some years on Ford, Dunville and Nevin Creeks though there are no gauging records to confirm this. After adjustment for upstream water use the "Elk Creek at Prairie Central Road, 08MF048" gauge records about 1,300 mm annual runoff which is lower than streams that drain to the Chilliwack River but higher than streams with most of their drainage basin on the Fraser Lowland.

The District of Chilliwack operates an intake on Elk Creek. Since 1988, a low flow bypass has been used to maintain flows downstream of the structure: minimum bypass flows are 0.2 m³/s during spawning and 0.11 m³/s during rearing. During droughts, flows in upper Elk Creek are often only half of the licensed volume and water for the distribution system is supplemented by two groundwater wells with a total capacity of around 1,700 gpm (Dayton and Knight 1983). The wells now provide a major portion of the annual water supply, and provide all the supply when Elk Creek waters are turbid or when discharges are low.

Zero flow was recorded downstream of the intake in July and August from 1965 to 1970. The Department of Fisheries and Oceans opposes further water removals from Elk Creek. Agricultural is the main activity in the Elk Creek watershed. Most of the lower 4 km of the creek are in a ditch and riparian vegetation has been removed (Schubert 1980). A "shale trap" (a debris basin) operates about 4 km from the mouth: removal of accumulated material from the trap has caused siltation in downstream reaches (Schubert 1980).

The Ministry of Forests is preparing an Integrated Watershed Resource Plan for the upper part of Elk Creek. Agriculture is the main activity in the lower reaches of Elk Creek and riparian planting and fencing are needed to control cattle access. The lower reaches of Elk, Ford, Nevin and Dunville Creeks flow in ditches or have been channelized.

Ford Creek: Critical low flows are reported on this stream.

Nevin and Dunville Creeks: The District of Chilliwack has intakes on both these streams which do not have low flow bypass structures. Low flow bypasses will be added during the next upgrade of the intakes. Waterworks and agricultural diversions reduce flows in these creeks and the Stream Summary Catalogue (Chilliwack) notes that DFO opposes further water removals.

Agriculture is the main activity in these watersheds and water demand for irrigation affects flows as well as diversion for waterworks. Along much of its lower 4 km, Dunville Creek has been channelized and riparian vegetation has been removed (Schubert 1980). Agricultural fields pond following heavy rains and Chatwin Engineering Ltd (1990) has proposed a program to rectify this with improvements (deepening) to ditches and culverts.

A "shale" trap operates in the upper reaches of Dunville Creek which is passable to salmon. It sometimes overflows and coarse sediment is carried down the stream during floods.

Wahleach Slough: The slough is very productive though sediments are deposited in the slough during freshets on the Fraser River, which aggrade the channel bed and eliminate habitat later in the year when flows are low. Scott Paper Ltd has a woodlot licence on the island between Wahleach Slough and the Fraser River. As compensation for crossing the slough they have dug channels to create spawning areas.

Popcum (Cheam) Creek: SEP has enhanced this stream by improving access through culverts and installing a fish ladder at Cheam Lake. A golf course and an urban development have been constructed along the lower reaches of Popcum Creek. A 30 m riparian corridor protects the lower reaches of the stream.

Anderson and Bridal Falls Creeks are the main tributaries to Popcum Creek. Both have been affected by forest harvesting, though the logging in Bridal Falls Creek watershed was in the early part of this century.

Recently, a debris torrent travelled down Anderson Creek, depositing in a farmer's field. The bed material in Anderson Creek is very coarse and the channel is often dry as flow moves through the bed sediments.

Wahleach (Jones) Creek: B.C. Hydro recently re-built their spillway at Wahleach Lake but did not incorporate any structure for releasing minimum flows. Releases are siphoned over the dam and into a spawning channel in the summer and fall.

Unstable slopes in the watershed lead to debris flows entering the stream. Evans and Lister (1983) report failures into Wahleach Creek following a storm in July of that year and in June 1993 a major slide entered the stream from a forestry road, blocking it and forcing it out of its channel. The Ministry of Forests removed the debris and restored the original channel alignment. A major program would be required to stabilize slopes and forest roads in this watershed so as to prevent further damage to the stream.

Lorenzetta Creek: The lower 2 or so km of Lorenzetta Creek cross the Fraser floodplain. Farmers along this reach have removed riparian vegetation. The upper watershed was logged in the late 1950's and 1960's (Schubert 1980).

Lorenzetta Creek is reported to have a very flashy hydrologic regime and to move large quantities of bedload. Channel instability and flooding have resulted from sediment accumulation on its fan. Emergency dredging has removed gravels from several sites on the stream.

Lorenzetta Creek takes a bend near the head of its fan and often overtops its outside bank and floods a farm field. This reach was dyked and dredged in 1976 and 1977. Gravel is still removed from the creek under the Provincial Emergency Program (PEP) even though this area is used for spawning.

Lorenzetta Creek is often dry during droughts as flows pass through gravels in the channel bed. The Stream Summary Catalogue (Chilliwack) notes that DFO opposes further water removals from this creek to ensure maintenance flows.

Silverhope Creek: The lower 3 km of Silverhope Creek are used by anadromous salmon. Falls and rapids at the fan head prevent upstream passage, except for steelhead. Silverhope Creek has flowed along the west side of its fan since the early part of this century. It is shallowly entrenched. Houses along the creek edge are at risk from channel avulsion, flooding and bank erosion. Since 1980, the channel has been widening from erosion and houses were lost in the 1984 flood and there was further erosion in both 1989 and 1990.

The stream bed is very mobile and about 1 m of debris has accumulated since the 1960's near bridges crossing the creek.

9. RESULTS AND CONCLUSIONS

9.1 Effects of Development on Hydrology

In the Cascade Mountains, flows in the salmon streams are greatest during snowmelt in May and June and remain moderately high throughout the summer, particularly in those tributaries with glacierized watersheds, such as Tamihi Creek. Annual runoff remains fairly constant in the Chilliwack River watershed at about 1,800 mm. The southerly tributaries, such as Liumchen and Foley Creeks, are potential sites for waterworks for the District of Chilliwack; otherwise, water demand only has a small effect on the flow regime. Average minimum flows in these streams occur from January to April, sometimes under ice-cover, though summer low flows are often nearly as low as those in winter and the annual minimum discharge may occur in either late summer or winter.

The annual floods in these streams often occur during snowmelt but the largest floods result from rainstorms or rain on snow in the fall. These floods transport large quantities of sediment and often re-arrange, aggrade or erode the channels of the streams. Stream stability seems to have a more important effect on fish production than water use. Current forest harvesting is not affecting the hydrologic regime of these watersheds but past practices may have affected the stability of channels even though the harvested areas have partly or completely regenerated.

In the northern half of the Chilliwack/Lower Fraser HMA, watersheds are exposed to a modified maritime climate. In some years snow accumulates at high elevations, but this often melts during the winter. Average streamflows are highest in November and December as a result of rainfall runoff from Pacific storms that regularly cross the watersheds. Annual floods occur in the fall and winter during these rainstorms though the largest floods often have a snowmelt component. Coarse sediment transported during these floods often accumulates on fans constructed where these streams enter the floodplain of the Fraser River. Stream reaches on these fans are often unstable during floods and flows are lost to groundwater during droughts.

Minimum flows in these streams typically occur in the late summer, particularly for those salmon streams with small watersheds. Diversion for waterworks, irrigation or industrial use affect a number of the streams, which seem over-subscribed compared to the estimated available flows. Storage in Hatzic Slough may be used to meet some of the water demands and help prevent very low discharges in the downstream channel. Many of the streams have very low summer 7 day low flows in relation to mean annual flow. A number of the salmon streams are old channels of Norrish Creek that receive groundwater from the Norrish Creek fan. It was not possible to develop good estimates of the discharge in these streams.

The salmon streams on the southern part of the Fraser Lowland have a similar regime to those on the north side but they have lower annual runoff, particularly in the Sumas Prairie. Annual runoff increases to the east, in Rosedale, where salmon streams have watersheds that extend to higher elevations. Snowmelt is an important part of the hydrologic regime for these streams and it elevates flows in the early part of the summer. Agricultural removals for irrigation, and diversions for waterworks, greatly reduce flows in a number of these streams. A number of the salmon streams are in old channels of the Chilliwack/Vedder River and receive part of their flow from groundwater. It was not possible to develop good estimates of their discharge.

The following sections provide a summary of the types of development affecting the hydrologic and sediment regime of the salmon streams:

Surface Water Use: The major surface water extractions for irrigation are from streams crossing Hatzic and Sumas Prairies, and those crossing the Chilliwack River fan near Rosedale. These demands, when industrial removals are included, are a very large part of summer low flows. The sensitive streams listed on Table 11 all apparently have more than 40% of their low flows potentially devoted to water demands.

The Water Management Branch does not keep records of the degree of utilization of the outstanding water licences and some licences may no longer be used. Recent increases in annual fees have led to some licences being abandoned by their holders and increases in application fees have reduced the backlog of applicants. Revision of the Water Act may result in more fee increases, which could further reduce the number of applications and lead to additional abandonment of under-utilized licences.

Future water demand for irrigation in Chilliwack/Lower Fraser HMA is not known as neither the Water Management Branch nor the Ministry of Agriculture prepare forecasts of agricultural expansion and concomitant requirements for irrigation.

Ground Water Use: Major shallow groundwater extractions occur at the Canadian Forces Base at Sardis, in the Sumas Prairie and from Elk Creek watershed. The effect of these extractions on flows in the salmon streams is not known.

Potential groundwater development in the Columbia Valley at the north end of Cultus Lake could reduce discharges to Cultus Lake and Sweltzer River. Development of the groundwater table aquifer on the Chilliwack River fan could reduce flows in the salmon streams and sloughs on the fan. Flows in these salmon streams are supported, at least in part, by groundwater discharges from aquifer and further development is expected to alter the hydrologic regime of Chilliwack Creek and its tributaries as well as a number of other similar streams. This has not been studied in detail.

Storage Developments: There are no applications before the Water Management Branch for large or medium-sized power projects in the Chilliwack/Lower Fraser HMA though, in the long term, Foley Creek may be developed for water supply by the District of Chilliwack with storage on upper or lower Foley Lake.

Urbanization: Only Luckakuck Creek has a significant percentage of its watershed in effectively impervious area (Table 8), though Draper Creek approaches 10% EIA. The other streams have less than 5% EIA and the majority are close to zero. Future development at Ryder Lake is expected to affect Ryder Creek and Semmihault Creek, greatly increasing the effective impervious area in these systems and potentially altering their flow regimes, depending on stormwater management practices.

Forestry: Harvesting in some of the watersheds began in the early part of the twentieth century. Railroads were used to log the Columbia Valley in the 1920's and by 1928 the line had reached Slesse Creek and was about 4 miles west of Chilliwack Lake by 1936. Logging began in Ryder Creek in the late 1930's and in Liumchen and Tamihi Creeks in the 1940's (McCombs and Chittenden 1990). While this harvesting no longer affects the hydrologic regime because of regeneration, coarse sediment added to streams may still be affecting stream stability.

Many streams also have cutblocks that were harvested 20 or 30 years ago. Re-generation should have greatly reduced the hydrologic impact of these clearcut areas. However, many of

the streams on the north side of the Fraser River appear to have sediment problems that have been partly aggravated by past logging practices.

During our interviews, concern was expressed about specific logging-related issues -- such as poor road construction, drainage control, road encroachments on streams, and slope failures -- that affect tributaries to the salmon streams and some of the smaller salmon streams. There was concern that roads were not meeting basic construction and maintenance standards.

There was no concern expressed about direct sediment or hydrology-related forestry impacts on the larger salmon streams. B.C. Environment and DFO are utilizing Interior Forestry Guidelines to examine rate-of-cut though these guidelines are not yet accepted or approved. Rate-of-cut is generally limited to 25% equivalent clearcut area (20% in Community Watersheds). DFO is also requesting a 30 m windfirm buffer (with possible selective harvest) along salmon streams and machine reserves along small streams.

The proposed cut over the next five years in the watersheds of most the salmon streams ranges from 0% to a maximum of 9% in Chilqua Creek. Proposed cuts in the other streams are: 6% in Kenworthy Creek, 4% in Nomish Creek, 3% in Borden and Hunter Creeks, 2% in Foley Creek, and 1% in the Chilliwack River, Liumchem, Tamihi, Nesakwatch, Paleface and Silverhope Creeks. Most watersheds have no proposed cut.

Removal of lands from the forestry land base for parks and streamside management zones (SMZ) is an important issue for fisheries. If the annual allowable cut (AAC) is not adjusted following these removals, pressure may be exerted to log sensitive or marginally stable lands to maintain the harvest. This has the potential to greatly increase sediment production and thus accelerate sedimentation in the salmon streams.

Flooding, Erosion and Sedimentation: A number of the salmon streams are unstable in their lower reaches, or on their fans, and sediment aggradation leads to loss of surface water to sub-gravel flow. In many instances, the instability results from deposition of coarse sediment on the channel bed. These sediments are a result of natural events on some streams but sediment delivery often seems to be aggravated by poor forestry practices, particularly by poor construction practices for roads. Coarse sediment is transferred slowly along the channel and increased sediment delivery may affect the stream for many years after forest harvesting or other developments are completed.

Several salmon streams have reportedly suffered bank and valley wall landslides that have contributed to sedimentation (Table 5). There is no systematic record of these erosion failures nor any coordinated program for remedial measures.

9.2 Technical and Management Recommendations

As well as the specific discussion of individual streams in this section, a number of general recommendations arise from this study that apply to management of the Habitat Management Areas as well as the individual streams. These include legislative, policy and technical issues. Instream flow needs for fish are not addressed in existing legislation and changes are required to ensure that these needs are considered during licensing of waters in salmon streams.

9.2.1 Estimation of Flows and Demands in the Salmon Streams

Flows for the salmon streams were estimated from complete gauging records, partial gauging records, transfer from nearby stations or regional analysis. As discussed, the estimated flows are of variable quality. Additional hydrologic studies are warranted, particularly for the most sensitive streams, to confirm the flow estimates. In a number of the salmon streams part of their flows are from groundwater and it is not possible to estimate the flow regime accurately unless there are gauging records.

We recommend for the ungauged streams that estimated flows, particularly low flows, should be confirmed by measurement programs perhaps in conjunction with the Water Management Branch and the Water Survey of Canada. This is particularly true for the groundwater influent streams in the Chilliwack/Lower Fraser, where little is known of natural flow regimes. On gauged streams, further analysis of additional gauging records on tributaries or the upper mainstem is warranted, where these are available.

Other gaps in technical knowledge limit our ability to adequately manage the flows of salmon streams:

1. The relationship between actual and licensed withdrawals is not known for various licence types. The distribution of irrigation demand by month has not been studied in detail but only estimated. As well, demand varies from year-to-year, based on a number of factors. *Management of the salmon streams requires some knowledge of the annual and seasonal variation of demand. We recommend regular monitoring of withdrawals to establish actual demand on the most sensitive streams.*
2. Management procedures to ensure adequate instream flows for fish have not been established. *We recommend that instream flow requirements be assessed for the more sensitive salmon streams and that appropriate water management plans be developed in conjunction with other agencies (Hamilton 1992).*

9.2.2 Water Licensing and Water Use

The streams on Table 11 all have more than 40% of their estimated low flows potentially devoted to agricultural, waterworks, and industrial demands. Further removals from these stream should be opposed until instream flow requirements are better understood. It appears that minimum flows, rather than summer monthly flows, are the limitation on these systems. Part of the available flows may travel as sub-gravel flow. *We recommend further study of flows in these systems, particularly of groundwater contributions to small streams, and recommend that further licencing of these streams be opposed until they have been studied in more detail.*

The streams with large demands have the lowest summer 7 day flows (as a percentage of mean flows). Low winter flows in relation to mean flows occur in those streams with industrial and waterworks development and also in tributaries of the Chilliwack River that lie in the Cascade Mountains. *We recommend careful study of water development proposals in these stream systems that may reduce winter low flows.* It is not known if increased urbanization will reduce flows in some of the salmon streams.

There may be management or technical options for improving those streams that either have the greatest water demands or the lowest flows. In those basins with only limited storage, additional reservoirs may be used to supplement minimum flows in the stream. If losses to groundwater or sub-gravel flow on fans are the main limitation releases from storage may not improve low flows but may instead be lost to groundwater. *We recommend that studies of storage potential, instream flow needs and investigation of losses along the channel should precede agreements on management of instream flows.*

The Water Management Branch classifies streams and restricts further water use in some streams. *We recommend that Department of Fisheries and Oceans review the basis for decisions on restricting or not restricting water use and participate in revising the list of reserved streams.*

We also recommend that, for salmon streams with high potential utilization, the Water Management Branch and Department of Fisheries and Oceans identify those irrigation or industrial licences that are not utilized or are under-utilized and attempt to purchase the licences or persuade owners to abandon them.

9.2.3 Groundwater Extractions

There are gaps in our technical knowledge that make it difficult to manage the effect of groundwater extractions on flows in the salmon streams:

1. Groundwater wells are reported on a voluntary-basis and there is no mechanism to track the volume or rate of extraction from different wells; and
2. Subsurface geology and groundwater movement are not always well enough understood to predict the relationship between extractions and reductions in streamflow.

We recommend that shallow wells be inventoried in basins of those salmon streams whose base flows may be substantially maintained by ground water discharges and that the potential reduction in streamflow from pumping from groundwater be evaluated.

9.2.4 Urbanization

Luckakuck Creek has licensed demand from agriculture and industry. Urbanization has also increased the effective impervious area to a point where it may alter the hydrologic regime, though changes to groundwater inflows may be more important than changes in surface water inflows.

The hydrologic regime is generally managed in urbanizing basins by developing detention storage to maintain frequent floods (i.e., the 2-year flood) at the pre-development discharge downstream of the development site. It is assumed that erosional and habitat changes to streams are caused mostly by frequent floods and that by maintaining pre-development discharges for these floods that the channel and habitat will be maintained. There have been no studies related to this issue in the Fraser Lowlands. Consequently, the approach to management of storm water and channel maintenance is based on results from other areas,

primarily Western Washington. *We recommend a study to evaluate whether the current management of stormwater is effectively maintaining channels in the Fraser Lowlands.*

One further weakness is that the cumulative effect of alterations in tributaries and at development sites on the overall hydrologic regime in the mainstem is not managed by onsite stormwater management. This issue has not been addressed in planning for stormwater management. Hydrologic modelling (simulation) remains the best approach to evaluation of the hydrologic regime in the basin. *We recommend that modelling be used in contentious watersheds, as is currently carried out in Washington State.* Initially, it may be preferable to select one watershed to demonstrate the effectiveness of hydrologic modelling, describe the typical effects of urbanization on streamflow regime, and test various stormwater retention and detention options.

9.2.5 Forest Harvesting

The salmon streams that are tributary to the upper Chilliwack River have insignificant or zero licensed demand and are not likely to experience increased agricultural demand in the near-future. In these streams, logging is the main land use with the potential to alter the hydrologic or sediment regimes or alter channel morphology. It is generally felt that the hydrologic regime may be preserved or managed by controlling the rate of clearcutting, and consequently, the portion of the basin that is in hydrologic recovery. It is not so easy to control or manage the sediment regime. Individual failures or poorly designed roads may alter downstream suspended sediment concentrations and deteriorate gravel quality. These must be investigated on a site by site basis and managed by following road construction and harvest prescription guidelines provided by the responsible agencies.

Managing the rate of clearcutting in the salmon streams poses a number of technical difficulties, which are discussed below:

1. It is difficult to manage the rate of cut because the Ministry of Forests does not present their existing and proposed cut data by watershed. *We recommend that DFO arrange with the Ministry of Forests to have the proposed cut on five-year plans sorted by watershed. Total previous and proposed cut within the watersheds should be established so that rate of cut can be monitored. Harvest in the United States that affects these watersheds should also be incorporated in the rate of cut assessment.*
2. The relationship between re-growth and hydrologic recovery is not known for the watersheds. Consequently, it is difficult to assess the effective clearcut area of watersheds with cut blocks of varying ages, and varying levels of regrowth, and the potential impact on the hydrologic regime: we recommend that further studies be undertaken. Research underway in the Stuart-Takla Fisheries/Forestry Interaction Project (Macdonald et al 1992) may examine rate of cut and cumulative impact issues. Studies in Carnation Creek have also addressed these issues to some extent.

Until the issue of hydrologic recovery is resolved, we recommend a conservative position on the total cut permitted within individual watersheds.

3. Within the basins of the individual salmon streams, the proposed cut should be distributed over the various tributary basins, to maintain the regime of the tributaries, as well as the main stem. *We recommend a detailed review of the history of cut within the watershed of salmon streams where a large percentage of the basin is harvested. Ultimately, a GIS database that includes logging history could be used to calculate clearcut effective area within the tributaries and main stem and to monitor forest harvesting. These databases are available from some Forest Districts.*
4. It is often difficult to determine the total harvested area in small watersheds from the records available from the Ministry of Forests. *We recommend further review and analysis in small watersheds.*

9.2.6 Sedimentation and Sediment Sources

The Ministry of Forests has prepared a policy document on prevention, reporting and mitigation of erosion events (MOF 1992). This document includes: the establishment of Erosion Control Teams; a formal system of reporting and inventorying erosion events; and remedial planning for past and present events. *Department of Fisheries and Oceans should ensure that they receive erosion reports and have an opportunity to participate in planning of remedial works, particularly in selecting those sites with highest priority.*

Ultimately, the erosion events should be mapped or incorporated into a GIS database for display with respect to habitat along the streams along with anecdotal information on the history of erosion, flooding, sedimentation and channel changes in the salmon streams in the Chilliwack/Lower Fraser HMA. Various individuals in federal and provincial government agencies have personal information that is not mapped or recorded in a fashion whereby it could be utilized in other studies.

Comprehensive planning requires an understanding of channel changes and sedimentation in the salmon streams in the Chilliwack/Lower Fraser HMA. Some of this information is available from various individuals. *We recommend that it be gathered, checked, collated, verified and mapped in some standard format in order to make the data usable.*

The watersheds of some of the salmon streams are small and the stream courses are reasonably short. *We recommend that the information on channel changes be combined with observations on passage at culverts, water extraction points, the state of riparian vegetation and banks, overwintering habitat, etc on a large scale map of the drainage system in a Geographic Information System. A workshop may be a suitable format to further explore this approach.*

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TABLES



Table 1: Salmon Streams in the Chilliwack/Lower Fraser HMA.

Stream Name	SSIS Number	WSC Gauge Data			Total Drainage Area (km ²)	Years of Record
		Gauge Name	Gauge No.	Drainage Area (km ²)		
HATZIC SLOUGH						
1 Hatzic Slough	00-0500	-	-	-	82.0	-
2 - Draper Ck.	00-0500-010	-	-	-	7.5	-
3 - Chilqua Slough	00-0500-020	-	-	-	12.0	-
4 - Chilqua Ck.	00-0500-020-020	-	-	-	1.9	-
5 - Kenworthy Ck.	00-0500-050*	near Hatzic	08MH077	4.9	6.9	1960-84 MS
6 - Boucher Ck.	00-0500-060-010*	near Hatzic	08MH045	-	1.6	1960-84 MS
7 - Lagace Ck.	00-0500-060	near Hatzic	08MH095	-	32.0	1960-84 MS
8 - Belcharton Ck.	00-0500-060-010-010*	-	-	-	5.8	-
9 - Scorey Ck.	00-0500-080	-	-	-	1.9	-
10 Wades Ck.	00-0550	-	-	-	8.2	-
NICOMEN SLOUGH						
11 Nicomen Slough	00-0552	at Deroche	08MH085	-	180.8	1960-84*MS
12 - Norrish Ck.	00-0552-020	at Dewdney	08MH086	-	123.0	1960-84 *MS
13 - Inches Ck.	00-0552-020-005	near Dewdney	08MH058	117	0.8	1959-81 RC
14 - Worth Ck.	00-0552-020-010	above Rose Ck.	08MH150	-	0.8	1963-81 RC
15 - Hawkins Ck.	00-0552-020-015	-	-	-	0.1	-
16 - Railway Ck.	00-0552-024	-	-	-	0.3	-
17 - Brousseau Ck.	00-0552-028	-	-	-	5.0	-
18 - Deroche Ck.	00-0552-030	at Deroche	08MH070	-	8.8	1960-84 MS
19 - Pye Ck.	00-0552-050	-	-	-	2.9	-
20 - Barnes Ck.	00-0552-060	-	-	-	3.5	-
21 - Siddle Ck.	00-0552-070	-	-	-	6.0	-
22 Sumas R. (a)	00-0600	near Huntingdon	08MH029	148	330	1935-81 RC
		near Sardis	08MH039	-	-	1951-84*RC
		at Atkinson Road	08MH093	-	-	1971-80*RC
		near Yarrow	08MH094	-	-	1960-84*MS
		near BC Hydro Railway Br.	08MH130	-	-	1969-75 *RC
		above pumphouse	08MH131	-	-	1970-74 *MC
		at McDermot Road	08MH133	-	-	1971-81 *RC
CHILLWACK RIVER						
23 - Chilliwack R. (lower) (b)	00-0600-020-000-000-991	at Vedder Crossing	08MH001	1230	1260	1911-31 MC + 1943-81 RC
24 - Chilliwack R. (upper) (c)	00-0600-020-000-000-992	below Slesse Ck.	08MH055	860	860	1956-82 RC
		above Slesse Ck.	08MH103	645	617	1963-81 RC
		at Outlet of Chilliwack Lk.	08MH016	329	329	1923-50 RC + 1957-81 RC
25 - Salwein Ck.	00-0600-020-008	-	-	-	0.3	-
26 - Street Ck.	00-0600-020-010	-	-	-	1.9	-
27 - Hopedale Slough	00-0600-020-010-010	-	-	-	0.9	-
28 - Barrett Ck.	00-0600-020-013	-	-	-	0.7	-
29 - Peach Ck.	00-0600-020-015	-	-	-	1.2	-
30 - Sweltzer R. (d)	00-0600-020-020	near Sardis	08MH012	90.7	134.3	1911-12 MS
		at Cultus Lk.	08MH033	65	65	1951-55 MC; 1956-84 MS
31 - Liumchen Ck. (e)	00-0600-020-040	near the mouth	08MH157	54.4	64.4	1985-89 RC
32 - Ryder Ck.	00-0600-020-050	-	-	-	8.9	-
33 - Little Tamhi Ck.	00-0600-020-070	-	-	-	5.3	-
34 - Tamhi Ck. (f)	00-0600-020-090	near Vedder Crossing	08MH037	-	123.0	1950-51 RS
35 - Thurston Ck.	00-0600-020-115	-	-	-	3.8	-
36 - Borden Ck.	00-0600-020-120	-	-	-	17.5	-
37 - Slesse Ck. (g)	00-0600-020-130	near Vedder Crossing	08MH056	162	166.0	1957-81 RC
38 - Foley Ck.	00-0600-020-160	above Foley Lk.	08MH163	-	77.7	1981 RC
39 - Nesakwatch Ck. (h)	00-0600-020-170	-	-	-	56.4	-
40 - Fourteen Mile Ck.	00-0600-020-173	-	-	-	2.4	-
41 - Fifteen Mile Ck.	00-0600-020-176	-	-	-	1.7	-
42 - Center Ck. (i)	00-0600-020-180	-	-	-	39.6	-
43 - Post Ck.	00-0600-020-200	-	-	-	24.5	-
44 - Paleface Ck.	00-0600-020-240	-	-	-	38.2	-
45 - Depot Ck. (j)	00-0600-020-250	-	-	-	58.0	-
46 - Lonzo Ck.	00-0600-050	near Abbotsford	08MH080	-	26.0	1960-84 MS
47 - Klgard Ck.	00-0600-050-010	(north Fork) near Klgard	08MH079	-	2.8	1961-84 MS
48 Chilliwack Ck.	00-0625	near Chilliwack	08MF061	-	78.4	1960-84 MS
49 - Alcheitz Ck.	00-0625-010	at Highway 1	08MF070	-	20.4	1986 R#
50 - Luckaluck Ck.	00-0625-030	-	-	-	8.1	-
51 - Semmihaut Ck.	No SISS Number	at Prairie Central Road	08MF069	-	18.5	1986 R#
52 - Calkins Ck.	00-0640-020-004*	-	-	-	3.5	-
53 - Marblehill Ck.	00-0640-020-004-800*	-	-	-	2.8	-
54 - Hope Slough	00-0640	near Rosedale	08MF036	-	100.3	1952-57 MS
55 - Elk Ck.	00-0640-020	near Rosedale	08MF018	11.1	33.7	1915-20 MC
		at Prairie Central Road	08MF048	11.9	11.9	1960-75 MC
56 - Ford Ck.	00-0640-020-020	-	-	-	5.8	-
57 - Durville Ck.	00-0640-030	-	-	-	19.0	-
58 - Nevin Ck.	00-0640-030-005	-	-	-	5.8	-
59 - Camp Slough	00-0640-010	-	-	-	15.5	-
60 Wahleach Slough	00-0685	-	-	-	28.2	-
61 Popcum Ck.	00-0690	-	-	-	20.4	-
62 Wahleach Ck.	00-0735	near Laidlaw (upper station)	08MF006	64.8	114.0	1911-26 MC + 1950-51 MS
		near Laidlaw (middle station)	08MF037	88.3	88.3	1951-52 MS
		near Laidlaw (lower station)	08MF034	114	114	1950-70 MC
63 Lorenzetta Ck.	00-0736	-	-	-	11.0	-
64 Hunter Ck.	00-0780	-	-	-	41.6	-
65 Silverhope Ck.	00-0780	near Hope	08MF009	350	328*	1964-71 MC

- "dash" (-) indicates that the stream has not been gauged.
 - "asterisk" (*) indicates that inconsistencies in local names and recent diversions leave coding suspect.

Table 2: Physiography and Ecoregions in the Chilliwack/Lower Fraser HMA.

Stream Name	SSIS Number	Total Drainage Area (km ²)	Physiographic Region (1)	Ecoregion (2)	Ecosection (3)
HATZIC SLOUGH					
1 Hatzic Slough	00-0500	82.0	FL	LM	FL
2 - Draper Ck.	00-0500-010	7.5	FL	LM	FL
3 - Chilqua Slough	00-0500-020	12.0	FL	LM	FL
4 - Chilqua Ck.	00-0500-020-020	1.9	FL	LM	FL
5 - Kenworthy Ck.	00-0500-050*	6.9	FL	LM	FL
6 - Bouchier Ck.	00-0500-060-010*	1.6	FL	LM	FL
7 - Lagace Ck.	00-0500-060	32.0	FL	LM	FL
8 - Belcharton Ck.	00-0500-060-010-010*	5.6	FL	LM	FL
9 - Scorey Ck.	00-0500-080	1.9	FL	LM	FL
10 Wades Ck.	00-0550	9.2	FL	LM	FL
NICOMEN SLOUGH					
11 Nicomen Slough	00-0552	180.8	FL	LM	FL
12 - Norrish Ck.	00-0552-020	123.0	FL	LM	FL
13 - Inches Ck.	00-0552-020-005	0.8	FL	LM	FL
14 - Worth Ck.	00-0552-020-010	0.6	FL	LM	FL
15 - Hawkins Ck.	00-0552-020-015	0.1	FL	LM	FL
16 - Railway Ck.	00-0552-024	0.3	FL	LM	FL
17 - Brousseau Ck.	00-0552-028	5.0	FL	LM	FL
18 - Deroche Ck.	00-0552-030	9.8	FL	LM	FL
19 - Pye Ck.	00-0552-050	2.9	FL	LM	FL
20 - Barnes Ck.	00-0552-060	3.5	FL	LM	FL
21 - Siddle Ck.	00-0552-070	6.0	FL	LM	FL
22 Sumas R. (a)	00-0600	330.0	FL	LM	FL
CHILLIWACK RIVER					
23 - Chilliwack R. (lower) (b)	00-0600-020-000-000-000-99	1260.0	FL/CM	LM/CR	FL/NCR
24 - Chilliwack R. (upper) (c)	00-0600-020-000-000-000-99	617.0	FL/CM	LM/CR	FL/NCR
25 - Salwein Ck.	00-0600-020-008	0.3	FL	LM	FL
26 - Street Ck.	00-0600-020-010	1.9	FL	LM	FL
27 - Hopedale Slough	00-0600-020-010-010	0.9	FL	LM	FL
28 - Barrett Ck.	00-0600-020-013	0.7	FL	LM	FL
29 - Peach Ck.	00-0600-020-015	1.2	FL	LM	FL
30 - Sweltzer R. (d)	00-0600-020-020	134.3	CM	CR	NCR
31 - Liumchen Ck. (e)	00-0600-020-040	64.4	CM	CR	NCR
32 - Ryder Ck.	00-0600-020-050	8.9	CM	CR	NCR
33 - Little Tamih Ck.	00-0600-020-070	5.3	CM	CR	NCR
34 - Tamih Ck. (f)	00-0600-020-090	123.0	CM	CR	NCR
35 - Thurston Ck.	00-0600-020-115	3.8	CM	CR	NCR
36 - Borden Ck.	00-0600-020-120	17.3	CM	CR	NCR
37 - Slesse Ck. (g)	00-0600-020-130	166.0	CM	CR	NCR
38 - Foley Ck.	00-0600-020-160	77.7	CM	CR	NCR
39 - Nesakwatch Ck. (h)	00-0600-020-170	56.4	CM	CR	NCR
40 - Fourteen Mile Ck.	00-0600-020-173	2.4	CM	CR	NCR
41 - Fifteen Mile Ck.	00-0600-020-176	1.7	CM	CR	NCR
42 - Center Ck. (i)	00-0600-020-180	39.6	CM	CR	NCR
43 - Post Ck.	00-0600-020-200	24.5	CM	CR	NCR
44 - Paleface Ck.	00-0600-020-240	38.2	CM	CR	NCR
45 - Depot Ck. (j)	00-0600-020-250	58.0	CM	CR	NCR
46 - Lonzo Ck.	00-0600-050	26.0	FL	LM	FL
47 - Kilgard Ck.	00-0600-050-010	2.8	FL	LM	FL
48 Chilliwack Ck.	00-0625	78.4	FL	LM	FL
49 - Atchelitz Ck.	00-0625-010	20.4	FL	LM	FL
50 - Luckakuck Ck.	00-0625-030	8.1	FL	LM	FL
51 - Semmihaut Ck.	No SISS Number	18.5	FL	LM	FL
52 - Calkins Ck.	00-0640-020-004	3.5	FL	LM	FL
53 - Marblehill Ck.	00-0640-020-004-800	2.8	FL	LM	FL
54 - Hope Slough	00-0640	100.3	FL	LM	FL
55 Camp Slough	00-0640-010	15.5	FL	LM	FL
56 - Elk Ck.	00-0640-020	33.7	FL/CM	LM/CR	FL/NCR
57 - Ford Ck.	00-0640-020-020	5.8	FL/CM	LM/CR	FL/NCR
58 - Dunville Ck.	00-0640-030	19.0	FL/CM	LM/CR	FL/NCR
59 - Nevin Ck.	00-0640-030-005	5.8	FL/CM	LM/CR	FL/NCR
60 Wahleach Slough	00-0685	28.2	FL/CM	LM/CR	FL/NCR
61 Popcum Ck.	00-0690	20.4	FL/CM	LM/CR	FL/NCR
62 Wahleach Ck.	00-0735	114.0	FL/CM	LM/CR	FL/NCR
63 Lorenzetta Ck.	00-0736	11.0	FL/CM	LM/CR	FL/NCR
64 Hunter Ck.	00-0760	41.6	FL/CM	LM/CR	FL/NCR
65 Silverhope Ck.	00-0790	328	FL/CM	LM/CR	FL/NCR

1. Physiographic Regions from Matthews (1986). FL is the Fraser Lowlands; CM, the Cascade Mountains.
 2. Ecoregions from Demarchi (1993). LM is the Lower Mainland; CR, the Cascade Ranges.
 3. Ecosections from Demarchi (1993). FL is the Fraser Lowland; NCR, the Northern Cascade Ranges.
- "asterisk" (*) indicates that inconsistencies in local names and recent diversions leave coding suspect.

Table 3: Regional Climate in the Chilliwack/Lower Fraser HMA.

Climate Station	Ecosection (1)	Physiographic Region (2)	Latitude	Longitude	Elevation (m)	Precipitation (mm) (3)				Mean Annual Temperature
						Annual	May to Sept	Annual Snowfall	Greatest Daily	
Lower Mainland Ecoregion										
Mission	FL	FL	49.08	122.18	56	1631.1	375.1	61.9	97.5	10.1
Mission West Abbey	FL	FL	49.09	122.16	221	1772.1	433.4	100.7	102.1	9.6
Hatzic Prairie	FL	FL	49.12	122.14	9	2052.2	473.1	84	103.1	-
Sumas Canal	FL	FL	49.07	122.07	6	1825.1	401.4	73.3	109	10.7
Cultus Lake	FL	FL	49.05	121.59	46	1470.5	342.5	75.2	164.1	9.7
Chilliwack	FL	FL	49.07	122.06	6	1880.4	399.7	129.4	122.6	10.2
Chilliwack Gibson Rd	FL	FL	49.11	121.53	12	1541.7	352.8	86.1	90.9	9.8
Sardis	FL	FL	49.05	121.54	107	1452.5	353.1	98.4	101	-
Rosedale	FL	FL	49.11	121.48	11	1504.3	359.1	92.4	82.6	9.8
Cascade Mountains Ecoregion										
Chilliwack R Centre Ck	NCR	CM	49.06	121.33	488	1566.6	335.3	196.6	127	-
Chilliwack R Foley Ck	NCR	CM	49.06	121.38	457	1536.5	349.2	166.5	119.4	-
Chilliwack R Mt Thurston	NCR	CM	49.05	121.46	198	1443.8	324.0	93.7	99.6	-

1. Physiographic Regions from Matthews (1986). FL is the Fraser Lowlands; CM, the Cascade Mountains.
2. Ecosections from Demarchi (1993). FL is the Fraser Lowland; NCR, the Northern Cascade Ranges.
3. Climate data from the 1951-1980 Canadian Climate Normals.

Table 4: Hydrologic Characteristics of the Ecoregions.

	<i>Fraser Lowland Ecosection</i>	<i>Nothern Cascade Ranges Ecosection</i>
<i>Mean Annual Runoff (mm)</i>	700	1900
<i>Month with Average Maximum Discharge</i>	January	June
<i>Timing of annual maximum discharge</i>	November through March	May and June; often in October to February
<i>Month with Average Minimum Discharge</i>	September	September
<i>Timing of annual minimum discharge</i>	August , September or October	September and October; often in winter
<i>Typical Stream</i>	Sumas River near Huntingdon 08MG001	Slesse Creek near Vedder Crossing 08MH056
<i>Basin Area (km2)</i>	149	162

Table 5: Channel Stability in the Chilliwack/Lower Fraser HMA.

Stream Name	SSIS Number	Channel Response					Human Modifications					
		Pattern Change	Erosion	Incision	Aggradation	Bed Material Scour	Sedimentation	Dyking	River Training	Encroachment	Gravel Removal	Veget. Removal
HATZIC SLOUGH												
1 Hatzic Slough	00-0500							●	●			
2 - Draper Ck.	00-0500-010											
3 - Chilqua Slough	00-0500-020											
4 - Chilqua Ck.	00-0500-020-020								▲			
5 - Kenworthy Ck.	00-0500-050*											
6 - Bouchier Ck.	00-0500-060-010*								●			
7 - Lagace Ck.	00-0500-060							●	●		●	●
8 - Belcharton Ck.	00-0500-060-010-010*										●	
9 - Scorey Ck.	00-0500-080										●	
10 Wades Ck.	00-0550											
NICOMEN SLOUGH												
11 Nicomen Slough	00-0552				●							
12 - Norrish Ck.	00-0552-020		●		●	●					●	
13 - Inches Ck.	00-0552-020-005											
14 - Worth Ck.	00-0552-020-010											
15 - Hawkins Ck.	00-0552-020-015											
16 - Railway Ck.	00-0552-024											
17 - Brousseau Ck.	00-0552-028											
18 - Deroche Ck.	00-0552-030	●			●	●						
19 - Pys Ck.	00-0552-050				●							
20 - Barnes Ck.	00-0552-060											
21 - Sidde Ck.	00-0552-070				●	●	●	●			●	●
22 Sumas R. (a)	00-0600							●				●
CHILLIWACK RIVER												
23 - Chilliwack R. (lower) (b)	00-0600-020-000-000-000-991	●	●		●	●	●	●	●		●	●
24 - Chilliwack R. (upper) (c)	00-0600-020-000-000-000-992	●	●									
25 - Salwein Ck.	00-0600-020-008						●		●		●	
26 - Hopedale Slough	00-0600-020-010-010											
27 - Street Ck.	00-0600-020-010											
28 - Barrett Ck.	00-0600-020-013											
29 - Peach Ck.	00-0600-020-015											
30 - Sweltzer R. (d)	00-0600-020-020											
31 - Liumchen Ck. (e)	00-0600-020-040											
32 - Ryder Ck.	00-0600-020-050		●			●	●					
33 - Little Tamih Ck.	00-0600-020-070											
34 - Tamih Ck. (f)	00-0600-020-090											
35 - Thurston Ck.	00-0600-020-115											
36 - Borden Ck.	00-0600-020-120											
37 - Slesse Ck. (g)	00-0600-020-130		●									
38 - Foley Ck.	00-0600-020-160											
39 - Nesakwatch Ck. (h)	00-0600-020-170											
40 - Fourteen Mile Ck.	00-0600-020-173											
41 - Fifteen Mile Ck.	00-0600-020-176											
42 - Center Ck. (i)	00-0600-020-180											
43 - Post Ck.	00-0600-020-200											
44 - Paleface Ck.	00-0600-020-240											
45 - Depot Ck. (j)	00-0600-020-250											
46 - Lonzo Ck.	00-0600-050							●		●		
47 - Kigard Ck.	00-0600-050-010							●				
48 Chilliwack Ck.	00-0625											
49 - Atchelitz Ck.	00-0625-010							●				●
50 - Luckakuck Ck.	00-0625-030								●			●
51 - Semmahault Ck.	No SISS Number											
52 - Calkins Ck.	00-0640-020-004											
53 - Marblehill Ck.	00-0640-020-004-800											
54 - Hope Slough	00-0640							●		●		●
55 Camp Slough	00-0640-010							●				●
56 - Elk Ck.	00-0640-020							●		●		●
57 - Ford Ck.	00-0640-020-020											●
58 - Dunville Ck.	00-0640-030									●		●
59 - Nevin Ck.	00-0640-030-005											
60 Wahleach Slough	00-0685				●							
61 Popcum Ck.	00-0690					▲						
62 Wahleach Ck.	00-0735	▲	▲									
63 Lorenzetta Ck.	00-0736		●		●			●			●	●
64 Hunter Ck.	00-0780											
65 Silverhope Ck.	00-0790		●		●							

* asterisk (*) indicates that inconsistencies in local names and recent diversions leave coding suspect.

■ " refers to upper river, ▲ " to middle river, ● " to lower river

Table 6: Definitions of Flow characteristics

Annual flood - Maximum or "peak" daily flow of the year.

Annual flow - Average of the daily flows between January 1 and December 31 for a particular year.

Annual 7 day low flow - The lowest average flow for 7 consecutive days between January 1 and December 31. Same as "7 day mean low" used in Appendix C.

Daily flow - Average flow for the period midnight to midnight.

Mean annual flood - Average of the annual floods for a stated historic period.

Mean annual flow - Average of the annual flows for a stated historic period.

Mean annual 7 day low flow - Average of the 7 day low flows for a stated historic period.

Mean August flow - Average of the August flows for a stated historic period.

Mean September flow - Average of the September flows for a stated historic period.

Mean summer 7 day low flow - Average of the summer 7 day low flows for a stated historic period.

Mean winter 7 day low flow - Average of the winter 7 day low flows for a stated historic period.

Naturalized flow - Measured flows, adjusted with upstream water licences, to represent the flows that would occur in the absence of regulation and extraction.

Summer 7 day low flow - The lowest average flow for 7 consecutive days between May 1 and October 31.

Water demand - Sum of all the consumptive uses upstream of a reference point, as estimated from water licences.

Winter 7 day low flow - The average flow for 7 consecutive days between November 1 and April 30.

Unit flow - The flow at a reference point, usually a Water Survey of Canada station, divided by the basin area above that reference point.

Table 7: Hydrology of the Salmon Streams in the Chilliwack/Lower Fraser HMA

Stream Name	WSC Gauge No.	Basin Area (mouth) (km2)	Logged Area					Total Water Licences					Licensed Demand (L/s)			Naturalized Flows in the Salmon Streams (m3/s)					
			Oldest (Pre 63) (km2)	Older (63-72) (km2)	Old (73-82) (km2)	Recent (83-92) (km2)	Proposed (93-97) (km2)	Domestic (g/day)	Irrigation (ac-ft)	Water-works (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
CHILLIWACK RIVER																					
- Chilliwack R. (lower) (b)	08MH001	640.9	25.1	5.8	0.3	0.5	3.9	109,850	667	1,510,000	543,500	14	208	161	114	64.0	313	37.00	25.00	17.72	25.36
- Chilliwack R. (upper) (c)	08MH103	310.9	38.1	42.4	7.9	1.3	2.6	6,000	190	4,000	5,000	140	27	14	1	34.91	200.0	23.40	14.90	9.58	11.45
- Salwein Ck.		0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.13	0.002	0.002	0.002	0.004
- Street Ck.		1.9	0	0	0	0	0	2,500	26	0	0	0	4	2	0	0.04	0.61	0.012	0.012	0.009	0.022
- Hopedale Slough		0.9	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0.006	0.31	0.006	0.006	0.004	0.010
- Barrett Ck.		0.7	0	0	0	0	0	1,500	4	0	0	0	1	0	0	0.02	0.23	0.004	0.004	0.003	0.008
- Peach Ck.		1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0.39	0.007	0.007	0.006	0.013
- Sweltzer R. (d)	08MH033	134.3	0	0	0	0	0	33,900	288	690,500	232,000	12	91	71	50	7.64	52.27	3.88	3.11	2.12	2.82
- Liumchen Ck. (e)	08MH157	53.9	0.6	0	0	0	0	0.6	0	100,000	21,000	0	6	6	6	3.40	22.99	0.55	0.53	0.75	0.90
- Ryder Ck.		8.9	0	0	0	0	0	10,250	39	0	14,000	2	7	4	1	0.56	4.55	0.33	0.21	0.12	0.15
- Little Tamihl Ck.		5.3	2.6	0	0	0	0	0	0	0	0	0	0	0	0	0.34	2.87	0.20	0.13	0.07	0.09
- Tamihl Ck. (f)		129.1	10.7	3.8	0.3	0	1.5	22,300	277	4,000	278,000	140	55	35	16	8.14	50.46	4.80	3.07	1.79	2.14
- Thurston Ck.		3.8	0	0	0	0	0	2,000	0	0	0	0	0	0	0	0.16	0.9	0.19	0.15	0.05	0.01
- Borden Ck.		21.0	4.6	1.9	0	0	0.5	0	4	0	0	0	1	0	0	1.32	9.84	0.78	0.50	0.29	0.35
- Slesse Ck. (g)	08MH056	162.0	5.0	0	0	0	0.8	0	0	0	0	0	0	0	0	10.21	61.9	6.02	3.85	2.24	2.69
- Foley Ck.		77.7	5.5	6.7	0.1	0	1.5	0	0	0	0	0	0	0	0	4.90	31.95	2.89	1.85	1.07	1.29
- Nesakwatch Ck. (h)		56.4	4.8	5.3	0	0	1.0	0	0	0	0	0	0	0	0	3.55	23.95	2.10	1.34	0.78	0.94
- Fourteen Mile Ck.		2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0.15	1.37	0.09	0.06	0.03	0.04
- Fifteen Mile Ck.		1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0.11	1.02	0.06	0.04	0.02	0.03
- Center Ck. (i)		39.6	3.4	2.6	0.3	1.0	0	0	0	0	0	0	0	0	0	2.50	17.42	1.47	0.94	0.55	0.66
- Post Ck.		24.5	0.3	0	0	0	0	0	0	0	0	0	0	0	0	1.55	11.32	0.91	0.58	0.34	0.41
- Paleface Ck.		38.2	3.2	5.9	3.5	0.4	0.2	0	0	0	0	0	0	0	0	2.40	16.85	1.42	0.91	0.53	0.63
- Depot Ck. (j)		78.0	2.4	2.1	4.1	0	0	0	0	0	0	0	0	0	0	4.92	32.06	2.90	1.85	1.08	1.30
- Lonzo Ck.	08MH080	26.0	0	0	0	0	0	18,000	601	0	1,110,500	9	144	102	59	1.31	9.40	0.61	0.67	0.53	0.95
- Kilgard Ck.	08MH096	2.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0.07	1.1	0.01	0.004	0.001	0.03
- Chilliwack Ck.	08MF061	78.4	0	0	0	0	0	19,300	1,357	0	1,517,043	0	271	176	81	1.85	9.00	0.52	0.47	0.41	0.69
- Atcheltz Ck.		20.4	0	0	0	0	0	0	263	0	10,000	0	37	19	1	0.48	2.68	0.14	0.12	0.11	0.18
- Luckaluck Ck.		8.1	0	0	0	0	0	500	317	0	1,500,500	0	123	101	79	0.19	1.16	0.05	0.05	0.04	0.07
- Semmihault Ck.		11.3	0	0	0	0	0	16,000	290	0	4,723	0	42	21	1	0.27	3.02	0.07	0.07	0.06	0.13
- Calkins Ck.		3.5	0	0	0	0	0	1,500	25	0	0	0	4	2	0	0.08	1.05	0.02	0.02	0.02	0.04
- Marblehill Ck.		2.8	0	0	0	0	0	11,500	46	0	1,000	0	7	4	1	0.07	0.85	0.02	0.02	0.01	0.03
- Hope Slough		100.3	0	0	0	0	0	6,050	1,788	4,700,000	162,315	0	504	380	256	2.24	21.57	0.77	0.80	0.58	1.00
- Elk Ck.	08MF048	33.7	0	0	0	0	0	3,500	1,038	3,000,000	161,000	0	312	239	167	1.15	7.23	0.49	0.50	0.36	0.47
- Ford Ck.		5.8	0	0	0	0	0	3,500	38	0	11,000	0	6	3	1	0.14	1.66	0.04	0.04	0.03	0.07
- Durville Ck.		19.0	0	0	0	0	0	2,550	90	1,700,000	200	0	102	96	90	0.45	4.83	0.12	0.12	0.09	0.22
- Nevin Ck.		5.8	0	0	0	0	0	1,000	32	1,000,000	0	0	57	55	53	0.14	1.65	0.04	0.04	0.03	0.07
- Camp Slough		15.5	0	0	0	0	0	850	658	0	0	0	92	46	0	0.37	4.01	0.10	0.10	0.08	0.18
- Wahleach Slough		28.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0.67	6.87	0.17	0.18	0.14	0.33
- Popcum Ck.		20.4	0	0	0	0	0	3,000	8	0	3,772,044	0	200	199	199	0.90	8.22	0.41	0.34	0.21	0.26
- Wahleach Ck.	08MF034	114.0	3.8	1.6	0	0	0	500	0	10,000	0	0	1	1	1	3.33	38.63	2.53	2.96	0.40	0.60
- Lorenzetta Ck.		11.0	0.6	0	0	0	0	150	0	0	8,898	0	0	0	0	0.48	4.71	0.22	0.18	0.11	0.14
- Hunter Ck.		41.6	4.0	2.7	0	0	1.4	3,000	0	9,000	0	0	1	1	1	1.83	15.58	0.84	0.68	0.42	0.53
- Silverhope Ck.	08MF009	328.0	13.2	1.2	1.2	0.0	4.8	11,000	15	26,000	0	0	4	3	2	14.40	100.0	6.63	5.38	3.33	4.19

- Gauge numbers in Column 2 indicate that flow characteristics were calculated from records at that gauge.
 - Total water licences for each salmon stream expressed in Imperial units, as provided by Water Management Branch.
 - Licenced demands (L/s) calculated from total water licences as described in Section 6 of the report.

- Logged areas calculated as described in Section 4 of the report.
 - Reference for all data in table is the mouth of the salmon stream.
 - Naturalized flows are estimates of those that would occur in the absence of all upstream water extractions.

Table 7, continued

Stream Name	WSC Gauge No.	Basin Area (mouth) (km ²)	Logged Area					Total Water Licenses					Licensed Demand (L/s)			Naturalized Flows in the Salmon Streams (m ³ /s)					
			Oldest (Pre 63) (km ²)	Older (63-72) (km ²)	Old (73-82) (km ²)	Recent (83-92) (km ²)	Proposed (93-97) (km ²)	Domestic (g/day)	Irrigation (ac-ft)	Water-works (g/day)	Industrial (g/day)	Conservation (cfs)	Aug	Sept	Feb	Mean Annual	Mean Flood	Mean Monthly		Mean 7-day Flow	
			Aug	Sept	Summer	Winter															
HATZIC SLOUGH																					
Hatzic Slough		82.0	0.6	0	2.3	3.0	0.2	45,300	834	0	4,432,696	0	353	294	236	3.93	37.7	1.09	1.20	0.82	1.54
- Draper Ck.		7.5	0	0	0	0	0.0	2,500	0	0	0	0	0	0	0	0.36	4.4	0.10	0.11	0.07	0.14
- Chiqua Slough		12.0	0.6	0	2.3	3.0	0.2	0	277	0	0	0	39	19	0	0.58	6.7	0.16	0.18	0.12	0.22
- Chiqua Ck.		1.9	0.1	0	0	0	0.2	0	159	0	0	0	22	11	0	0.09	1.2	0.02	0.03	0.02	0.03
- Kenworthy Ck.		6.9	0	0	0	0	0.4	13,300	0	0	0	0	1	1	1	0.33	4.1	0.09	0.10	0.07	0.13
- Bouchier Ck.		1.6	0	0	0	0	0	4,800	0	0	0	0	0	0	0	0.08	1.1	0.02	0.02	0.02	0.03
- Lagace Ck.		32.0	0	0	0	0	0	27,900	91	0	4,381,093	0	245	238	232	1.53	16.2	0.42	0.47	0.32	0.60
- Belcharton Ck.		5.6	0	0	0	0	0	4,000	1	0	2,761,746	0	146	146	146	0.27	3.4	0.07	0.08	0.06	0.10
- Scorey Ck.		1.9	0	0	0	0	0	1,000	0	0	0	0	0	0	0	0.09	1.2	0.02	0.03	0.02	0.03
Wades Ck.		9.2	0	0	0	0	0	4,000	125	3,500	0	0	18	9	0	0.22	2.52	0.06	0.06	0.05	0.11
NICOMEN SLOUGH																					
Nicomen Slough		180.8	4.4	0	0	0	5.1	13,300	376	8,473,425	10,100	0	500	473	447	15.65	110.0	4.53	6.96	2.38	5.94
- Norrish Ck.	08MH058	123.0	4.4	0	0	0	5.1	0	0	8,473,425	0	0	446	446	446	12.10	110.0	3.55	5.86	1.74	4.15
- Inches Ck.		0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.29	0.01	0.01	0.00	0.01
- Worth Ck.		0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.23	0.004	0.004	0.003	0.007
- Hawkins Ck.		0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.05	0.001	0.001	0.001	0.001
- Railway Ck.		0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.12	0.002	0.002	0.002	0.004
- Brousseau Ck.		5.0	0	0	0	0	0	13,000	267	20,000	10,100	0	40	21	2	0.49	6.2	0.14	0.24	0.07	0.17
- Deroche Ck.		9.8	0	0	0	0	0	2,500	5	20,000	0	0	2	2	1	0.96	11.3	0.28	0.47	0.14	0.33
- Pye Ck.		2.9	0	0	0	0	0	4,000	3	0	0	0	1	0	0	0.29	3.8	0.08	0.14	0.04	0.10
- Barnes Ck.		3.5	0	0	0	0	0	3,000	6	0	100	0	1	1	0	0.34	4.5	0.10	0.17	0.05	0.12
- Sidde Ck.		6.0	0	0	0	0	0	300	0	0	0	0	0	0	0	0.59	7.3	0.17	0.29	0.08	0.20
Sumas R. (a)	08MH029	643.6	4.3	0.3	0.0	0.0	0.3	182,850	7,351	419,500	1,213,402	148.8	1128	612	96	15.2	115	3.97	4.15	3.15	7.90

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- Gauge numbers in Column 2 indicate that flow characteristics were calculated from records at that gauge.
- Logged areas calculated as described in Section 4 of the report.
- Total water licences for each salmon stream expressed in Imperial units, as provided by Water Management Branch.
- Reference for all data in table is the mouth of the salmon stream.
- Licensed demands (L/s) calculated from total water licences as described in Section 6 of the report.
- Naturalized flows are estimates of those that would occur in the absence of all upstream water extractions.

Table 8: Urban Development in the Chilliwack/Lower Fraser HMA.

Stream Name	SSIS Number	Drainage Area (km ²)	%EIA (1)	EIA (km ²)	Urban Development				
					Low Density (km ²)	Medium Density (km ²)	High Density (km ²)	Multi-Family (km ²)	Commercial Industrial (km ²)
2 - Draper Ck.	00-0500-010	7.5	9.0%	0.667	3.298	0.415	0.293	0	0.499
26 - Street Ck.	00-0600-020-010	1.9	0.6%	0.011	0.282	0	0	0	0
27 - Hopedale Slough	00-0600-020-010-010	0.9	1.2%	0.011	0.282	0	0	0	0
28 - Barrett Ck.	00-0600-020-013	0.7	2.4%	0.015	0.335	0.02	0	0	0
29 - Peach Ck.	00-0600-020-015	1.2	1.4%	0.016	0.371	0.011	0	0	0
32 - Ryder Ck.	00-0600-020-050	26.0	0.2%	0.057	1.429	0	0	0	0
46 - Lonzo Ck.	00-0600-050	26.0	6.0%	1.559	0.307	0.638	1.749	0	1.264
47 - Kilgard Ck.	00-0600-050-010	2.8	2.9%	0.082	0	0.101	0	0	0.084
48 Chilliwack Ck.	00-0625	78.4	6.2%	4.857	4.778	0.763	6.881	0.853	3.038
49 - Atchelitz Ck.	00-0625-010	20.4	3.2%	0.646	0.636	0.004	0.865	0.059	0.459
50 - Luckakuck Ck.	00-0625-030	8.1	21.4%	1.724	0	0.129	2.491	0.516	1.041
51 - Semmihault Ck.	*	18.5	2.1%	0.387	1.679	0	0.766	0.097	0.114
52 - Calkins Ck.	00-0640-020-004	3.5	0.4%	0.014	0.35	0	0	0	0
53 - Marblehill Ck.	00-0640-020-004-800	2.8	0.5%	0.014	0.35	0	0	0	0
Shefford Slough	*	105.2	0.0%	0					
54 - Hope Slough	00-0640	100.3	2.4%	2.375	2.877	0.961	6.012	0.535	0.613
56 - Elk Ck.	00-0640-020	33.7	0.2%	0.072	0.851	0.36	0	0	0.002
57 - Ford Ck.	00-0640-020-020	5.8	0.0%	0	0	0	0	0	0
58 - Dunville Ck.	00-0640-030	19.0	0.2%	0.043	0.14	0.193	0	0	0.021
59 - Nevin Ck.	00-0640-030-005	5.8	0.2%	0.010	0.083	0.062	0	0	0
55 - Camp Slough	00-0640-010	15.5	0.8%	0.121	0.628	0.187	0.33	0	0.002

Table 9: Storage in the Salmon Streams of the Chilliwack/Lower Fraser HMA.

Stream Name	Basin Area (mouth) (km2)	Total Non-Power Storage (ac-ft)	Total Conservation Storage (ac-ft)	Total Irrigation Licences (ac-ft)	Percent with Storage (%)
HATZIC SLOUGH					
Hatzic Slough	82.0	0	0	834	0%
- Draper Ck.	7.5	0	0	0	0%
- Chilqua Slough	12.0	0	0	277	0%
- Chilqua Ck.	1.9	0	0	159	0%
- Kenworthy Ck.	6.9	0	0	0	0%
- Bouchier Ck.	1.6	0	0	0	0%
- Lagace Ck.	32.0	0	0	91	0%
- Belcharton Ck.	5.6	0	0	1	0%
- Scorey Ck.	1.9	0	0	0	0%
Wades Ck.	9.2	0	0	125	0%
NICOMEN SLOUGH					
Nicomen Slough	180.8	12,890	0	376	0%
- Norrish Ck.	123.0	12,890	0	0	0%
- Inches Ck.	0.8	0	0	0	0%
- Worth Ck.	0.6	0	0	0	0%
- Hawkins Ck.	0.1	0	0	0	0%
- Railway Ck.	0.3	0	0	0	0%
- Brousseau Ck.	5.0	0	0	267	0%
- Deroche Ck.	9.8	0	0	5	0%
- Pye Ck.	2.9	0	0	3	0%
- Barnes Ck.	3.5	0	0	6	0%
- Siddle Ck.	6.0	0	0	0	0%
Sumas R. (a)	330.0	2	326	8,018	0%
CHILLIWACK RIVER					
- Chilliwack R. (lower) (b)	1260.0	2	0	667	0%
- Chilliwack R. (upper) (c)	617.0	0	0	190	0%
- Salwein Ck.	0.3	0	0	0	0%
- Hopedale Slough	0.9	0	0	0	0%
- Street Ck.	1.9	2	0	26	8%
- Barrett Ck.	0.7	0	0	4	0%
- Peach Ck.	1.2	0	0	0	0%
- Sweltzer R. (d)	134.3	0	0	288	0%
- Ljumchen Ck. (e)	64.4	0	0	0	0%
- Ryder Ck.	8.9	0	0	39	0%
- Little Tamihl Ck.	5.3	0	0	0	0%
- Tamihl Ck. (f)	123.0	0	0	277	0%
- Thurston Ck.	3.8	0	0	0	0%
- Borden Ck.	17.3	0	0	4	0%
- Slesse Ck. (g)	166.0	0	0	0	0%
- Foley Ck.	77.7	0	0	0	0%
- Nesakwatch Ck. (h)	56.4	0	0	0	0%
- Fourteen Mile Ck.	2.4	0	0	0	0%
- Fifteen Mile Ck.	1.7	0	0	0	0%
- Center Ck. (i)	39.6	0	0	0	0%
- Post Ck.	24.5	0	0	0	0%
- Paleface Ck.	38.2	0	0	0	0%
- Depot Ck. (j)	58.0	0	0	0	0%
- Lonzo Ck.	26.0	0	1	601	0%
- Kilgard Ck.	2.8	0	0	0	0%
Chilliwack Ck.	78.4	0	0	1,357	0%
- Atchelitz Ck.	20.4	0	0	263	0%
- Luckakuck Ck.	8.1	0	0	317	0%
- Semmihault Ck.	18.5	0	0	290	0%
- Calkins Ck.	3.5	0	0	25	0%
- Marblehill Ck.	2.8	0	0	46	0%
- Hope Slough	100.3	15	0	1,768	0%
- Elk Ck.	33.7	0	0	1,038	0%
- Ford Ck.	5.8	0	0	38	0%
- Dunville Ck.	19.0	0	0	90	0%
- Nevin Ck.	5.8	0	0	32	0%
- Camp Slough	15.5	0	0	658	0%
Wahleach Slough	28.2	0	0	0	0%
Popcum Ck.	20.4	0	455	8	0%
Wahleach Ck.	114.0	0	0	0	0%
Lorenzetta Ck.	11.0	0	0	0	0%
Hunter Ck.	41.6	0	0	0	0%
Silverhope Ck.	328.0	0	0	15	0%

- Nonpower includes all storage for domestic, waterworks, industrial, and irrigation licences. Conservation licences are not included in the nonpower totals.
 - Irrigation licences for each salmon stream are from Table 7.
 - Percent with storage calculated by dividing nonpower storage by total irrigation licences for each stream.

Table 10: Sensitivity Indices -- Chilliwack/Lower Fraser HMA

Stream Name	Status	SUMMER WATER USE				LOW FLOWS		PEAK FLOWS	LOGGING		
		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	Index 10 Recent & Proposed
CHILLIWACK RIVER											
- Chilliwack R. (lower) (b)		1%	1%	1%	1%	27%	39%	5	0%	5%	1%
- Chilliwack R. (upper) (c)		0%	0%	0%	0%	27%	33%	6	0%	29%	1%
- Salwein Ck.		0%	0%	0%	0%	21%	49%	16	0%	0%	0%
- Street Ck.		41%	21%	32%	16%	16%	49%	14	0%	0%	0%
- Hopedale Slough		0%	0%	0%	0%	21%	49%	15	0%	0%	10%
- Barrett Ck.		20%	11%	16%	9%	18%	49%	15	0%	0%	0%
- Peach Ck.		0%	0%	0%	0%	21%	49%	14	0%	0%	0%
- Sweitzer R. (d)		4%	3%	2%	2%	27%	36%	7	0%	0%	0%
- Llumchen Ck. (e)		1%	1%	1%	1%	22%	26%	7	0%	1%	1%
- Ryder Ck.		5%	3%	2%	2%	21%	26%	8	0%	0%	0%
- Little Tamihl Ck.		0%	0%	0%	0%	22%	26%	9	0%	48%	0%
- Tamihl Ck. (f)		3%	2%	1%	1%	22%	26%	6	0%	11%	1%
- Thurston Ck.		0%	0%	0%	0%	34%	9%	5	0%	0%	0%
- Borden Ck.		0%	0%	0%	0%	22%	26%	7	0%	31%	2%
- Slesse Ck. (g)		0%	0%	0%	0%	22%	26%	6	0%	3%	0%
- Foley Ck.		0%	0%	0%	0%	22%	26%	7	0%	16%	2%
- Nesakwach Ck. (h)		0%	0%	0%	0%	22%	26%	7	0%	18%	2%
- Fourteen Mile Ck.		0%	0%	0%	0%	22%	26%	9	0%	0%	0%
- Fifteen Mile Ck.		0%	0%	0%	0%	22%	26%	10	0%	0%	0%
- Center Ck. (i)		0%	0%	0%	0%	22%	26%	7	2%	18%	2%
- Post Ck.		0%	0%	0%	0%	22%	26%	7	0%	1%	0%
- Paleface Ck.		0%	0%	0%	0%	22%	26%	7	1%	34%	1%
- Depot Ck. (j)		0%	0%	0%	0%	22%	26%	7	0%	11%	0%
- Lonzo Ck.		27%	19%	24%	15%	32%	68%	7	0%	0%	0%
- Kilgard Ck.		0%	0%	0%	0%	1%	37%	16	0%	0%	0%
Chilliwack Ck.											
- Chilliwack Ck.		67%	43%	52%	37%	12%	33%	5	0%	0%	0%
- Atcheltz Ck.		35%	18%	28%	15%	18%	37%	6	0%	0%	0%
- Luckakuck Ck.		296%	242%	230%	209%	0%	0%	6	0%	0%	0%
- Semmihault Ck.		46%	24%	37%	18%	13%	49%	11	0%	0%	0%
- Calkins Ck.		21%	11%	17%	8%	19%	49%	13	0%	0%	0%
- Marblehill Ck.		52%	29%	42%	22%	15%	48%	13	0%	0%	0%
- Hope Slough		87%	65%	65%	46%	9%	33%	10	0%	0%	0%
- Elk Ck.		87%	67%	64%	48%	10%	26%	6	0%	0%	0%
- Ford Ck.		21%	12%	17%	9%	18%	49%	12	0%	0%	0%
- Dunville Ck.		110%	103%	87%	78%	0%	29%	11	0%	0%	0%
- Nevin Ck.		202%	194%	160%	147%	0%	11%	12	0%	0%	0%
- Camp Slough		122%	61%	97%	46%	8%	49%	11	0%	0%	0%
Wahleach Slough											
- Wahleach Slough		0%	0%	0%	0%	21%	49%	10	0%	0%	0%
- Popcum Ck.		96%	96%	48%	69%	0%	7%	9	0%	0%	0%
Wahleach Ck.											
- Wahleach Ck.		0%	0%	0%	0%	12%	18%	12	0%	5%	0%
- Lorenzetta Ck.		0%	0%	0%	0%	23%	29%	10	0%	5%	0%
- Hunter Ck.		0%	0%	0%	0%	23%	29%	9	0%	16%	3%
- Silverhope Ck.		0%	0%	0%	0%	23%	29%	7	0%	5%	1%

-Status refers to restrictions noted by the Water Management Branch: FR, fully recorded with exceptions for storage; OR, office reserve, 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 Sept are mean August and September monthly flows;
 QAA is mean annual flow; Q2 is the mean annual flood; Recent, Total and Proposed are logged areas. Basin is basin area above the mouth
 -Indices expressed as percentages except 7, which is a direct ratio.

Table 10, continued

Stream Name	Status	SUMMER WATER USE				LOW FLOWS		PEAK FLOWS	LOGGING		
		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	Index 10 Recent & Proposed
HATZIC SLOUGH											
Hatzic Slough		43%	36%	32%	25%	0%	x	10	4%	7%	4%
- Draper Ck.		0%	0%	0%	0%	21%	39%	12	0%	0%	0%
- Chiqua Slough		32%	16%	25%	11%	18%	39%	12	28%	50%	26%
- Chiqua Ck.		120%	60%	91%	41%	8%	39%	14	0%	4%	9%
- Kerworthy Ck.		1%	1%	1%	1%	21%	39%	12	0%	0%	6%
- Boucher Ck.		2%	2%	1%	1%	21%	39%	14	0%	0%	0%
- Lagace Ck.		76%	74%	58%	61%	8%	0%	11	0%	0%	0%
- Belcharton Ck.		259%	269%	197%	178%	0%	0%	13	0%	0%	0%
- Scorey Ck.		0%	0%	0%	0%	21%	39%	14	0%	0%	0%
Wades Ck.		40%	20%	31%	15%	17%	49%	12	0%	0%	0%
NICOMEN SLOUGH											
Nicomen Slough		21%	20%	11%	7%	12%	35%	7	0%	2%	3%
- Norrish Ck.		26%	26%	13%	8%	11%	31%	9	0%	4%	4%
- Inches Ck.		0%	0%	0%	0%	21%	49%	15	0%	0%	0%
- Worth Ck.		0%	0%	0%	0%	21%	49%	15	0%	0%	0%
- Hawkins Ck.		0%	0%	0%	0%	21%	49%	18	0%	0%	0%
- Railway Ck.		0%	0%	0%	0%	21%	49%	16	0%	0%	0%
- Brousseau Ck.		66%	30%	27%	8%	10%	34%	13	0%	0%	0%
- Deroche Ck.		1%	1%	1%	0%	14%	34%	12	0%	0%	0%
- Pye Ck.		2%	1%	1%	0%	14%	34%	13	0%	0%	0%
- Barnes Ck.		2%	1%	1%	0%	14%	34%	13	0%	0%	0%
- Siddle Ck.		0%	0%	0%	0%	14%	34%	12	0%	0%	0%
Sumas R. (a)		36%	19%	28%	15%	17%	51%	8	0%	1%	0%

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-Status refers to restrictions noted by the Water Management Branch: FR, fully recorded with exceptions for storage; OR, office reserve, 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 Sept are mean August and September monthly flows; QAA is mean annual flow; Q2 is the mean annual flood; Recent, Total and Proposed are logged areas. Basin is basin area above the mouth.
 -Indices expressed as percentages except 7, which is a direct ratio.

Table 11: Most Sensitive Streams -- Chilliwack/Lower Fraser HMA

<i>Water Demand</i>	<i>Summer Low Flows</i>	<i>Winter Low Flows</i>	<i>Urbanization</i>	<i>Forest Harvesting</i>
<i>1 to 4</i>	<i>5</i>	<i>6</i>	<i>Table 8</i>	<i>8 to 10</i>
Hatzic Slough	Hatzic Slough	Hatzic Slough	Luckakuck Ck	Chilqua Slough
Chilqua Ck	Chilqua Ck	Lagace Ck		Little Tamahi Ck
Lagace Ck	Lagace Ck	Belcharton Ck		Borden Ck
Belcharton Ck	Belcharton Ck	Luckakuck Ck		Paleface Ck
Brousseau Ck	Nicomen Slough	Elk Ck		
Sumas R.	Norrish Ck.	Nevin Ck		
Street Ck	Brousseau Ck.	Popcum Ck		
Chilliwack Ck	Kilgard Ck.	Wahleach Ck		
Luckakuck Ck	Sumas R.	tributaries to upper		
MarbleHill Ck	Chilliwack Ck.	Chilliwack River		
Hope Slough	Luckakuck Ck			
Elk Creek	Hope Slough			
Dunville Ck.	Elk Creek			
Nevin Ck.	Dunville Ck.			
Camp Slough	Nevin Ck.			
Popcum Ck.	Camp Slough			
	Popcum Ck.			
	Wahleach Ck.			

FIGURES

Figure 1: Fraser River Habitat Management Areas

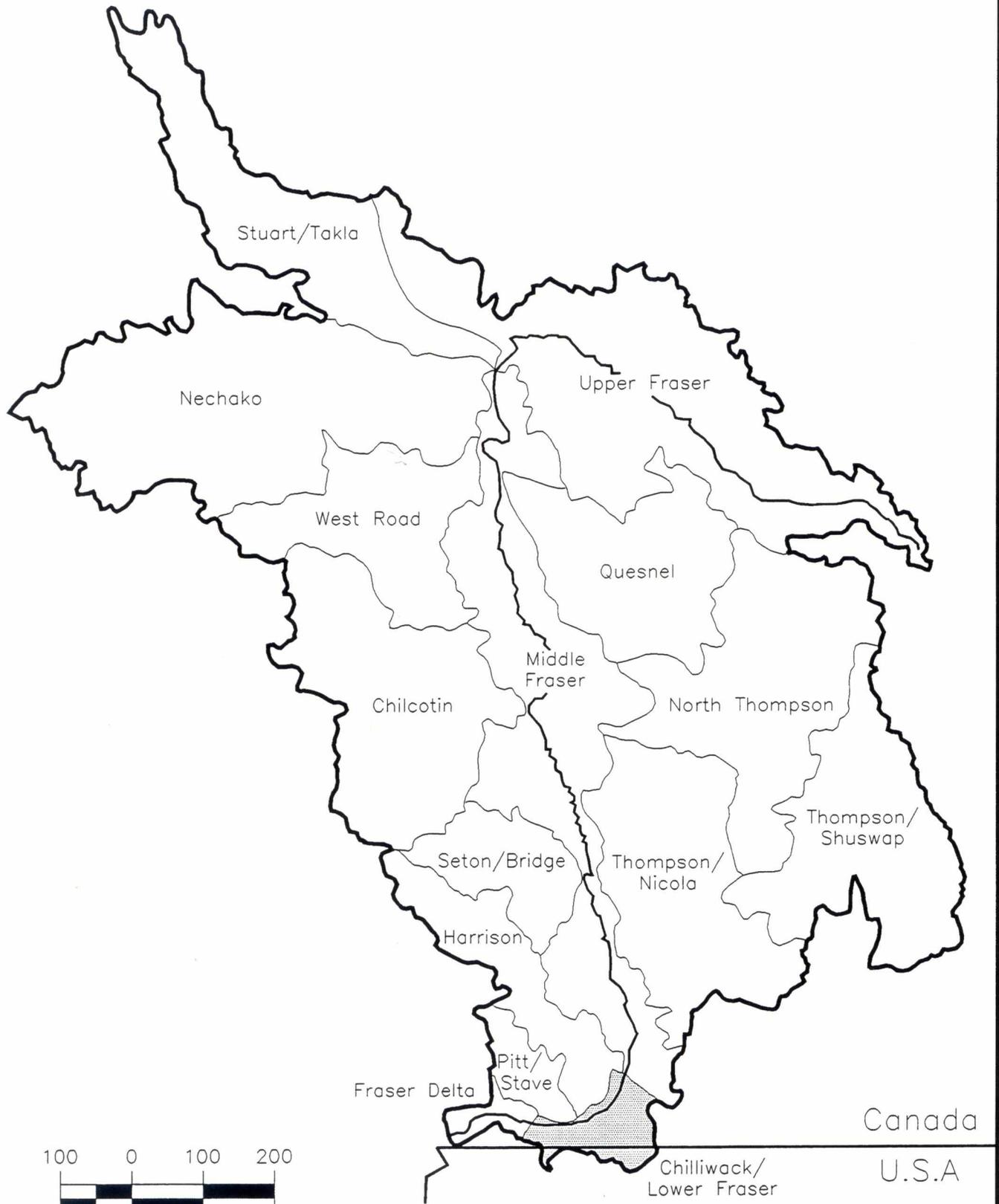


Figure 2a: Salmon Streams in the Chilliwack/Lower Fraser HMA

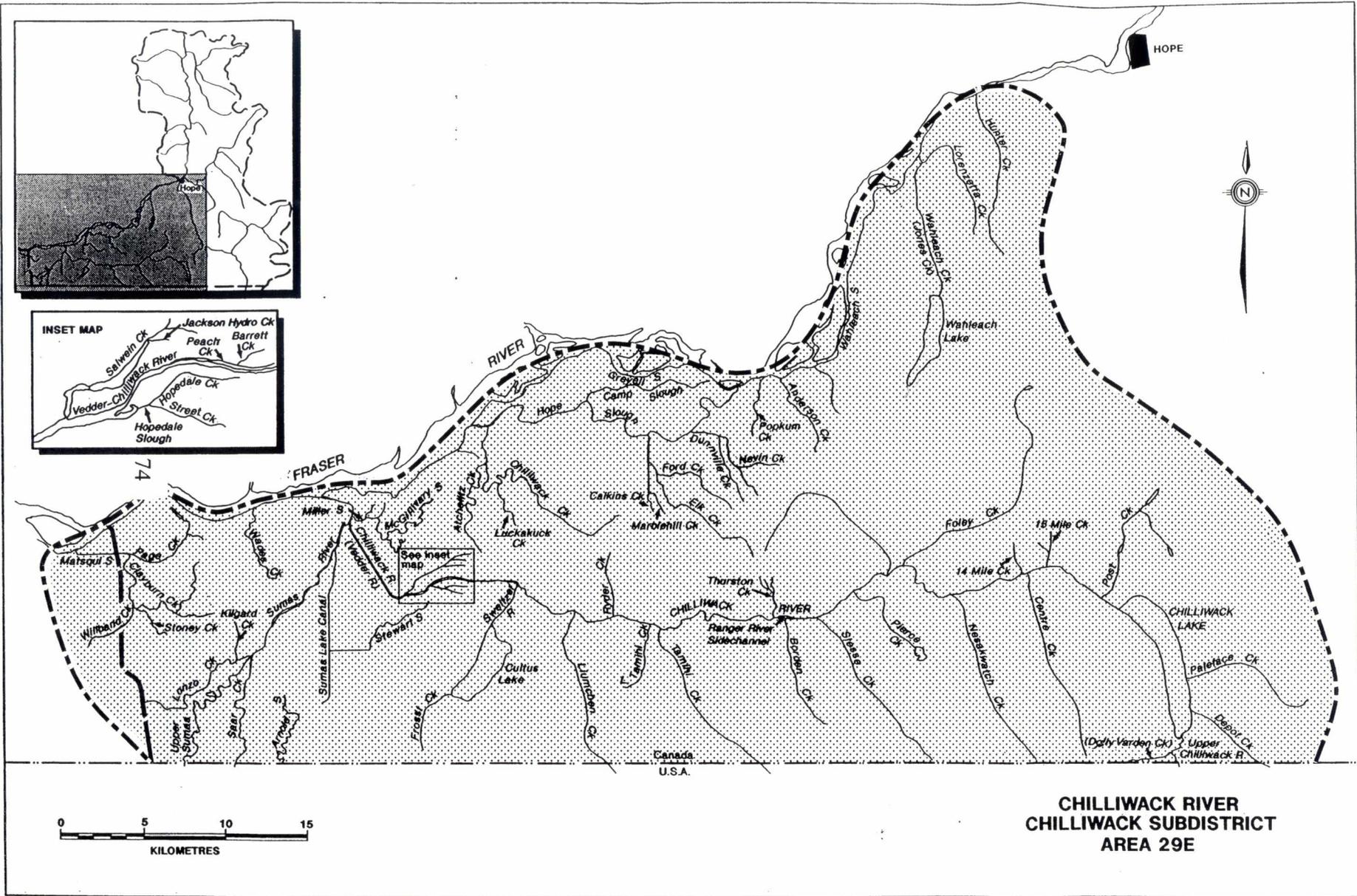


Figure 2c: Salmon Streams in the Chilliwack/Lower Fraser HMA

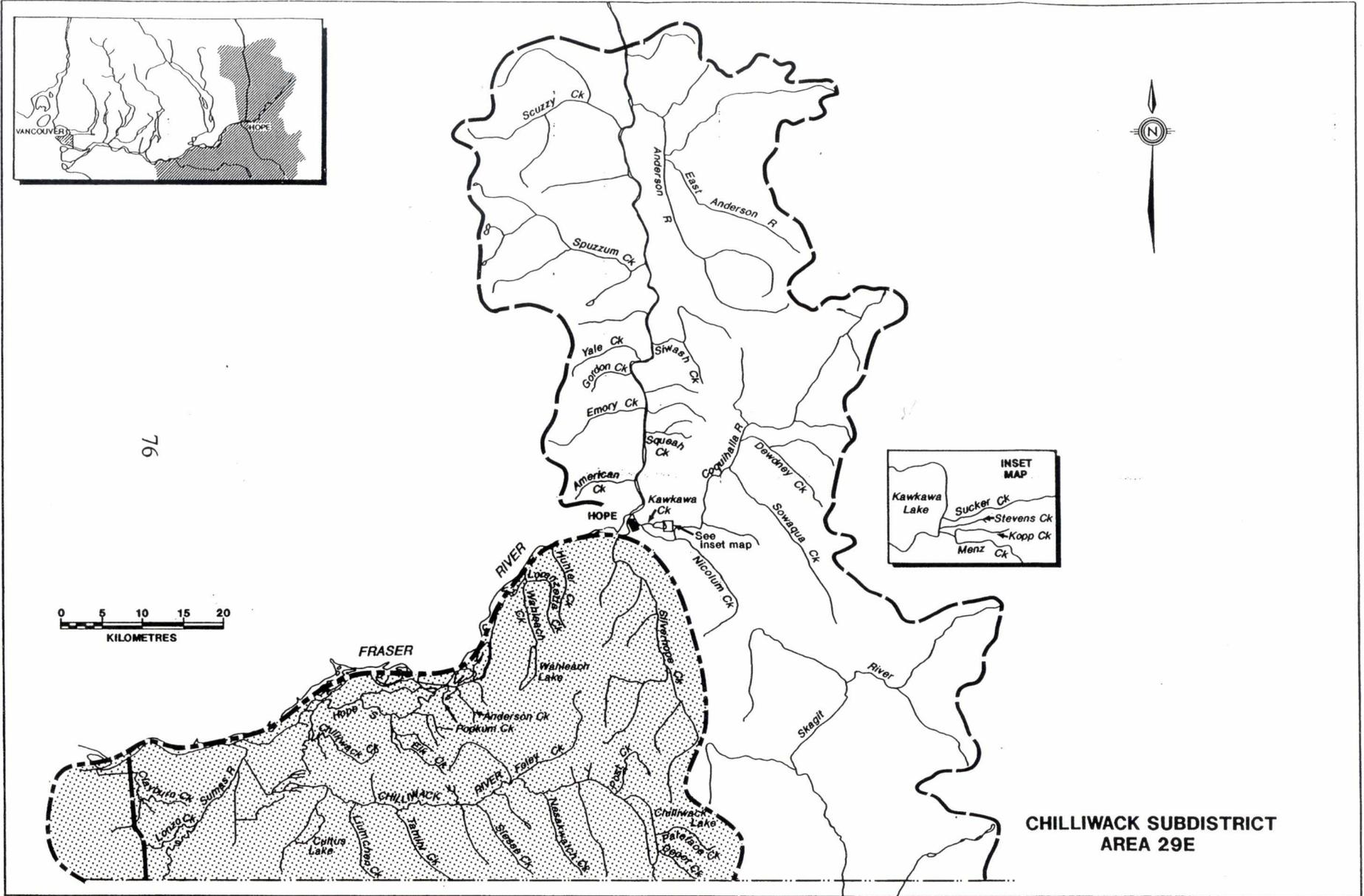
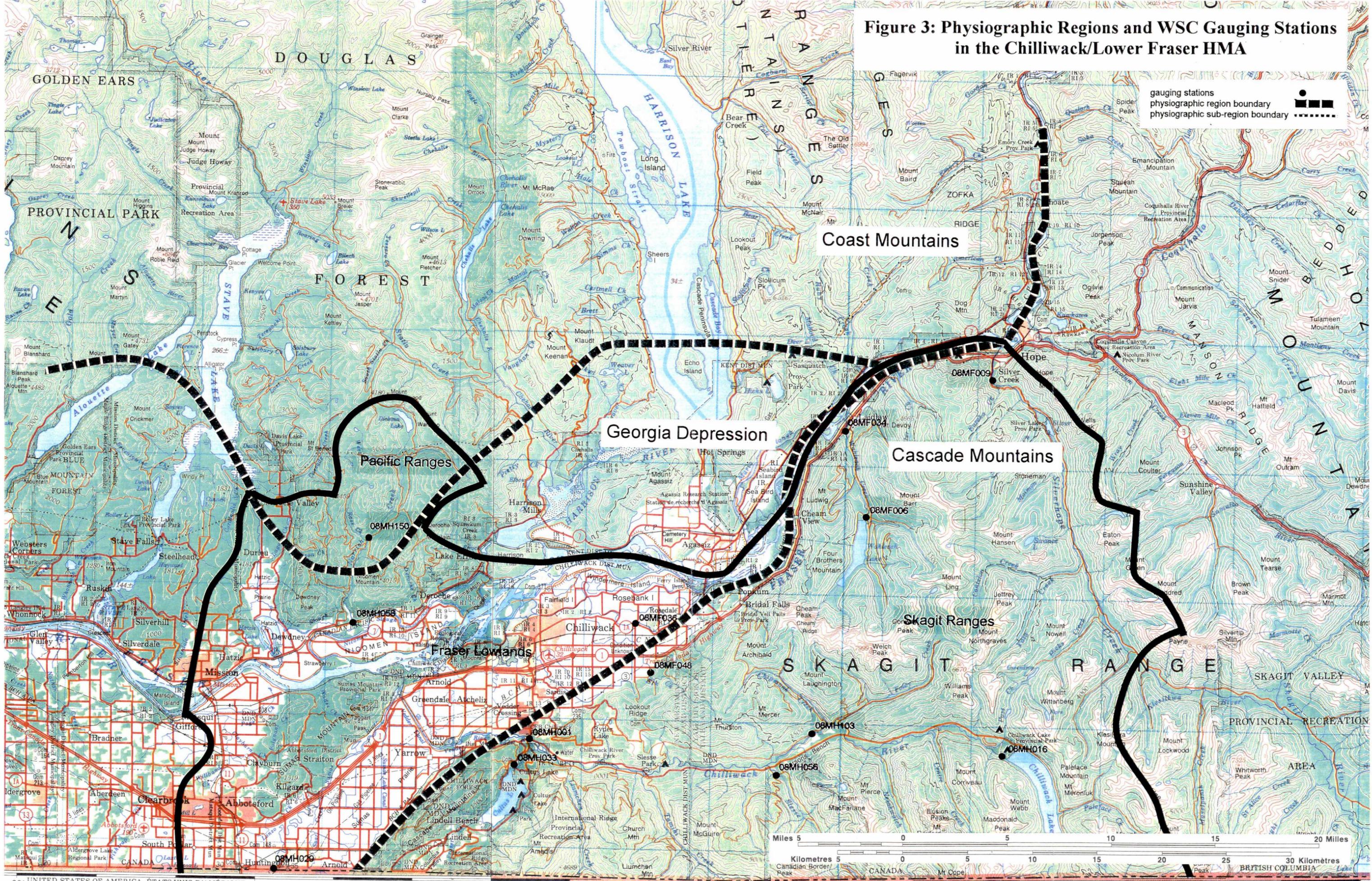


Figure 3: Physiographic Regions and WSC Gauging Stations in the Chilliwack/Lower Fraser HMA



gauging stations
 physiographic region boundary
 physiographic sub-region boundary

Coast Mountains

Georgia Depression

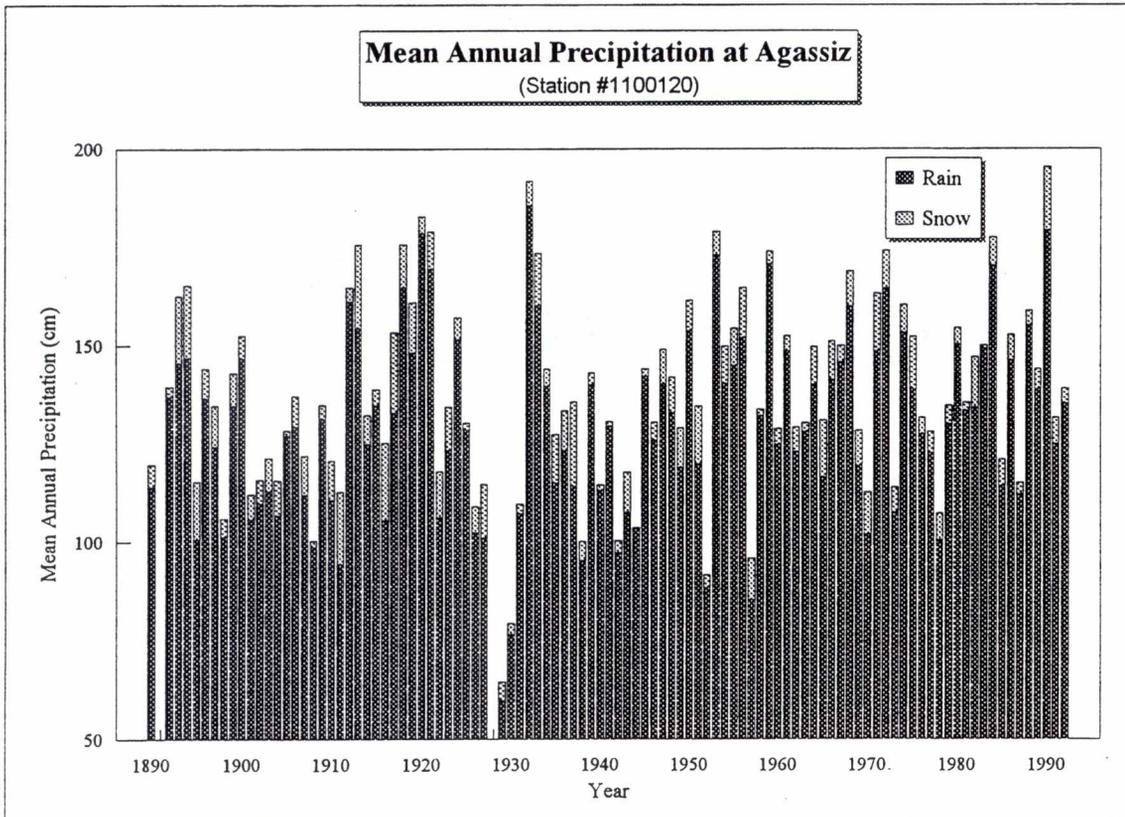
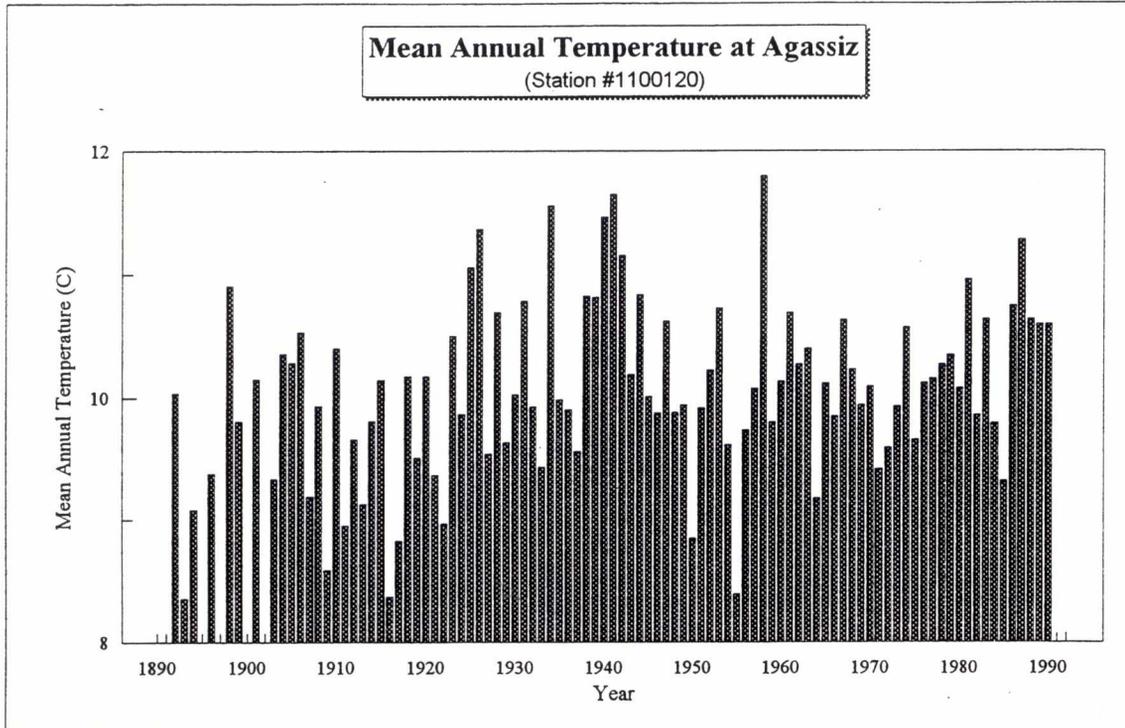
Cascade Mountains

Pacific Ranges

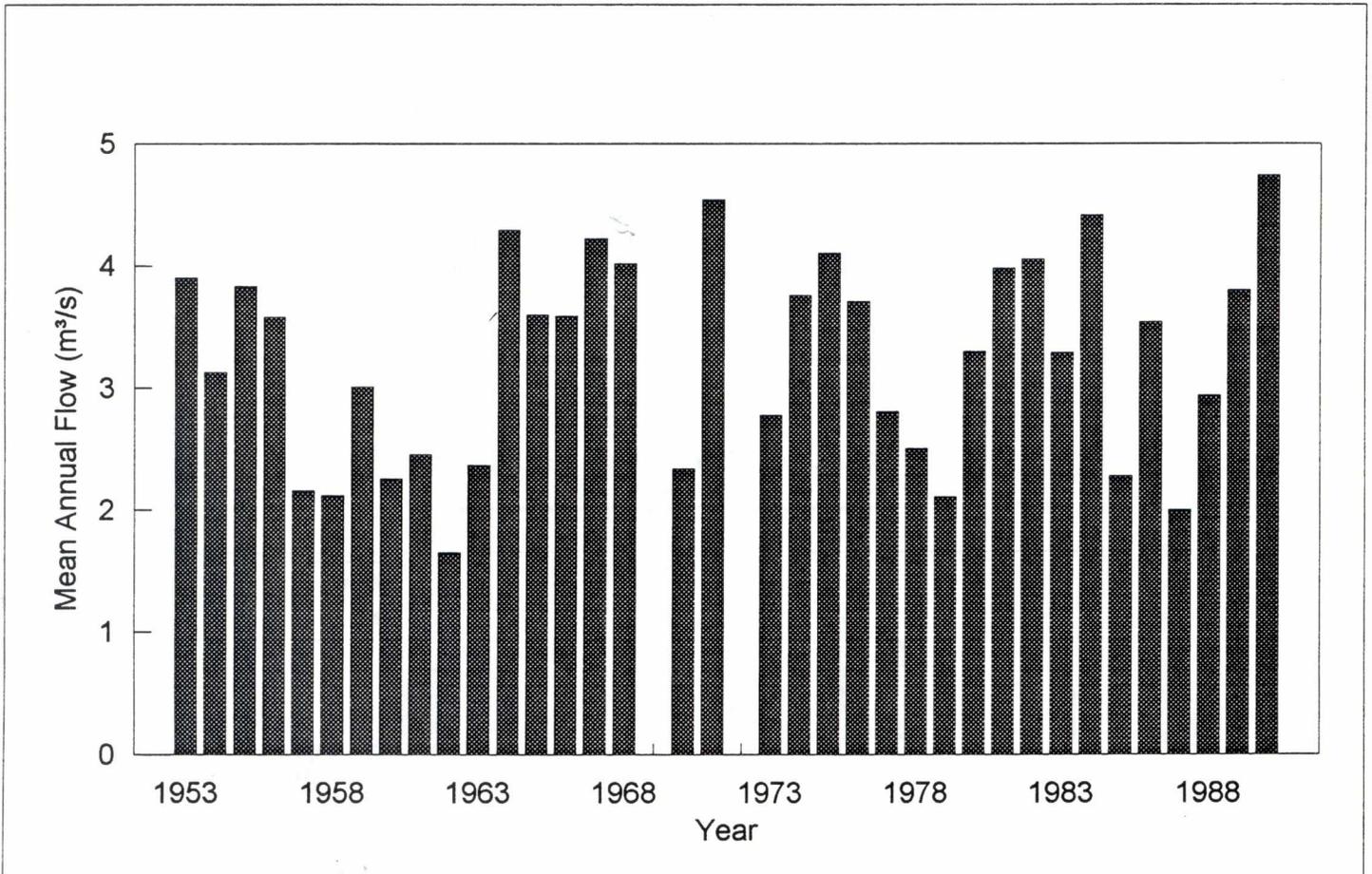
Skagit Ranges

Fraser Lowlands

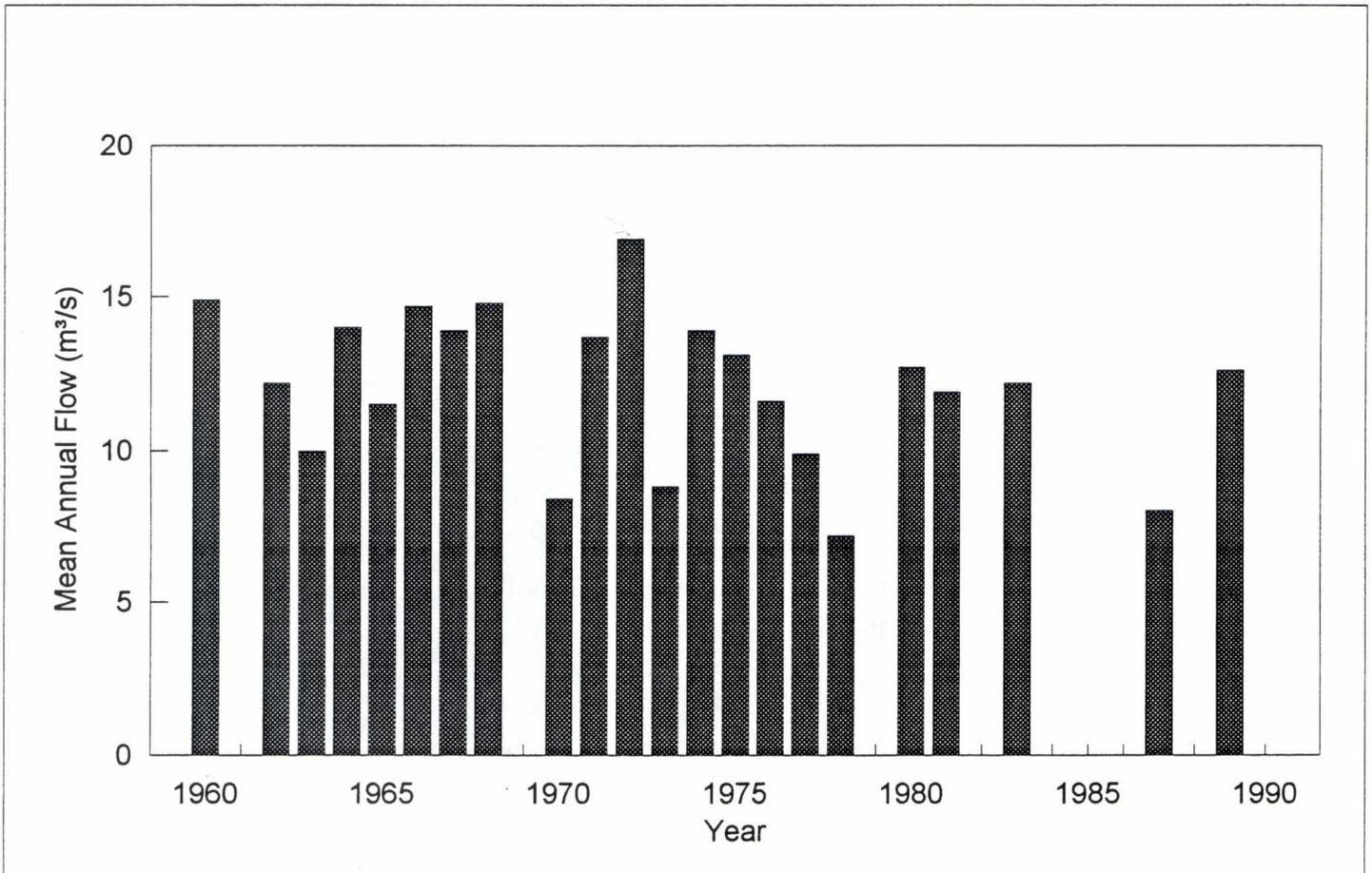
Figure 4: Long-Term Temperature and Precipitation Trends at Agassiz



**Figure 5a: Long-Term Variation in Discharge:
Sumas River Near Huntingdon**



**Figure 5b: Long-Term Variation in Discharge:
Norrish Creek Near Dewdney**



**Figure 5c: Long-Term Variation in Discharge:
Slesse Creek Near Vedder Crossing**

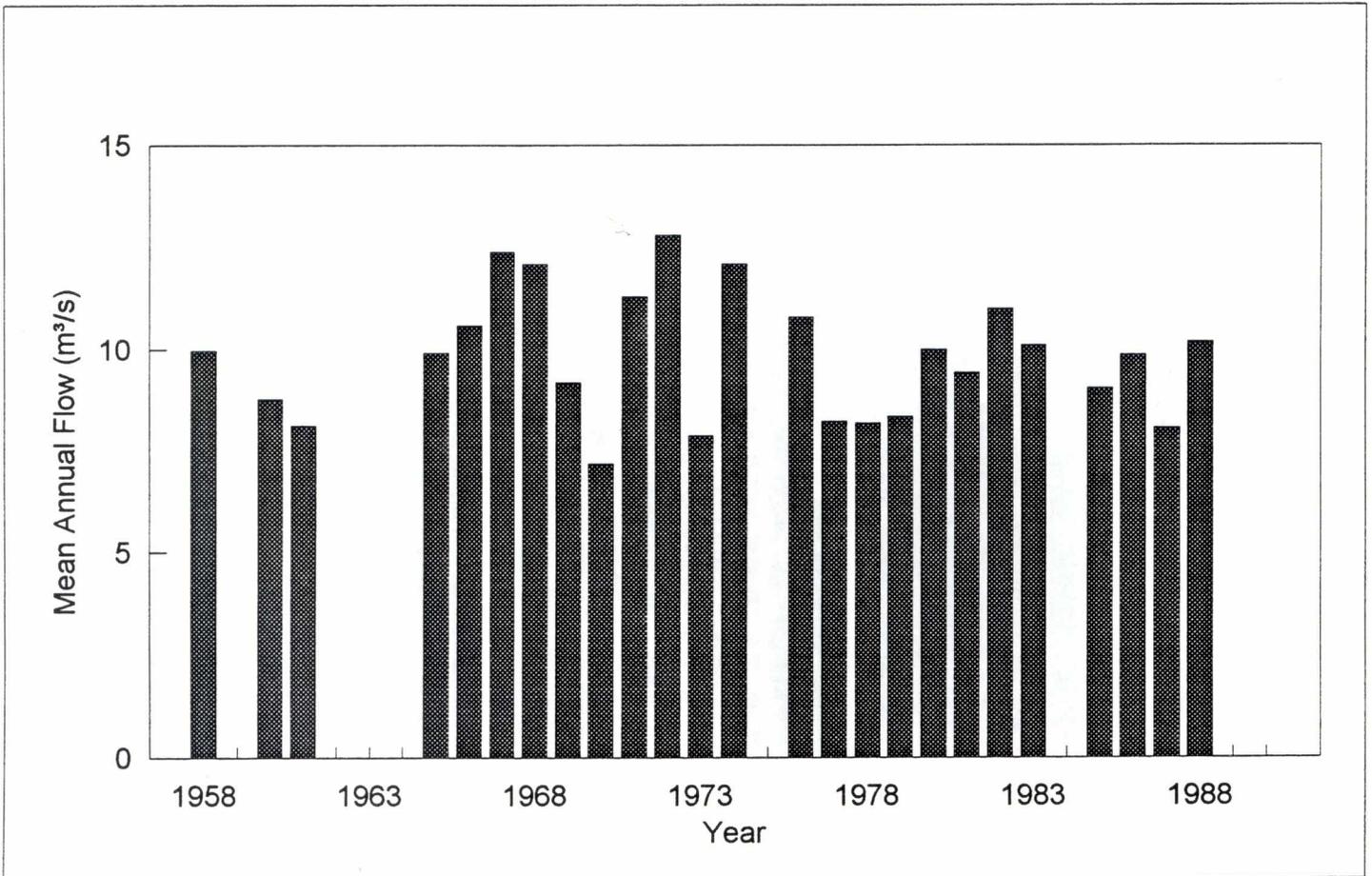
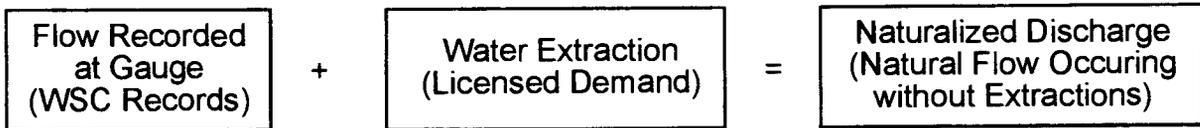


Figure 6: Calculation of Natural and Naturalized Flows for the Salmon Streams

GAUGED STREAMS



UNGAUGED STREAMS

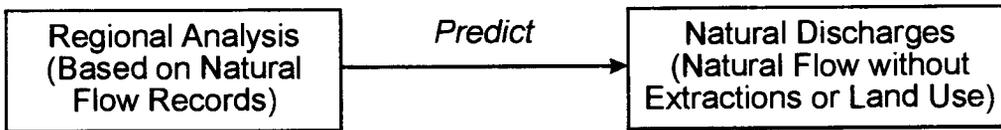


FIGURE 7: Classification of British Columbia Water Licences

No.	USE CLASS	DESCRIPTION (uses included)	UNITS
CONSUMPTIVE			
1	Waterworks	- conveyed by local authority (municipality, regional or improvement district) - conveyed by others (individual, utility, Indian band)	gallons/day gallons/year
2	Domestic use		gallons/day
3	Pulpmills		cubic feet/second
4	Industrial	- processing (sawmills, food, manufacturing, etc.) - cooling - enterprise (hotels, motels, restaurants, etc.) - ponds - watering - bottling for sale - commercial bulk export - mineral water sold in containers and used in bathing pools - all other industrial uses	any
5	Irrigation	- conveyed by local authority (municipal) - private agricultural use	acre-feet
6	Land improvement	e.g. draining property, creating ponds	any
7	Mining	- hydraulic, washing coal, processing ore, placer	any
NON-CONSUMPTIVE			
8	Power generation	- residential, commercial, general	cubic feet/second
9	Storage - nonpower		acre-feet
10	Storage - power		acre-feet
11	Conservation	- storage (e.g. waterfowl habitat enhancement) - use of water (e.g. hatchery) - construction of works in and around a stream (e.g. fish culture, fish ponds, personal)	any

APPENDIX A

MEASURING STREAM FLOW AT THE MOUTHS OF UNGAUGED SALMON STREAMS

A. ESTIMATING FLOWS AT THE MOUTHS OF UNGAUGED SALMON STREAMS

Most of the salmon streams have been gauged by the Water Survey of Canada at one time or another but only Norrish Creek, Chilliwack River (upper and lower), and Slesse Creek met the requirements for gauged salmon streams, as they have Water Survey of Canada stations operating near their mouths and (nearly) continuous records from 1981 to 1990. Very few of the groundwater influent streams and few of the smaller salmon streams have been gauged.

The hydrologic characteristics of the other salmon streams were estimated by adjusting and transferring Water Survey of Canada gauging records to the mouth of the stream, by transferring records from nearby gauges or by adjusting older records. Precipitation varies rapidly with elevation and there are too few gauging stations in, or around, the HMA to develop regression equations relating flow characteristics to basin characteristics for the different hydrologic regions. The following sections describe the procedures used to estimate flows at the mouth of each of the salmon streams. It was necessary to rely on older, incomplete records in order to obtain as accurate as possible a picture of the hydrologic characteristics of the streams.

The Hatzic Prairie Streams. A few of the streams have seasonal records from the early 1960's and the salmon streams are expected to have annual runoff of around 1,500 to 2,000 mm. Mean annual discharge, mean flood, mean August and September flow and summer and winter 7 day low flows were calculated and naturalized for the Silverdale Creek near Mission (08MH091) gauge, which is a nearby station with roughly similar annual runoff in the Pitt/Stave HMA. Flow characteristics were transferred to the Hatzic Valley streams based on the drainage area ratio $(A_u/A_g)^n$; where A_u is the drainage area of the ungauged stream, A_g is the drainage area of the gauged stream and n is equal to 0.9 for mean floods and 1.0 for all other flow characteristics.

Norrish, Brousseau, Deroche, Pye, Barnes, and Siddle Creeks. These streams drain the low hills on the south face of the Coast Mountains, where maximum elevations are about 1,200 m. Norrish is a larger watershed that extends further into the Coast Mountains and may have higher runoff. Mean annual discharge, mean flood, mean August and September flow and summer and winter 7 day low flows were calculated for the Norrish River near Dewdney (08MH058) gauge. Flow characteristics were transferred to the other streams based on the drainage area ratio $(A_u/A_g)^n$; where A_u is the drainage area of the ungauged stream, A_g is the drainage area of the gauged stream and n is equal to 0.9 for mean floods and 1.0 for all other flow characteristics.

Norrish Creek Fan. Inches, Worth, Hawkins and Railway Creeks are old channels of Norrish Creek whose flows are sustained by groundwater inflows. Groundwater pumped to the Inches Creek Hatchery is discharged to Inches Creek and maintains a moderately high constant flow in this creek. There are no flow measurements on these creeks and, as a result, it is very difficult to estimate their flow characteristics. We have transferred characteristics from Sumas River (see below) based on the drainage area ratio $(A_u/A_g)^n$; where A_u is the drainage area at the creek, A_g is the drainage area at the Sumas River gauge and n is equal to 0.9 for mean floods and 1.0 for all other flow characteristics. This is expected to underestimate flows in these streams.

Sumas Prairie. The Sumas River is assumed to be representative of the hydrologic regime of salmon streams in the Fraser Lowlands. Flow characteristics were calculated for the "Sumas River near Huntingdon, 08MH029" gauge for 1981 to 1990. Flow characteristics were adjusted to the mouth of the river based on the drainage area ratio $(A_u/A_g)^n$; where A_u is the drainage area at the mouth, A_g is the drainage area at the gauge and n is equal to 0.9 for mean floods and 1.0 for all other flow characteristics. Flows at the mouth of Lonzo Creek were estimated by transferring the flow characteristics from the Sumas River, based on the ratio of drainage areas, and adding the flows measured at "Lonzo Creek near Abbotsford, 08MH080" which measured groundwater inflows to the upper watershed from the Abbotsford aquifer. September flows and summer and winter 7 day lows for Kilgard Creek were calculated from the seasonal records at "Lonzo Creek (north fork) near Kilgard, 08MH079"; others were estimated by transferring flow characteristics from the Sumas River gauge.

The flow characteristics at the Sumas River gauge were also transferred to Salwein Creek, Hopedale Slough, Street Creek, Barrett Creek, Peach Creek, Calkins Creek, Marbehill Creek, Hope Slough, Elk Creek, Ford Creek, Dunville Creek, Nevin Creek, Camp Slough, Wahleach Slough, Wades Creek and the groundwater tributaries on the Norrish Creek fan. The transfer was based on the drainage area ratio $(A_u/A_g)^n$; where A_u is the drainage area of the ungauged stream, A_g is the drainage area of the gauged stream and n is equal to 0.9 for mean floods and 1.0 for all other flow characteristics.

Sweltzer Creek. Flow characteristics were calculated by transferring the flow characteristics of the Sumas River to the watershed downstream of Cultus Lake and adding the flows measured at the outlet at the "Sweltzer River at Cultus Lake, 08MH033" gauge. Mean annual flood was adjusted to the mouth by the drainage area ratio $(A_u/A_g)^n$; where A_u is the area at the mouth, A_g is the drainage area at the gauge and n is equal to 0.9. The older records were adjusted to 1981 to 1990 with the Chilliwack at Vedder Crossing gauge. The adjustment consisted of determining the ratio of the flow characteristic over the gauging period, and over 1981-1990, at the Chilliwack River gauge and applying the ratio of the two to the Sweltzer Creek record.

Liumchem Creek. Flow characteristics were calculated at the "Liumchem Creek near the mouth, 08MH157" gauge and adjusted to the 1981 to 1990 base period with the records collected at the Slesse Creek gauge. The adjustment consisted of determining the ratio of the flow characteristic over the gauging period, and over 1981-1990, at the Slesse Creek gauge and applying the ratio of the two to the Liumchen Creek record.

Chilliwack River Tributaries. Flow characteristics were calculated for the "Slesse Creek near Vedder Crossing, 08MH056" gauge and transferred to the other streams based on the drainage area ratio $(A_u/A_g)^n$; where A_u is the drainage area of the ungauged stream, A_g is the drainage area of the gauged stream and n is equal to 0.9 for mean floods and 1.0 for all other flow characteristics.

Chilliwack Creek and Tributaries. Flow characteristics were calculated from the "Chilliwack Creek near Chilliwack, 08MF061" gauge. Mean annual flow was transferred from the Sumas River record. The flows were adjusted to the other streams based on the drainage area ratio $(A_u/A_g)^n$; where A_u is the drainage area of the ungauged stream, A_g is the drainage area of the gauged stream and n is equal to 0.9 for mean floods and 1.0 for all other flow characteristics.

Elk Creek. Flow characteristics were calculated for the "Elk River at Prairie Central Road, 08MF048" gauge and adjusted for upstream diversion for waterworks to create naturalized flows. These flow characteristics were then adjusted to 1981 to 1990 with the Slesse Creek gauge. The flows from the lower watershed were estimated by transfer from the Sumas River gauge and were added to the naturalized flows at the Elk Creek gauge.

Popcum, Wahleach, Lorenzetta, Hunter and Silverhope Creeks. Flow characteristics were calculated for the "Wahleach Creek near Laidlaw (lower station), 08MF034" (post-1952) and "Silverhope Creek near Hope, 08MF009" gauges. The flow characteristics were adjusted to 1981 to 1990 with the Slesse Creek gauge. The Wahleach represent flows from the watershed downstream of Wahleach Dam as well as releases from the dam in the 1960's and 1970's.

The flow characteristics for Silverhope Creek were transferred to the other streams based on the drainage area ratio $(A_u/A_g)^n$; where A_u is the drainage area of the ungauged stream, A_g is the drainage area of the gauged stream and n is equal to 0.9 for mean floods and 1.0 for all other flow characteristics.

APPENDIX B

STREAM SUMMARIES

B. STREAM SUMMARIES

A two page summary has been prepared for each salmon stream. Those streams with six or more complete years of records at a gauge have a detailed summary of hydrology, as described in Section 3 of the main text. Those salmon streams with limited or no gauging records have a less detailed summary.

The stream summary consists of 5 main elements each of which is explained in detail in the following sections. Some of the information is abridged.

B.1 Licensed Water Demand

Total licensed demand above the Water Survey of Canada gauge on the stream, or above the mouth for ungauged streams, are given in the units currently used by the Water Rights Branch. The monthly demand is calculated from the licensed amounts for the three characteristic months of February, August and September and is quoted in litres per second (L/s). The final separate row at the bottom of the table is the mean monthly flow of the stream during the three characteristics months.

B.2 Mean Annual Hydrograph

The mean annual hydrograph is an average of the flow recorded on each day for all complete years of record. In order to provide a smooth hydrograph a nine day running average of the daily values was incorporated. For comparative purposes, the vertical scale is the same for all streams. The mean annual flow is included in a box on the hydrograph; this, together with the percent values on the vertical axis, allows estimation of the flows for various times of the year.

For ungauged streams, the mean annual hydrograph is transferred from a hydrologically-similar, nearby stream.

B.3 Sensitivity Indices

As described in the main text, each index is a ratio or percentage. For example, Index 1 is the ratio of the August water use to the Mean summer 7 day low flow. Index 3 is similar to Index 1 except that it shows the ratio of August water use to the mean August flow.

The bar graphs show how the indices for the stream compare with the indices for the other salmon streams in the HMA. (Streams included for logging analysis only are not used in calculating the sensitivity indices.) For example, if Index 7 is above the median it indicates that peak flows are more severe than average, relative to the other streams.

The bar graph provides a visual summary of the relative sensitivity of the stream to various land and water uses and is incorporated for both the gauged and ungauged streams.

B.4 7 Day Low Flows

Distribution, by month, of 7 Day Low Flow. This bar graph shows the months of the year when the annual 7 day low flow (the lowest consecutive 7 day flow in a calendar year) has

occurred. The height of the bar shows the percentage of annual 7 day low flows that have occurred in that month.

The bar graph may not provide a good indication of the distribution of annual 7 day low flows if there are only a few years of record at the gauging station. No distribution is provided for the ungauged streams.

7 Day Low Flow Frequency Curve

The frequency curve shows an Extreme Value Type III (Gumbel) Distribution fit to the annual 7 day low flows recorded at the gauging station. The curve shows the predicted annual 7 day low flow, in m^3/s , for return periods up to about 100 years. Note that the confidence in the estimated flow at a given return period depends on the length of record available at the gauging station. For streams with only a few years of record (as shown by the number of data points) the curve is an approximation. Also note that estimates beyond about 50 years are only approximate even when there is ten or twenty years of record. No distribution is produced for the ungauged streams.

Annual daily floods and 7 day low flows, for various return periods, are given in a common table.

B.5 Summary Notes and Recommendations

This section provides an abbreviated summary of important activities in the basin, together with suggestions and recommendations where these can be provided.

HATZIC SLOUGH

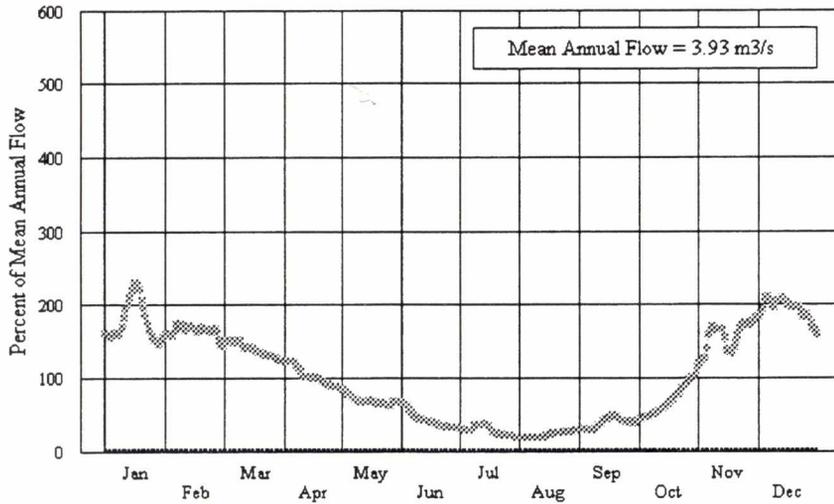
LICENSED WATER DEMAND

Stream number 00-0500
 Ungauged
 Tributary to Fraser River
 Drainage Area = 82.0 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	45,300 g/d	2.4	2.4	2.4
Irrigation	834 ac.ft.		115.2	59.5
Waterworks	0 g/d			
Industrial	4432696g/d	233	233	233
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			1,090	1,200

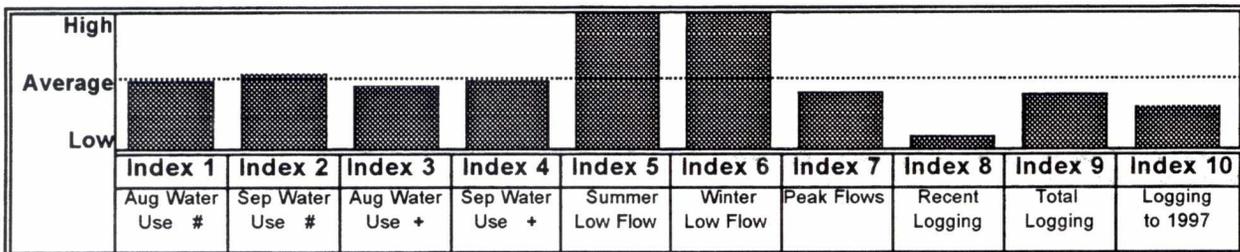
MEAN ANNUAL HYDROGRAPH

(Estimated, using Silverdale Creek Station 08MH091)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow
 + Water use as a proportion of the mean monthly flow for the same month

HATZIC SLOUGH

SUMMARY NOTES AND RECOMMENDATIONS

1. Hatzic Prairie, through which Hatzic Slough flows, is an agricultural area where the main impact on aquatic productivity results from ditching of streams, subsequent clearing and maintenance, removal of riparian vegetation, and the use of herbicides and pesticides.

DRAPER CREEK

LICENSED WATER DEMAND

Stream number 00-0500-010

Ungauged

Tributary to Hatzic Lake

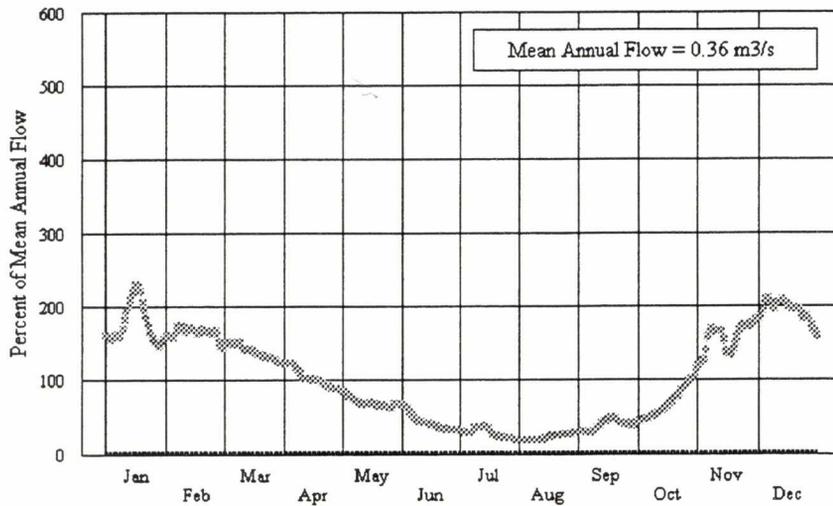
Drainage Area = 7.5 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	2,500 g/d	0.13	0.13	0.13
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

	Feb	Aug	Sep
MEAN STREAM FLOW L/S		100	110

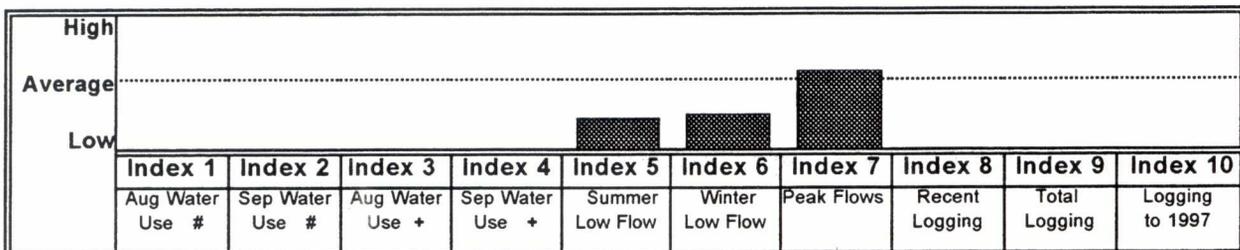
MEAN ANNUAL HYDROGRAPH

(Estimated, using Silverdale Creek Station 08MH091)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

DRAPER CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. The upper reaches of Draper Creek (which flows into Hatzic Lake) are in Mission and are being urbanized. As Mission does not have a requirement for on-site detention for suburban developments, storm drainage may eventually cause problems.

CHILQUA SLOUGH

LICENSED WATER DEMAND

Stream number 00-0500-020

Ungauged

Tributary to Hatzic Lake

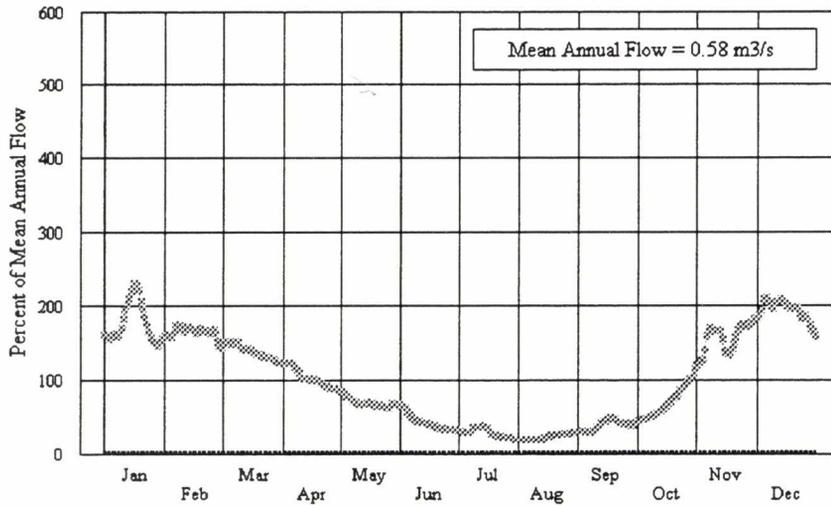
Drainage Area = 12.0 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	277 ac.ft.		38.3	19.8
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

	Feb	Aug	Sep
MEAN STREAM FLOW L/S		160	180

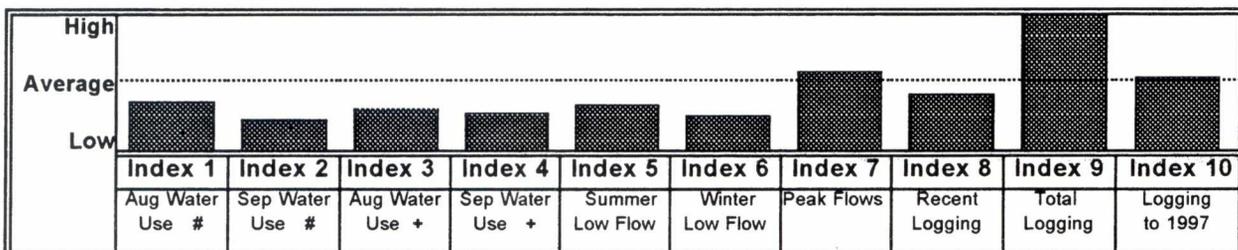
MEAN ANNUAL HYDROGRAPH

(Estimated, using Silverdale Creek Station 08MH091)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

CHILQUA SLOUGH

SUMMARY NOTES AND RECOMMENDATIONS

- 1. Much of the drainage area of Chilqua Slough is farmland, but summer water use is rated as being below average.*
- 2. The B.C. Ministry of Environment is concerned that Norrish Creek could shift channels and travel down Chilqua Slough to Hatzic Prairie.*
- 3. Logging activity has been very high. Fifty percent of the watershed area has been logged.*

CHILQUA CREEK

LICENSED WATER DEMAND

Stream number 00-0500-020-020

Ungauged

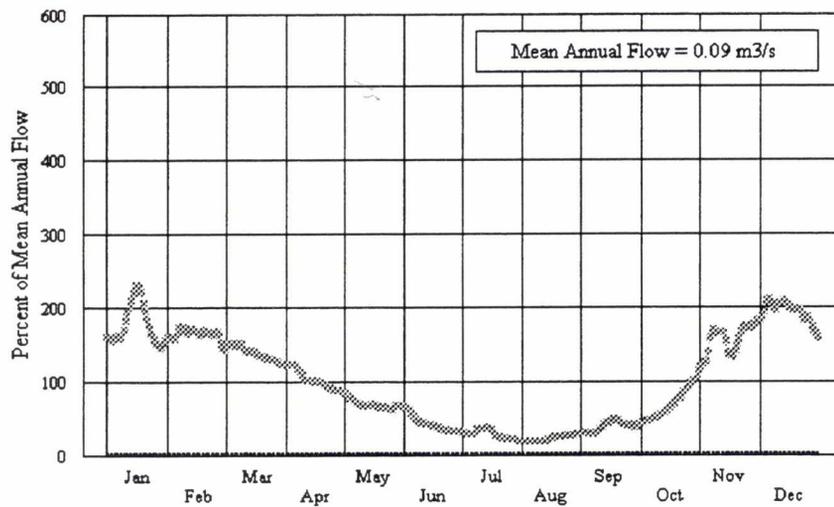
Tributary to Chilqua Slough

Drainage Area = 1.9 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	159 ac.ft.		22.0	11.4
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			20	30

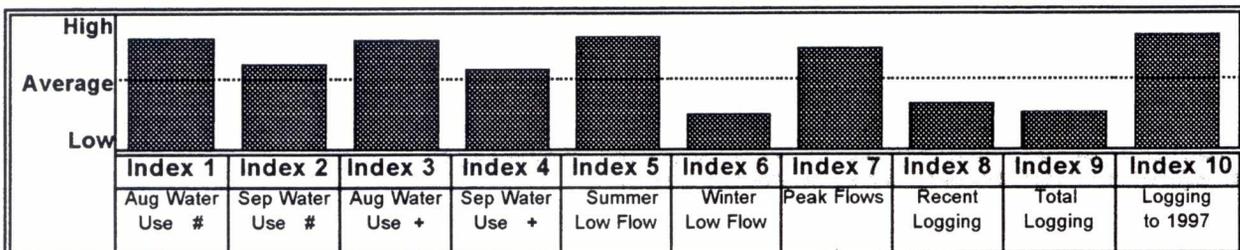
MEAN ANNUAL HYDROGRAPH

(Estimated, using Silverdale Creek Station 08MH091)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

CHILQUA CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Chilqua Creek flows into Chilqua Slough. Much of the drainage area of Chilqua Creek is farmland and summer water use is high: potential August use is about 120% of the average summer 7-day low flow.

2. The north branch of Chilqua Creek flows in a drainage ditch for most of its 1.5 kilometre length. The Stream Summary Catalogue recommends excavation of pools, bank stabilization and gravel placement.

KENWORTHY CREEK

LICENSED WATER DEMAND

Stream number 00-0500-050

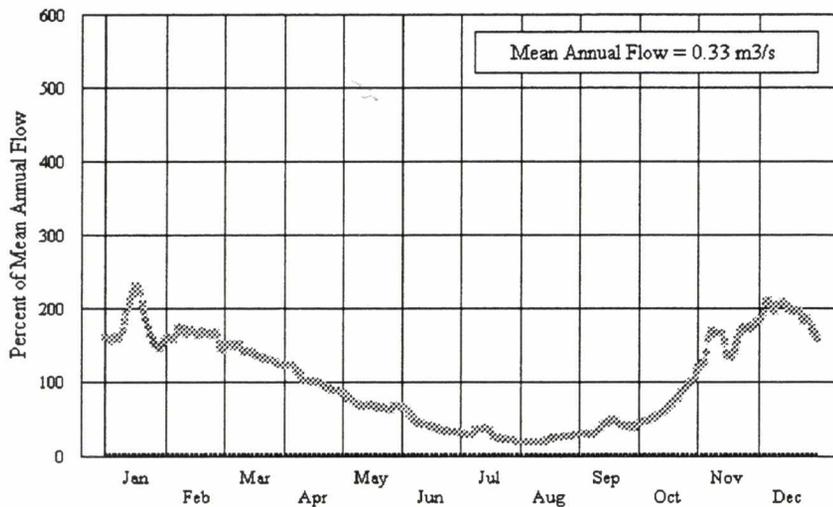
Tributary to Hatzic Slough

Drainage Area = 6.9 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	13,300 g/d	0.70	0.70	0.70
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			90	100

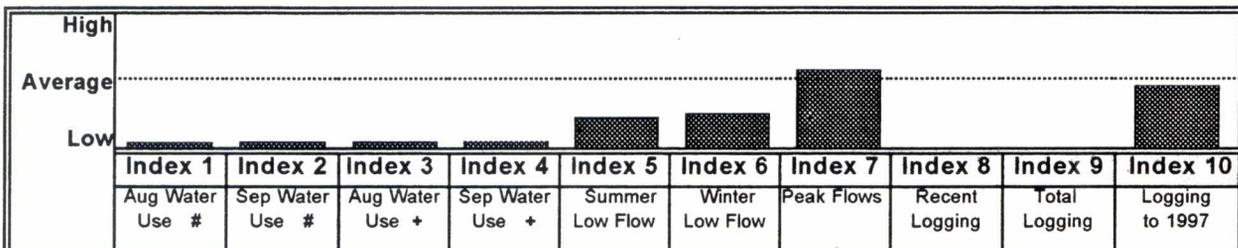
MEAN ANNUAL HYDROGRAPH

(Estimated, using Silverdale Creek Station 08MH091)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

KENWORTHY CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Kenworthy Creek is a tributary to Hatzic Slough. Little is known about the creek, although a debris flow was recorded in the early 1980's.

2. Logging of about 6% of the watershed is being proposed in the 5-year plan.

BOUCHIER CREEK

LICENSED WATER DEMAND

Stream number 00-0500-060-010

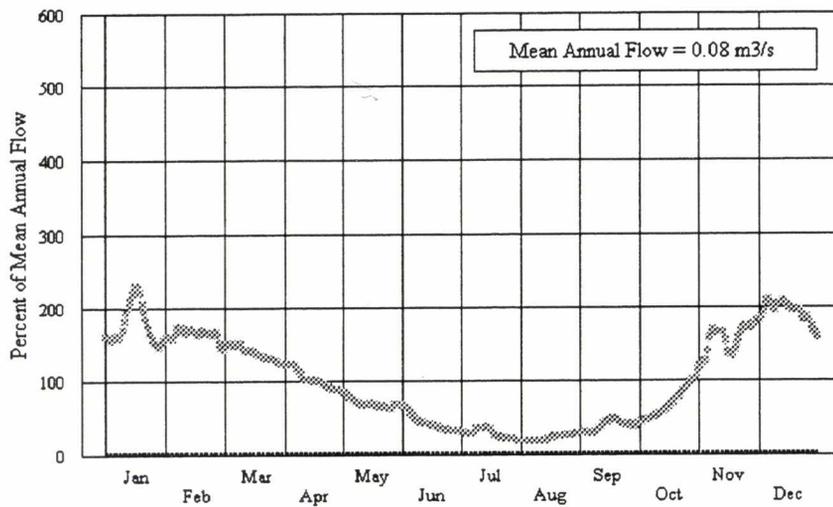
Tributary to Kenworthy Creek

Drainage Area = 1.6 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	4,800 g/d	0.25	0.25	0.25
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			20	20

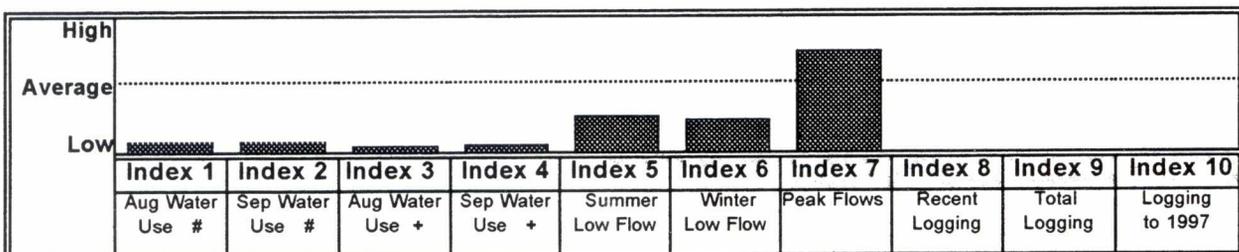
MEAN ANNUAL HYDROGRAPH

(Estimated, using Silverdale Creek Station 08MH091)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

BOUCHIER CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Bouchier Creek is a tributary to Kenworthy Creek. Little is known about the creek, although a debris flow has been recorded. Peak flows are higher than average.

LAGACE CREEK

LICENSED WATER DEMAND

Stream number 00-0500-060

Tributary to Hatzic Slough

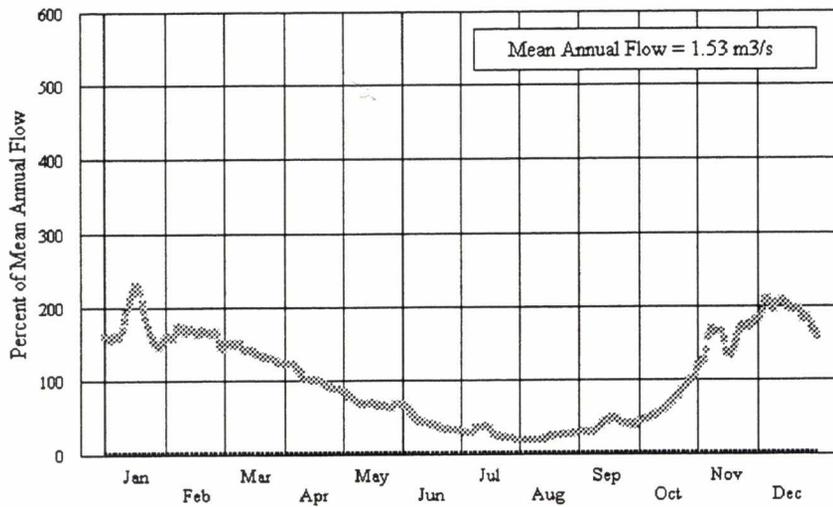
Drainage Area = 32.0 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	27,900 g/d	0.25	0.25	0.25
Irrigation	91 ac.ft.		12.6	6.5
Waterworks	0 g/d			
Industrial	4,381,093g/d	230.5	230.5	230.5
Conservation	0 cfs			

	Feb	Aug	Sep
MEAN STREAM FLOW L/S		420	470

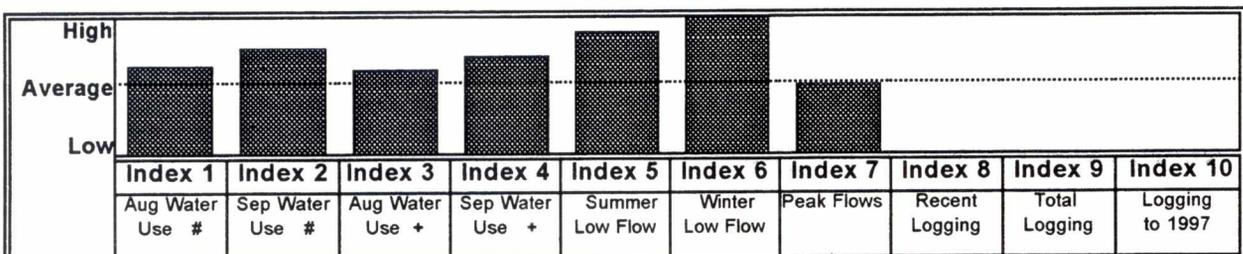
MEAN ANNUAL HYDROGRAPH

(Estimated, using Silverdale Creek Station 08MH091)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

LAGACE CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Debris torrents in Patterson Creek, a tributary of Lagace Creek, has resulted in large amounts of sediment being transported downstream and deposited in Lagace Creek. This has led to channel aggradation and widening, resulting in loss of low flows into the substrate. Several alternatives for managing sediment, including settling basins, have been recommended by a consultant, but they have not yet been implemented.

BELCHARTON CREEK

LICENSED WATER DEMAND

Stream number 00-0500-060-010-010

Ungauged

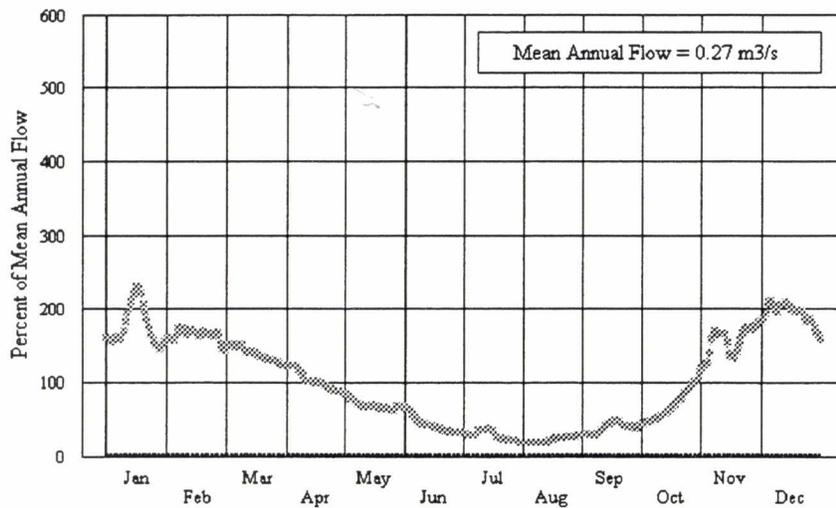
Tributary to Lagace Creek

Drainage Area = 5.6 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	4,000 g/d	0.21	0.21	0.21
Irrigation	1 ac.ft.		0.14	0.071
Waterworks	0 g/d			
Industrial	2,761,746g/d	145.3	145.3	145.3
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			70	80

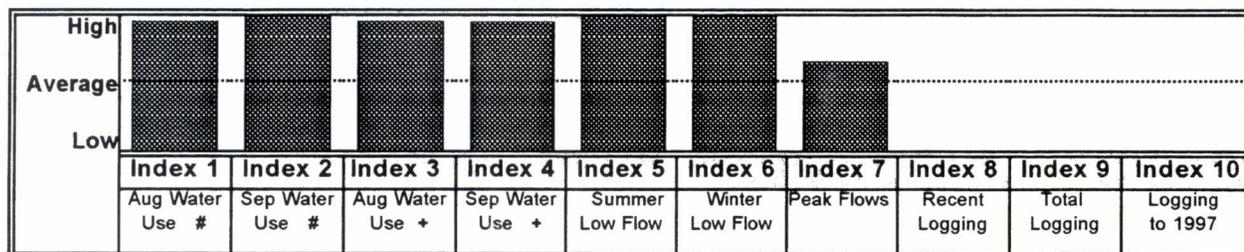
MEAN ANNUAL HYDROGRAPH

(Estimated, using Silverdale Creek Station 08MH091)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

BELCHARTON CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Summer water use is rated as extreme: industrial water licences on Belcharton Creek amount to about 200 % of the mean August flow!

SCOREY CREEK

LICENSED WATER DEMAND

Stream number 00-0500-080

Ungauged

Tributary to Hatzic Slough

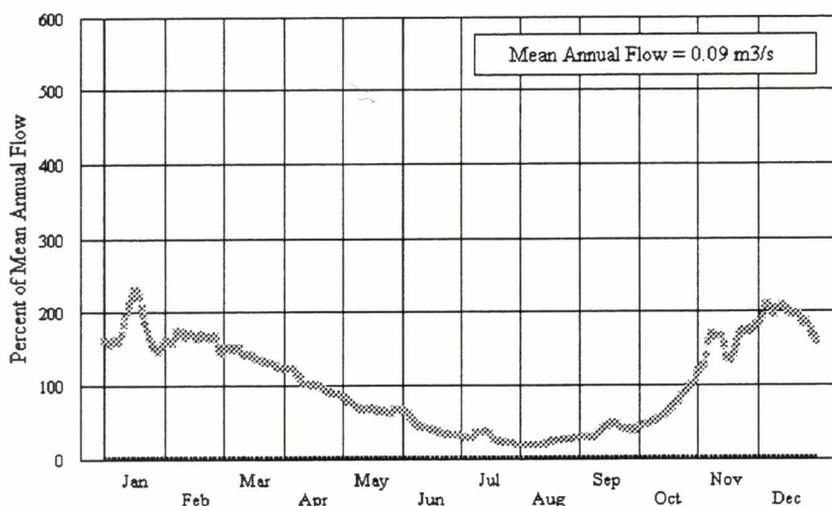
Drainage Area = 1.9 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	1,000 g/d	0.05	0.05	0.05
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

	Feb	Aug	Sep
MEAN STREAM FLOW L/S		20	30

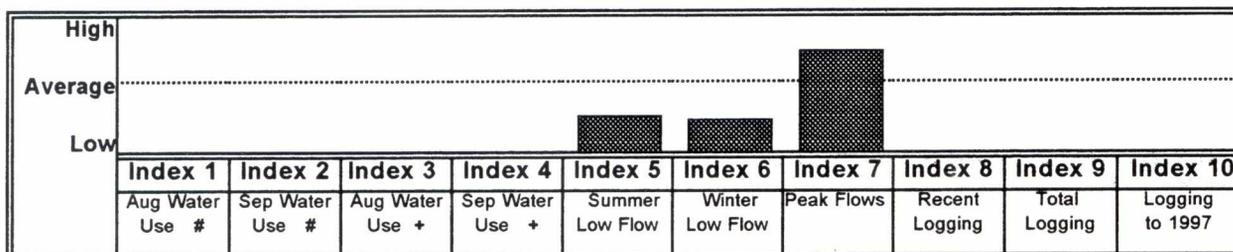
MEAN ANNUAL HYDROGRAPH

(Estimated, using Silverdale Creek Station 08MH091)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

SCOREY CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Scorey Creek is a tributary to Hatzic Slough. Little is known about the creek, although it has a large fan with urban development and gravel has been removed from the channel to prevent flooding.

WADES CREEK

LICENSED WATER DEMAND

Stream number 00-0550
 Ungauged
 Tributary to the Fraser River

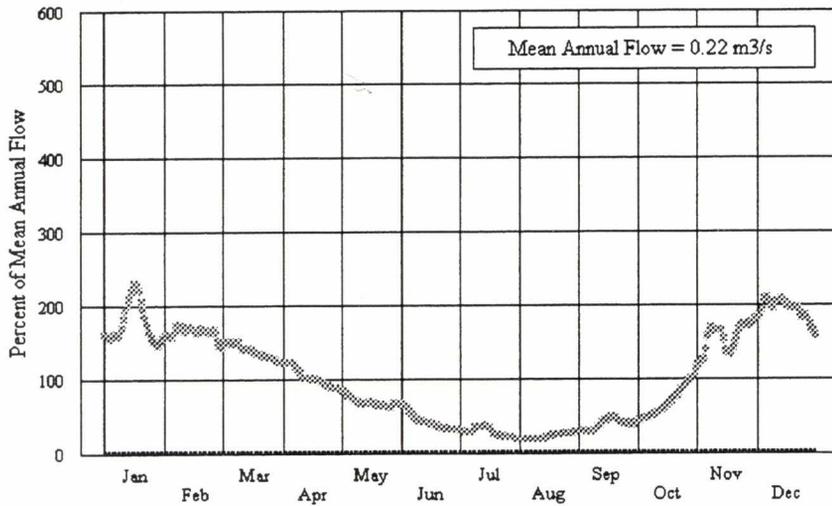
Drainage Area = 9.2 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	4,000 g/d	0.21	0.21	0.21
Irrigation	125 ac.ft.		17.3	8.92
Waterworks	3,500 g/d	0.18	0.18	0.18
Industrial	0 g/d			
Conservation	0 cfs			

	Feb	Aug	Sep
MEAN STREAM FLOW L/S		60	60

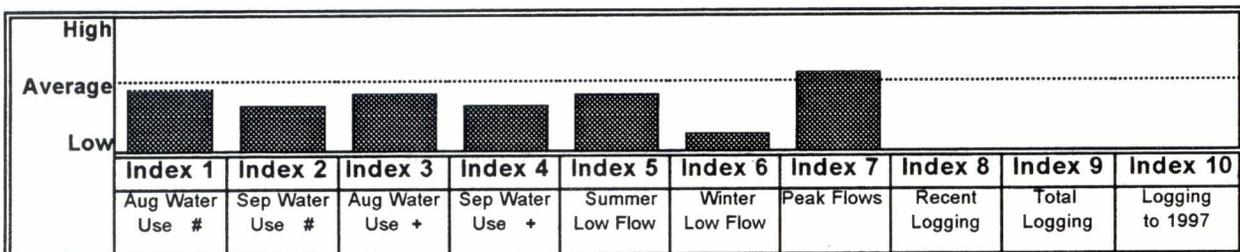
MEAN ANNUAL HYDROGRAPH

(Estimated, using Silverdale Creek Station 08MH091)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow
 + Water use as a proportion of the mean monthly flow for the same month

WADES CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Wades Creek has domestic, irrigation and waterworks demands, but summer water use is rated as below average.

NICOMEN SLOUGH

LICENSED WATER DEMAND

Stream number 00-0552

Ungauged

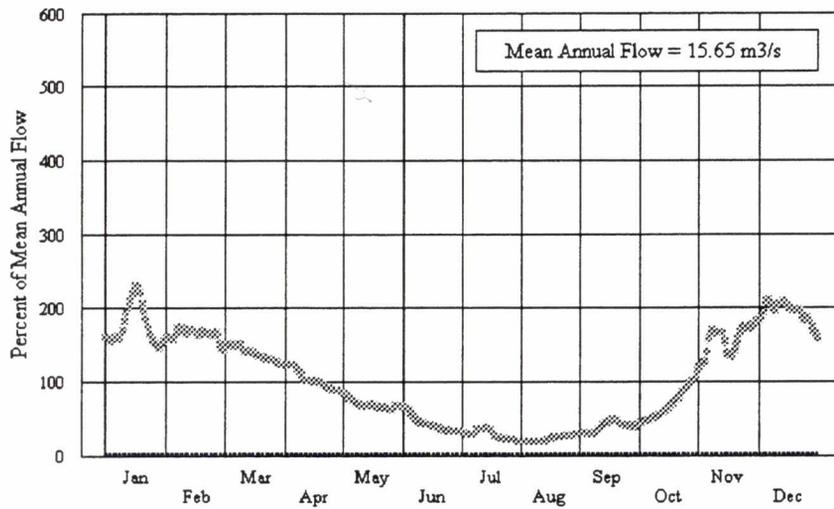
Tributary to the Fraser River

Drainage Area = 181 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	13,300 g/d	0.70	0.70	0.70
Irrigation	376 ac.ft.		52.0	26.8
Waterworks	8,473,425g/d	445.9	445.9	445.9
Industrial	10,100 g/d	0.53	0.53	0.53
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			4,530	6,960

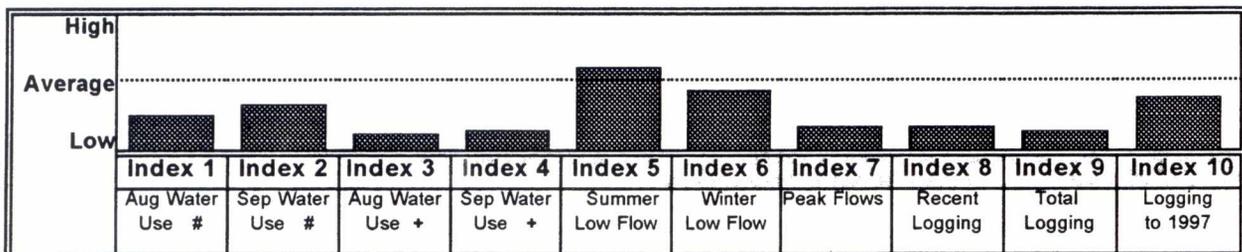
MEAN ANNUAL HYDROGRAPH

(Estimated, using Silverdale Creek Station 08MH091)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

NICOMEN SLOUGH

SUMMARY NOTES AND RECOMMENDATIONS

1. Nicomen Slough has domestic, irrigation, waterworks and industrial water demands, but summer water use is rated as well below average.

2. About 3% of the watershed is proposed to be logged according to the 5 year plan.

NORRISH CREEK

LICENSED WATER DEMAND

Stream number 00-0552-020

Water Survey of Canada Station 08MH058

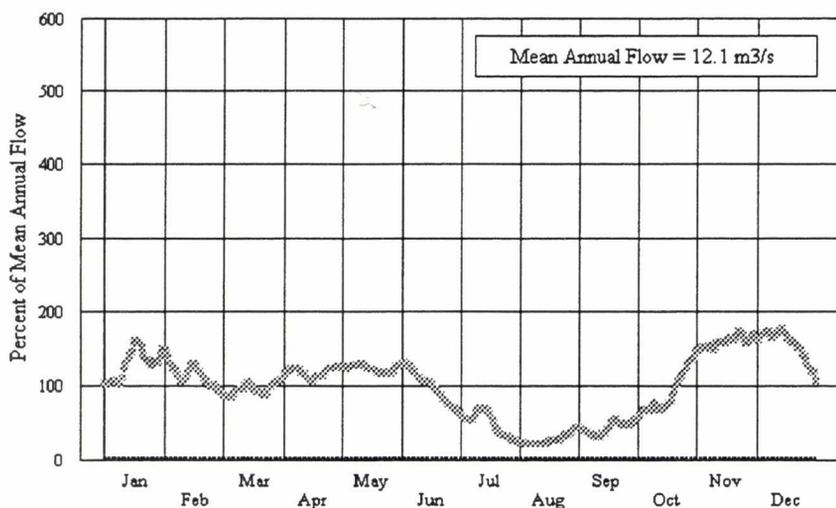
Norrish Creek near Dewdney

Records 1959 to 1990

Drainage Area = 117 km²

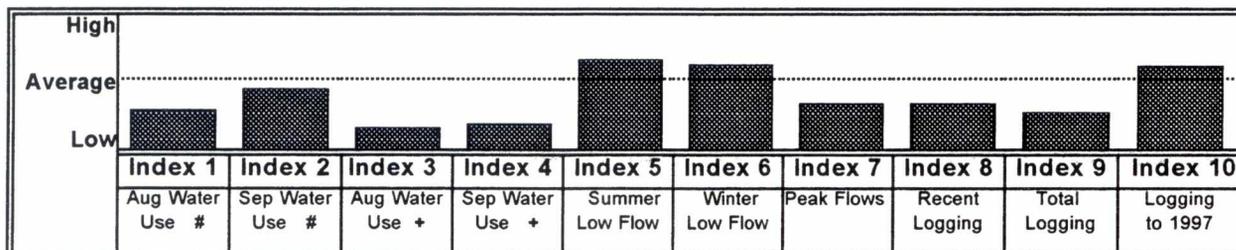
Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	8,473,425g/d	446	446	446
Industrial	0 g/d			
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S		14,900	3,060	5,430

MEAN ANNUAL HYDROGRAPH



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.

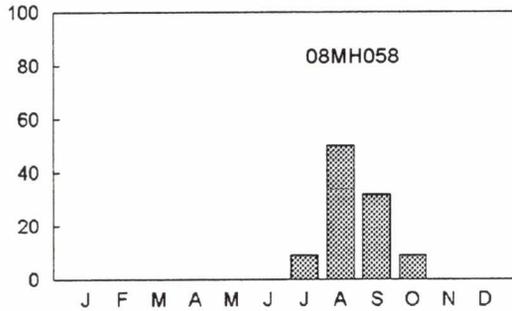


Water use as a proportion of the 7 day low flow

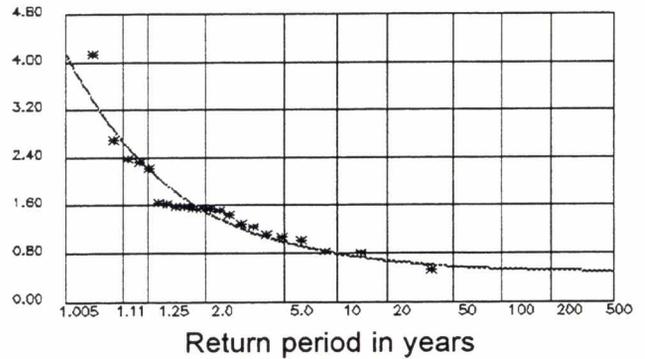
+ Water use as a proportion of the mean monthly flow for the same month

7 DAY LOW FLOWS

*Distribution , by month, of
7 Day Low Flow (in percent)*



*7 Day Low Flow Frequency Curve
(Flow in m³/s)*



Return period	2 years	10 years	20 years	50 years	100 years
7 Day Low Flow	1.49 m ³ /s	0.78 m ³ /s	0.66 m ³ /s	0.57 m ³ /s	0.53 m ³ /s
Annual Flood	91 m ³ /s	164 m ³ /s	192 m ³ /s	229 m ³ /s	257 m ³ /s

SUMMARY NOTES AND RECOMMENDATIONS

- 1. Gravel accumulation and bed instability on the fan of Norrish Creek has been a problem for many years, dating back to the 50's and 60's. Gravel has frequently been removed from the area just upstream of the CPR bridge.*
- 2. Portions of the creek bed go dry during low flows because of losses to sub-gravel flow . To alleviate this condition, gravel is removed to lower the bed profile and regain some surface flow.*
- 3. The Dewdney-Alouette Regional District operate an intake on Norrish Creek and a reservoir (Dickson Lake) which is operated to maintain instream flows below their intake. The district has applied for an increase in their licensed diversion and storage amounts.*
- 4. An Integrated Watershed Management Plan has been prepared to manage low flows, reservoir releases, and resource development.*

INCHES CREEK

LICENSED WATER DEMAND

Stream number 00-0552-020-005

Ungauged

Tributary to Norrish Creek

Drainage Area = 0.8 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

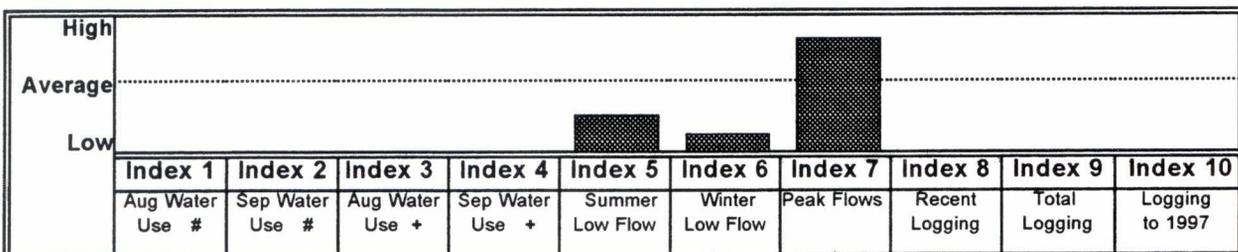
	Feb	Aug	Sep
MEAN STREAM FLOW L/S		10	10

MEAN ANNUAL HYDROGRAPH

(No hydrograph available)

SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

INCHES CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Prior to 1965 flows in Inches Creek came from groundwater in the Norrish Creek fan and, occasionally, flood flows in Norrish Creek. However, work done on Norrish Creek since 1965 has reduced inflow from both these sources.

2. Groundwater has been developed by wells for the Inches Creek hatchery and spawning channel. Discharge from the hatchery maintains flow in the lower creek.

WORTH CREEK

LICENSED WATER DEMAND

Stream number 00-0552-020-010

Ungauged

Tributary to Norrish Creek

Drainage Area = 0.6 km²

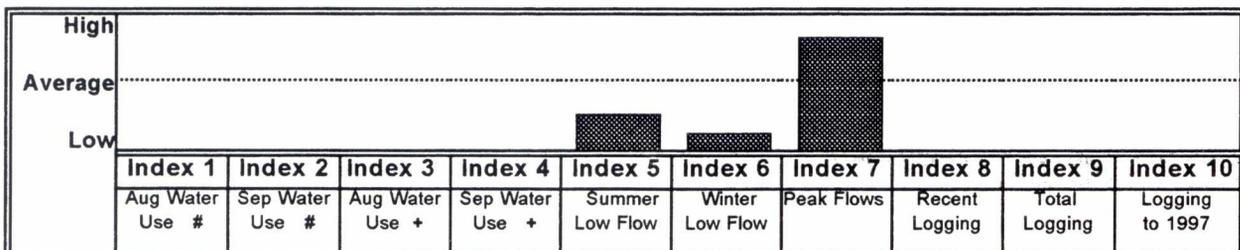
Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			4	4

MEAN ANNUAL HYDROGRAPH

(No hydrograph available)

SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

WORTH CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Worth Creek was once a channel of Norrish Creek but flows are now maintained by groundwater inflows. Under the Salmon Enhancement Program a drop structure was built to improve water depths and gravel was placed to provide a spawning channel.

HAWKINS CREEK

LICENSED WATER DEMAND

Stream number 00-0552-020-015

Ungauged

Tributary to Norrish Creek

Drainage Area = 0.1 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

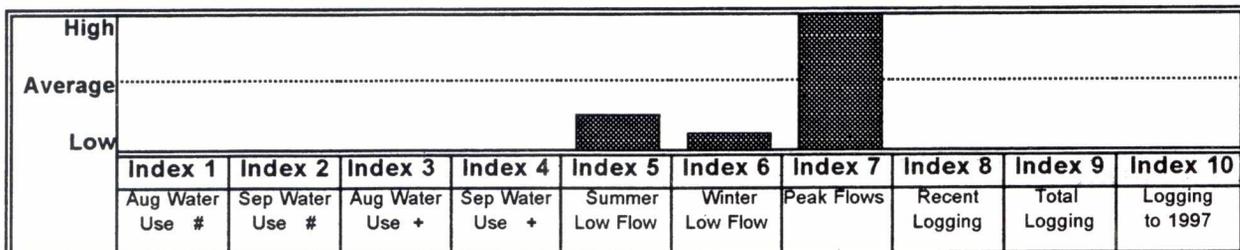
	Feb	Aug	Sep
MEAN STREAM FLOW L/S		1	1

MEAN ANNUAL HYDROGRAPH

(No hydrograph available)

SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

HAWKINS CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Hawkins Creek is a tributary of Norrish Creek which is often dry and suffers extremely low flows that prevent access by salmon.

RAILWAY CREEK

LICENSED WATER DEMAND

Stream number 00-0552-024
 Ungauged
 Tributary to Nicomen Slough

Drainage Area = 0.3 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

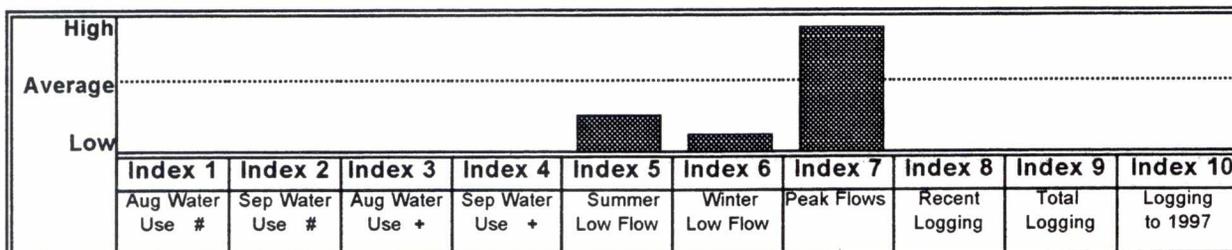
	Feb	Aug	Sep
MEAN STREAM FLOW L/S		2	2

MEAN ANNUAL HYDROGRAPH

(No hydrograph available)

SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

RAILWAY CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Railway Creek is a former channel of Norrish Creek. It is primarily supplied by ground water, with some surface contribution during heavy rainfalls.

BROUSSEAU CREEK

LICENSED WATER DEMAND

Stream number 00-0552-028
 Ungauged
 Tributary to Nicomen Slough

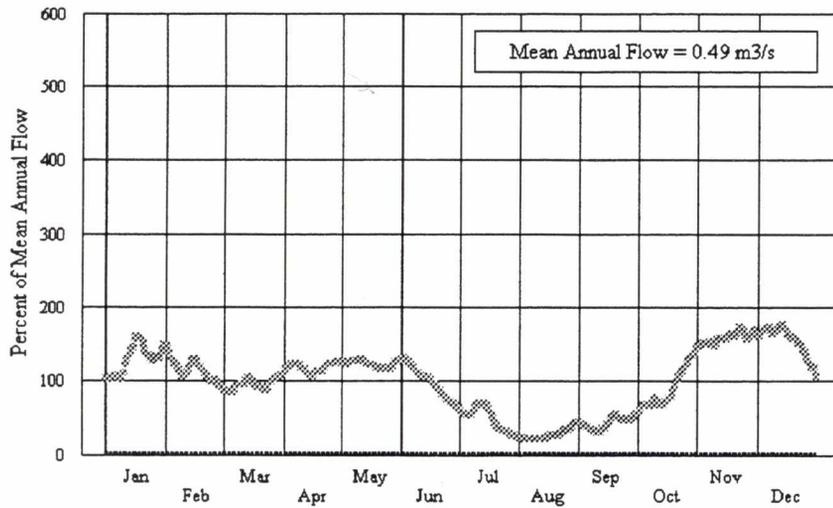
Drainage Area = 5.0 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	13,000 g/d	0.68	0.68	0.68
Irrigation	267 ac.ft.		36.9	19.1
Waterworks	20,000 g/d	1.05	1.05	1.05
Industrial	10,100 g/d	0.53	0.53	0.53
Conservation	0 cfs			

	Feb	Aug	Sep
MEAN STREAM FLOW L/S		140	240

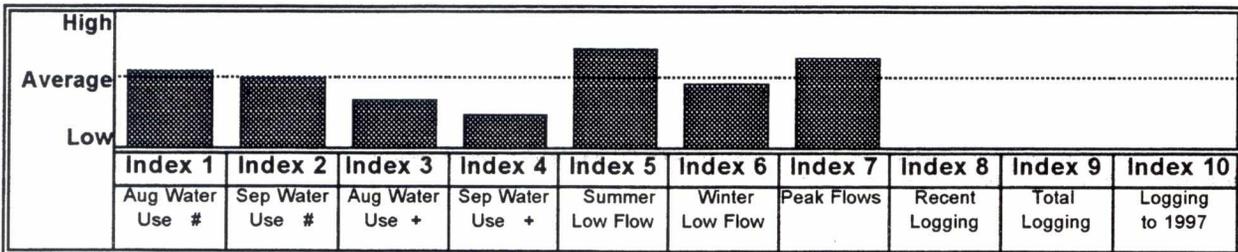
MEAN ANNUAL HYDROGRAPH

(Estimated, using Norrish Creek Station 08MH058)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow
 + Water use as a proportion of the mean monthly flow for the same month

BROUSSEAU CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Brousseau Creek has domestic, irrigation, waterworks and industrial water demands which represent about 56% of the mean 7-day summer low flow.

DEROCHE CREEK

LICENSED WATER DEMAND

Stream number 00-0552-030

Tributary to Nicomen Slough

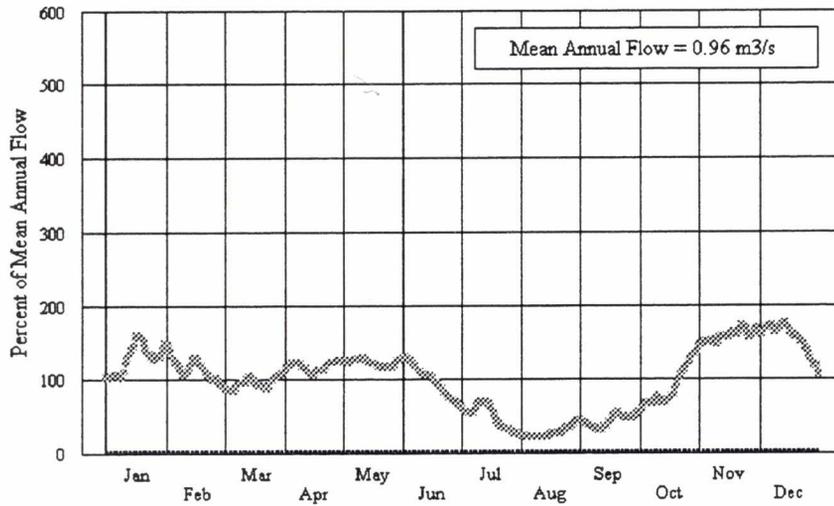
Drainage Area = 9.8 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	2,500 g/d	0.13	0.13	0.13
Irrigation	5 ac.ft.		0.69	0.36
Waterworks	20,000 g/d	1.05	1.05	1.05
Industrial	0 g/d			
Conservation	0 cfs			

	Feb	Aug	Sep
MEAN STREAM FLOW L/S		280	470

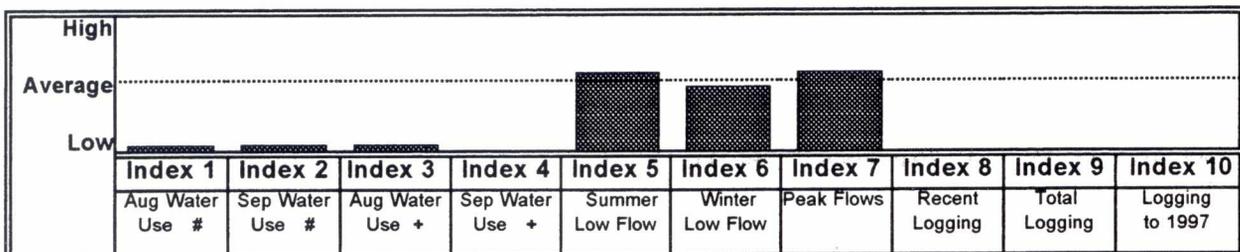
MEAN ANNUAL HYDROGRAPH

(Estimated, using Norrish Creek Station 08MH058)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

DEROCHE CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Deroche Creek transports large quantities of gravel onto its fan which could cause it to leave its channel upstream of the CN Rail bridge. The Dewdney-Alouette Regional District intends to undertake a study that would lead to control of development on the fan and provide a solution to the sediment accumulation, such as a debris basin near the head of the fan.

2. The Stream Summary Catalogue reports that spawning grounds have been disrupted by regular gravel removals.

PYE CREEK

LICENSED WATER DEMAND

Stream number 00-0552-050
 Ungauged
 Tributary to Nicomen Slough

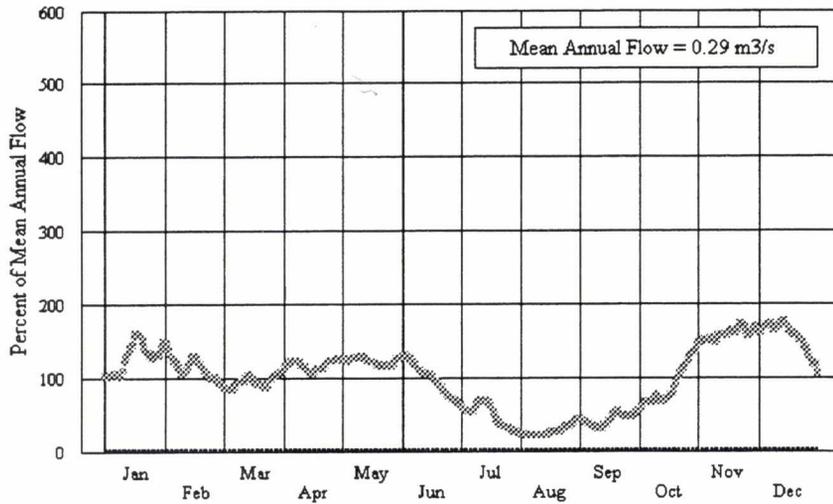
Drainage Area = 2.9 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	4,000 g/d	0.21	0.21	0.21
Irrigation	3 ac.ft.		0.41	0.21
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

	Feb	Aug	Sep
MEAN STREAM FLOW L/S		80	140

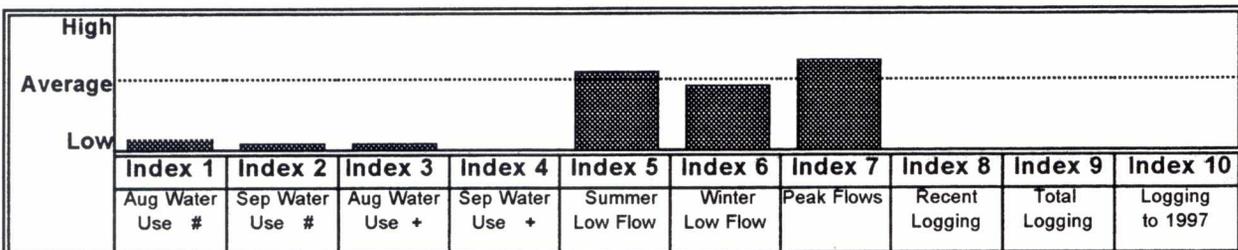
MEAN ANNUAL HYDROGRAPH

(Estimated, using Norrish Creek Station 08MH058)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow
 + Water use as a proportion of the mean monthly flow for the same month

PYE CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. A culvert at Lougheed Highway prevents upstream migration of salmon; however, the upstream habitat is very limited. There is good habitat downstream of the bridge but it is reported to be often dry, although there may be sub-gravel flow.

2. Pye Creek has a flashy regime and moves large quantities of coarse gravel. CP Rail often has to clear their culvert. The farm downstream of the railway is regularly flooded and the owner would like to have the creek dyked.

BARNES CREEK

LICENSED WATER DEMAND

Stream number 00-0552-060
 Ungauged
 Tributary to Nicomen Slough

Drainage Area = 3.5 km²

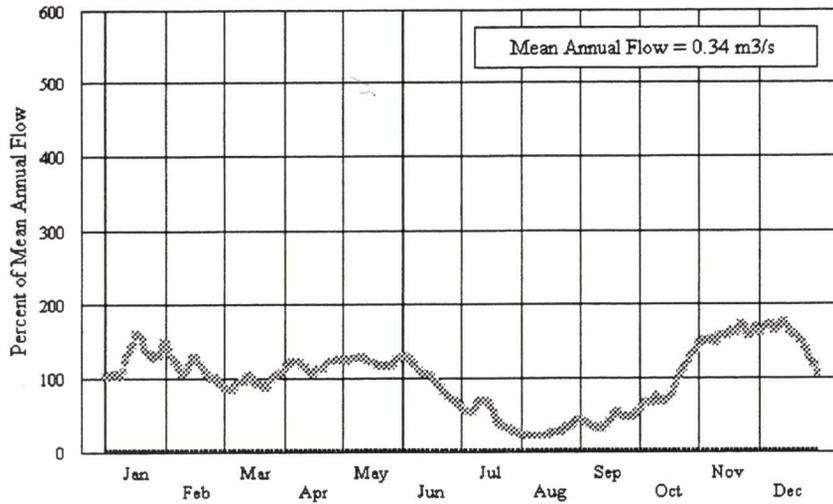
Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	3,000 g/d	0.16	0.16	0.16
Irrigation	6 ac.ft.		0.83	0.43
Waterworks	0 g/d			
Industrial	100 g/d	0.01	0.01	0.01
Conservation	0 cfs			

Feb Aug Sep

MEAN STREAM FLOW L/S	Feb	Aug	Sep
		100	170

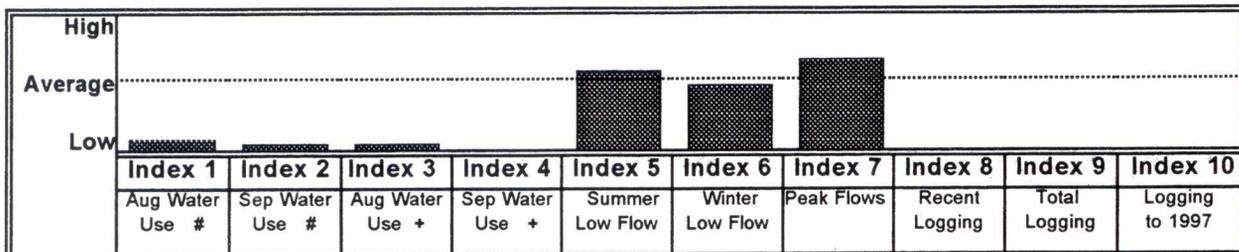
MEAN ANNUAL HYDROGRAPH

(Estimated, using Norrish Creek Station 08MH058)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

BARNES CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Suburban development is proceeding in the upper watershed of Barnes Creek, but most lots are large and leave strips have been incorporated to protect the creek.

2. The lower reaches of Barnes Creek are stable and sediment does not accumulate in the channel, but it is reported to be often dry in the late summer. Riparian vegetation has been left along these lower reaches.

SIDDLE CREEK

LICENSED WATER DEMAND

Stream number 00-0552-070

Ungauged

Tributary to Nicomen Slough

Drainage Area = 6 km²

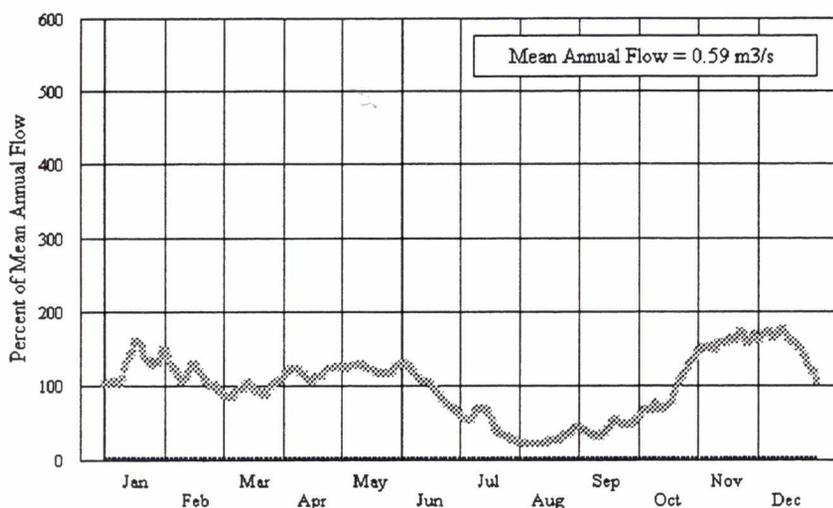
Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	300 g/d	0.02	0.02	0.02
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

Feb Aug Sep

MEAN STREAM FLOW L/S	Feb	Aug	Sep
		170	290

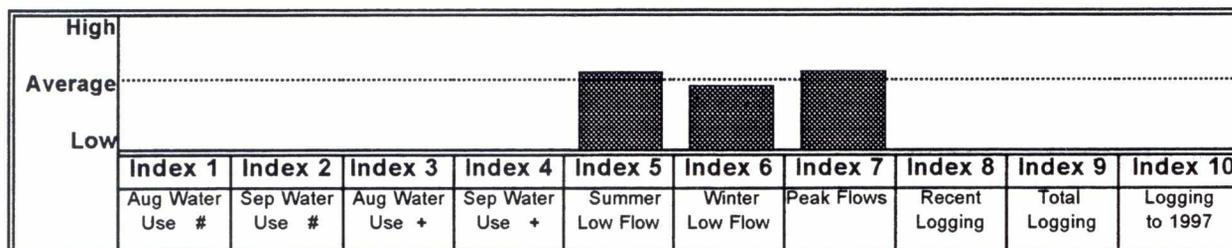
MEAN ANNUAL HYDROGRAPH

(Estimated, using Norrish Creek Station 08MH058)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

SIDDLE CREEK

SUMMARY NOTES AND RECOMMENDATIONS

- 1. CP Rail regularly remove gravel upstream of their culvert on Siddle Creek as the narrow culvert tends to block. They would like to construct a debris basin to simplify gravel removal. Gravel also accumulates in the lower reaches of the creek, creating the potential for flooding and sudden channel change.*
- 2. Enhancement opportunities that have been suggested include creation of pools and provision of cover along the creek downstream of the railway, and the improvement of fish access to the west branch of the channel.*
- 3. A farmer on the lower creek wishes to subdivide his land and is prepared to leave a 15m wide strip along the creek.*

SUMAS RIVER

LICENSED WATER DEMAND

(not including U.S. demand)

Stream number 00-0600

Water Survey of Canada Station 08MH029

Sumas River near Huntingdon

Records 1952 to 1990

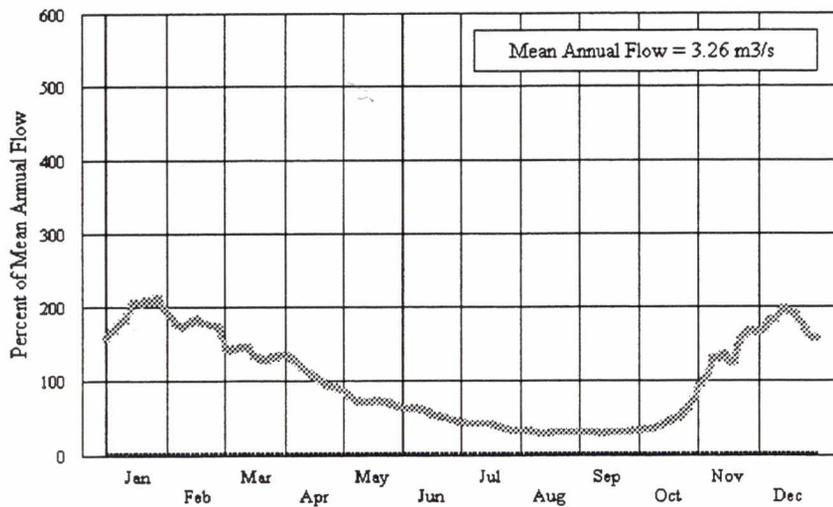
Drainage Area = 149 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

Feb Aug Sep

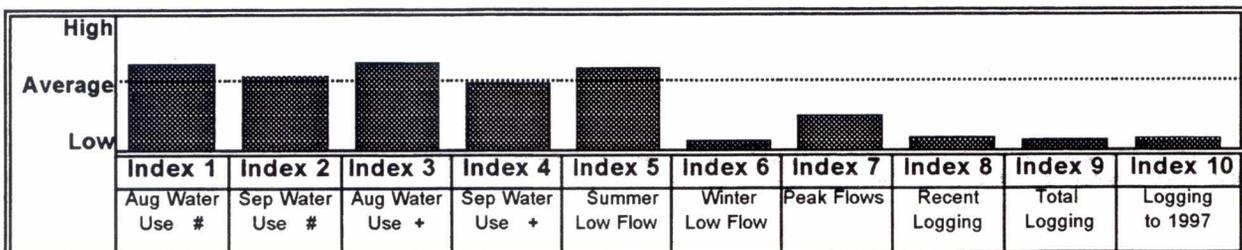
MEAN STREAM FLOW L/S	Feb	Aug	Sep
	5,800	1,030	1,020

MEAN ANNUAL HYDROGRAPH



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.

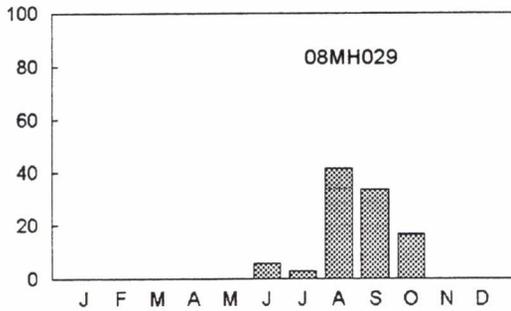


Water use as a proportion of the 7 day low flow

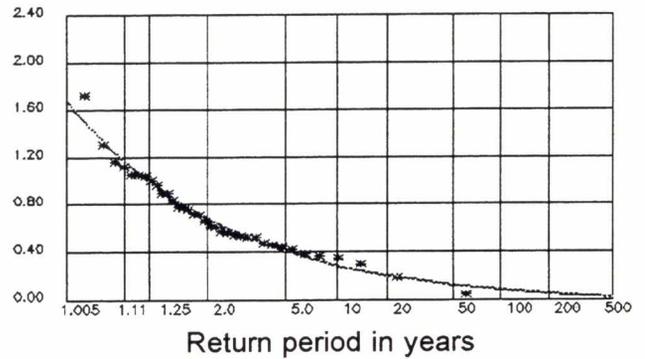
+ Water use as a proportion of the mean monthly flow for the same month

7 DAY LOW FLOWS

*Distribution , by month, of
7 Day Low Flow (in percent)*



*7 Day Low Flow Frequency Curve
(Flow in m³/s)*



Return period	2 years	10 years	20 years	50 years	100 years
7 Day Low Flow	0.674 m ³ /s	0.276 m ³ /s	0.191 m ³ /s	0.113 m ³ /s	0.073 m ³ /s
Annual Flood	22 m ³ /s	40 m ³ /s	47 m ³ /s	56 m ³ /s	63 m ³ /s

SUMMARY NOTES AND RECOMMENDATIONS

1. Sumas River is slow moving with very little shade. The water temperature is high and the dissolved oxygen is low. Narrow dykes contain the river and riparian vegetation is removed as part of dyke maintenance.

CHILLIWACK RIVER (LOWER)

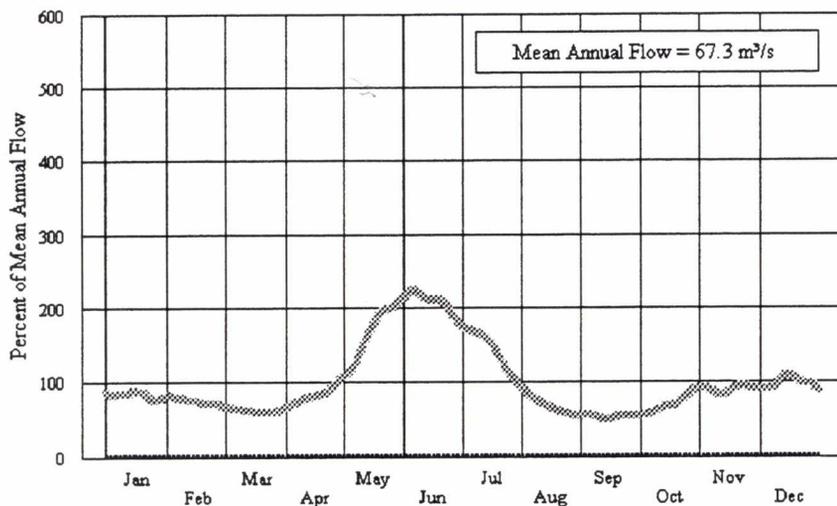
Stream number 00-0600-020-000-000-991
 Water Survey of Canada Station 08MH001
 Chilliwack River at Vedder Crossing
 Records 1911 to 1990
 Drainage Area = 1,230 km²

LICENSED WATER DEMAND

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	108,850 g/d	5.73	5.73	5.73
Irrigation	712.8 ac.ft.		98.5	50.9
Waterworks	794,500 g/d	41.8	41.8	41.8
Industrial	548,500 g/d	28.9	28.9	28.9
Conservation	153.8 cfs			

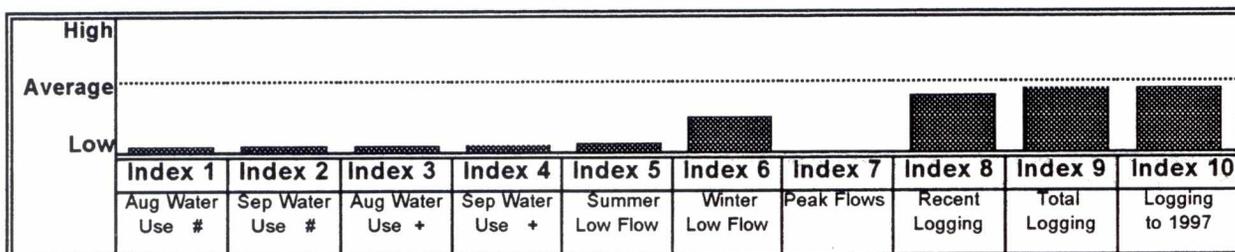
	Feb	Aug	Sep
MEAN STREAM FLOW L/S	51,200	45,500	35,600

MEAN ANNUAL HYDROGRAPH



SENSITIVITY INDICES

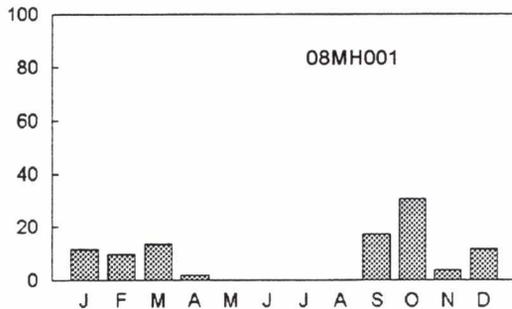
The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



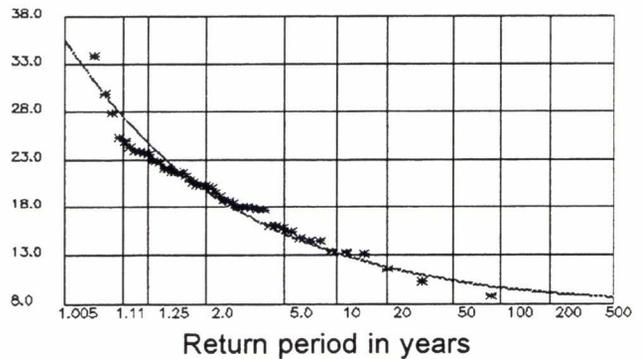
Water use as a proportion of the 7 day low flow
 + Water use as a proportion of the mean monthly flow for the same month

7 DAY LOW FLOWS

*Distribution , by month, of
7 Day Low Flow (in percent)*



*7 Day Low Flow Frequency Curve
(Flow in m³/s)*



Return period	2 years	10 years	20 years	50 years	100 years
7 Day Low Flow	19.7 m ³ /s	13.1 m ³ /s	11.6 m ³ /s	10.3 m ³ /s	9.6 m ³ /s
Annual Flood	291 m ³ /s	466 m ³ /s	539 m ³ /s	638 m ³ /s	717 m ³ /s

SUMMARY NOTES AND RECOMMENDATIONS

1. The Vedder Management Committee manages the Lower Chilliwack River. Regular surveys are made to assess channel capacity, and bars are scalped when necessary to ensure that the capacity is sufficient to pass the 200 year instantaneous discharge.

2. Setback dykes, river training works and bank revetments have cut off or blocked secondary channels. Large organic debris has also been lost.

CHILLIWACK RIVER (UPPER)

Stream number 00-0600-020-000-000-992
 Water Survey of Canada Station 08MH103
 Chilliwack River above Slesse Creek
 Records 1963 to 1990
 Drainage Area = 645 km²

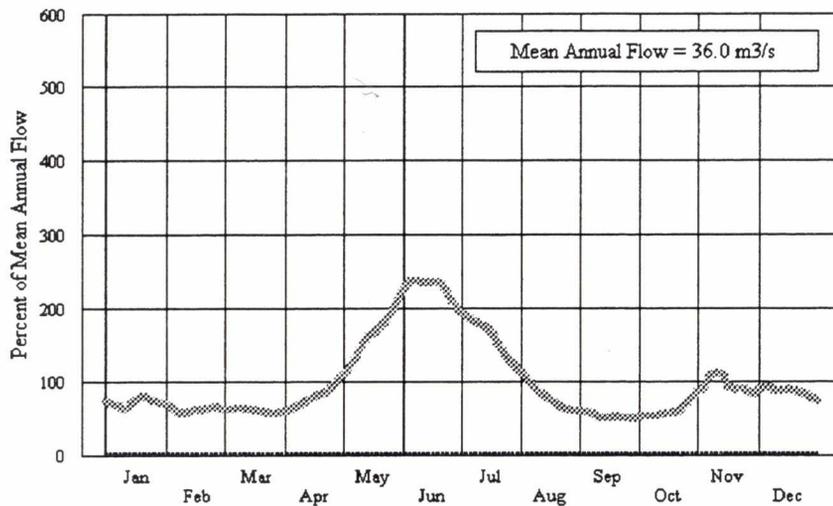
LICENSED WATER DEMAND

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	4,000 g/d	0.21	0.21	0.21
Irrigation	190 ac.ft.		26.2	13.6
Waterworks	4,000 g/d	0.21	0.21	0.21
Industrial	5,000 g/d	0.26	0.26	0.26
Conservation	140.3 cfs			

Feb Aug Sep

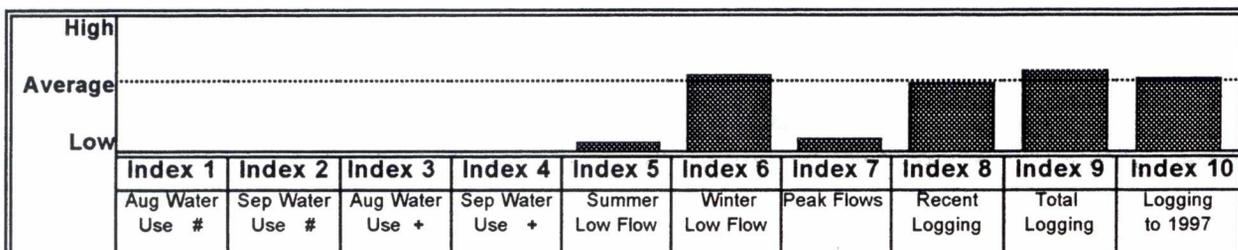
MEAN STREAM FLOW L/S	22,300	28,000	19,000
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MEAN ANNUAL HYDROGRAPH



SENSITIVITY INDICES

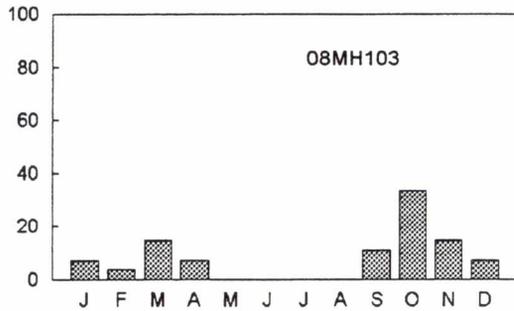
The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



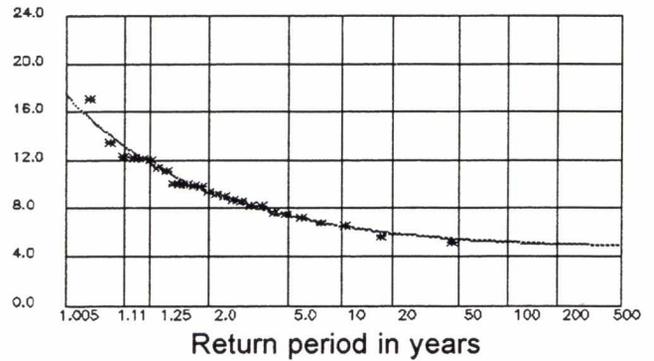
Water use as a proportion of the 7 day low flow
 + Water use as a proportion of the mean monthly flow for the same month

7 DAY LOW FLOWS

*Distribution , by month, of
7 Day Low Flow (in percent)*



*7 Day Low Flow Frequency Curve
(Flow in m³/s)*



Return period	2 years	10 years	20 years	50 years	100 years
7 Day Low Flow	9.33 m ³ /s	6.48 m ³ /s	5.91 m ³ /s	5.43 m ³ /s	5.18 m ³ /s
Annual Flood	138 m ³ /s	249 m ³ /s	312 m ³ /s	416 m ³ /s	514 m ³ /s

SUMMARY NOTES AND RECOMMENDATIONS

1. About 15% of the Upper Chilliwack River watershed has been logged and, according to the 5 year plan, another 1% is proposed to be logged.

SALWEIN CREEK

LICENSED WATER DEMAND

Stream number 00-0600-020-008

Ungauged

Tributary to Chilliwack River

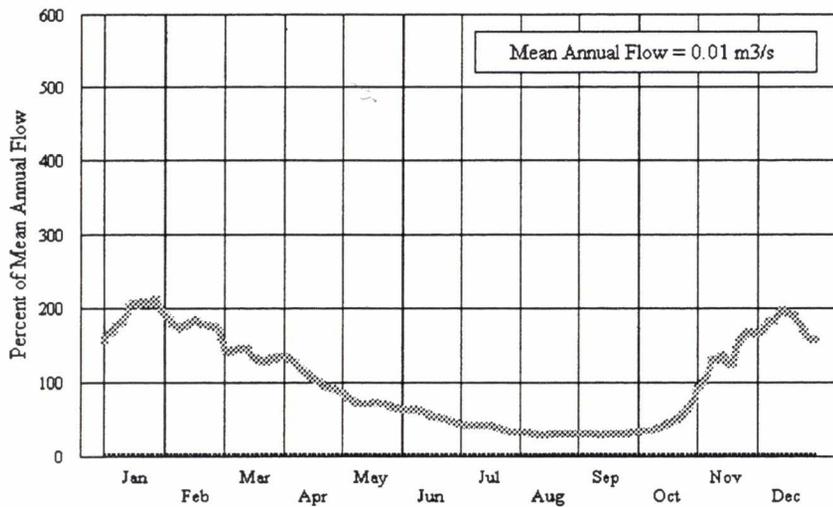
Drainage Area = 0.3 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

	Feb	Aug	Sep
MEAN STREAM FLOW L/S		2	2

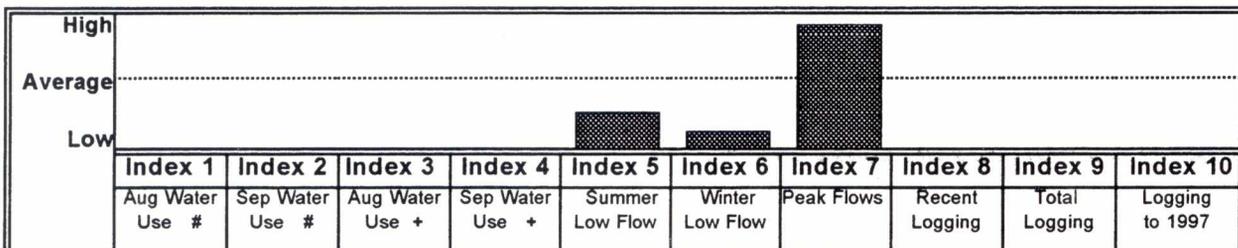
MEAN ANNUAL HYDROGRAPH

(Estimated, using Sumas River Station 08MH029)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

SALWEIN CREEK

SUMMARY NOTES AND RECOMMENDATIONS

- 1. Agriculture is the main activity in the upper Salwein Creek watershed. Channel maintenance is required most years to prevent flooding of fields. DFO has refused to approve further gravel removal permits until the creek is fenced.*
- 2. Siltation from agriculture has affected spawning gravels in the east branch of Salwein Creek but, according to the Stream Summary Catalogue, the west branch is spring fed and stable.*

STREET CREEK

LICENSED WATER DEMAND

Stream number 00-0600-020-010

Ungauged

Tributary to Chilliwack River

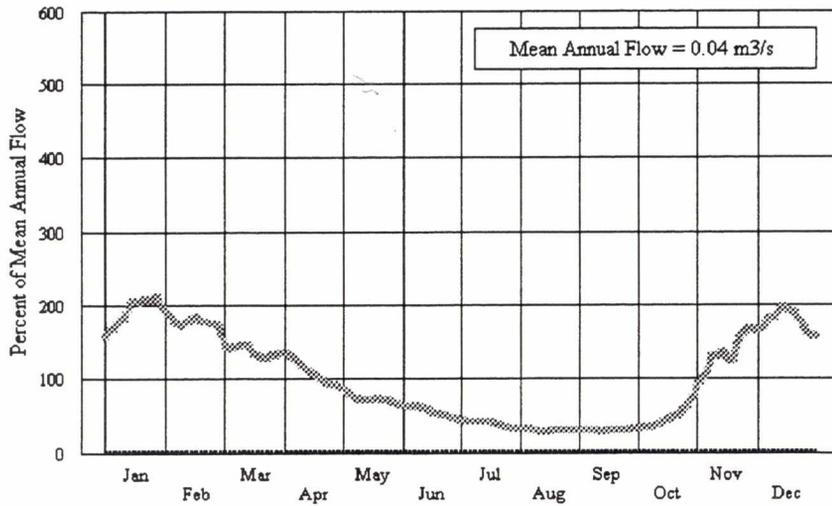
Drainage Area = 1.9 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	2,500 g/d	0.13	0.13	0.13
Irrigation	26 ac.ft.		3.6	1.86
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

MEAN STREAM FLOW L/S	Feb	Aug	Sep
			0.012

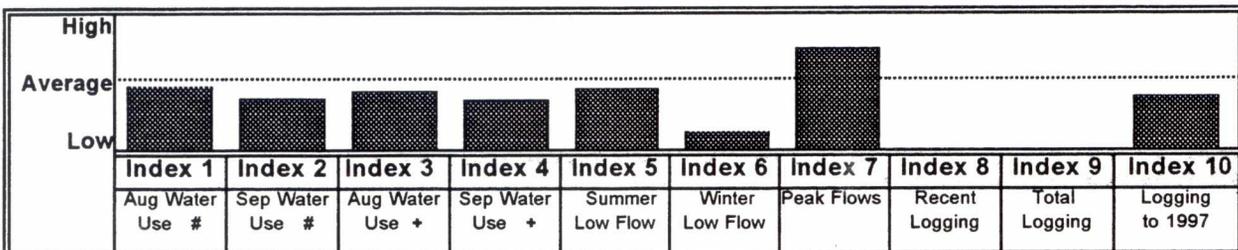
MEAN ANNUAL HYDROGRAPH

(Estimated, using Sumas River Station 08MH029)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

STREET CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Street Creek is a stable, spring fed, low gradient stream that flows into a side channel of the Chilliwack River where SEP has developed a groundwater spawning channel.

HOPEDALE SLOUGH

LICENSED WATER DEMAND

Stream number 00-0600-020-010-010

Ungauged

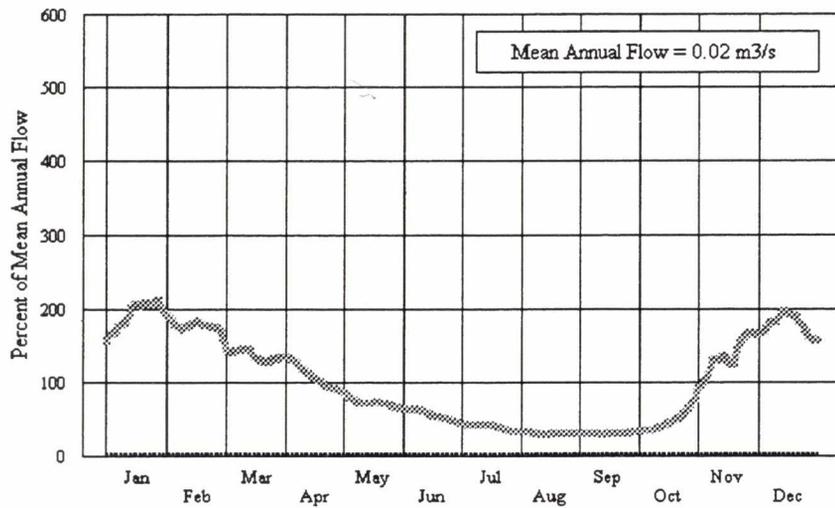
Tributary to Street Creek

Drainage Area = 0.09 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			0.006	0.006

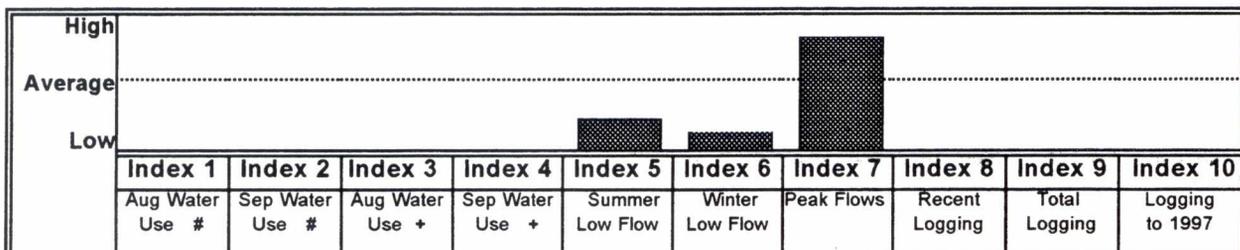
MEAN ANNUAL HYDROGRAPH

(Estimated, using Sumas River Station 08MH029)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

HOPEDALE SLOUGH

SUMMARY NOTES AND RECOMMENDATIONS

1. Peak flows on Hopedale Slough are rated well above average. There are no water demands and there has been no logging.

BARRETT CREEK

LICENSED WATER DEMAND

Stream number 00-0600-020-013
 Ungauged
 Tributary to Chilliwack River

Drainage Area = 0.7 km²

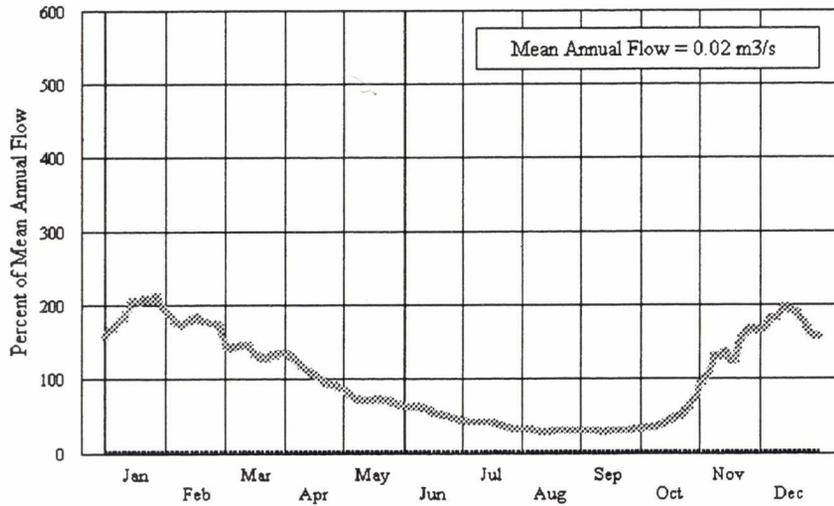
Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	1,500 g/d	0.08	0.08	0.08
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

Feb Aug Sep

MEAN STREAM FLOW L/S	Feb	Aug	Sep
		4	4

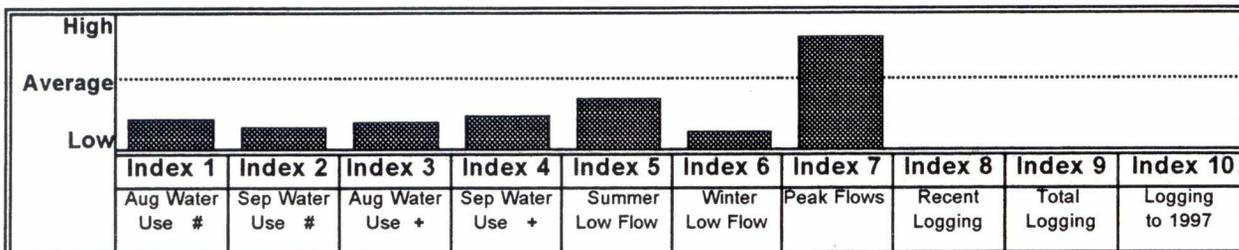
MEAN ANNUAL HYDROGRAPH

(Estimated, using Sumas River Station 08MH029)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow
 + Water use as a proportion of the mean monthly flow for the same month

BARRETT CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Barrett Creek joins the Chilliwack River near Lickman Road. As part of an enhancement project, SEP dredged the stream, placed spawning gravel and joined it to Peach Creek.

PEACH CREEK

LICENSED WATER DEMAND

Stream number 00-0600-020-053

Ungauged

Tributary to Chilliwack River

Drainage Area = 1.2 km²

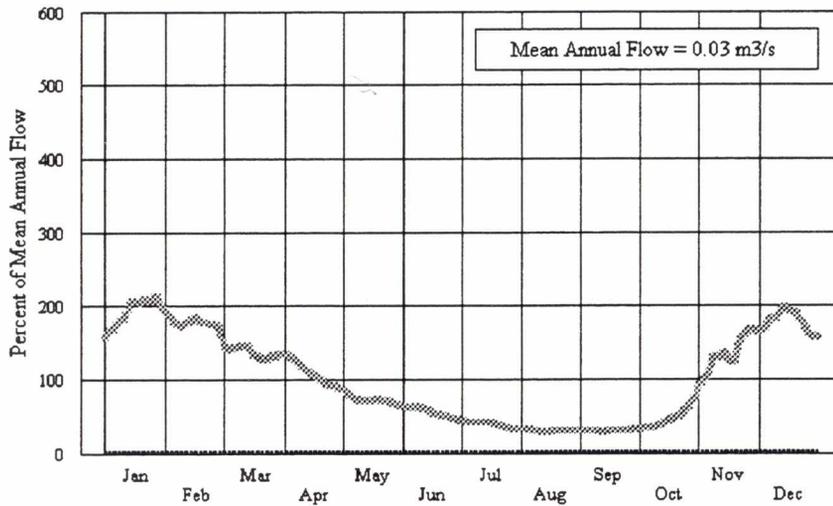
Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

Feb Aug Sep

MEAN STREAM FLOW L/S	Feb	Aug	Sep
		7	7

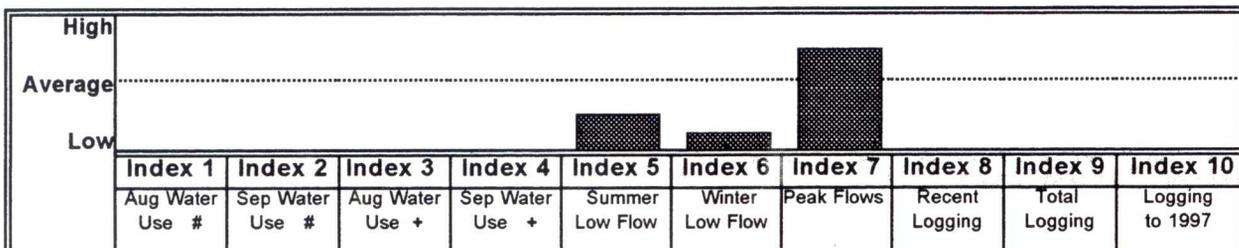
MEAN ANNUAL HYDROGRAPH

(Estimated, using Sumas River Station 08MH029)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

PEACH CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Peach Creek is an artificial stream occupying what used to be a secondary channel of the Chilliwack river. The stream Summary Catalogue reports that the channel goes dry at its lower end and freezes to the bed during cold winters.

SWELTZER RIVER

LICENSED WATER DEMAND

Stream number 00-0600-020-020

Water Survey of Canada Station 08MH033

Sweltzer River at Cultus Lake

Records 1947 to 1964

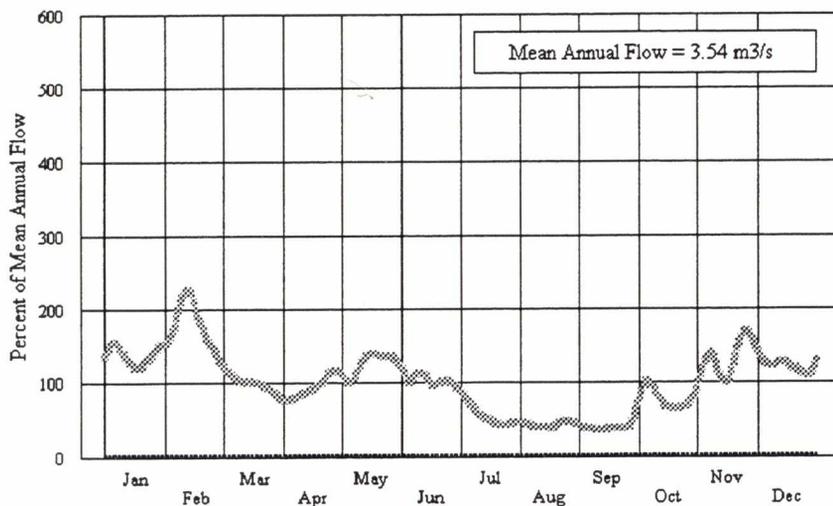
Drainage Area = 65 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	30,600 g/d	1.61	1.61	1.61
Irrigation	238.4 ac.ft.		32.9	17.0
Waterworks	690,500 g/d	36.3	36.3	36.3
Industrial	232,000 g/d	12.2	12.2	12.2
Conservation	4 cfs			

Feb Aug Sep

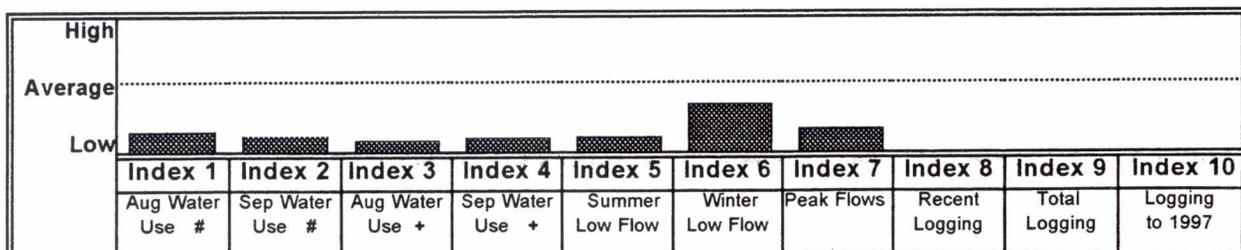
MEAN STREAM FLOW L/S	Feb	Aug	Sep
	5,120	1,460	1,570

MEAN ANNUAL HYDROGRAPH



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

SWELTZER RIVER

SUMMARY NOTES AND RECOMMENDATIONS

- 1. Sweltzer River flows out of Cultus Lake and through the Soowahlie Reserve where the Band has completed some habitat improvements.*
- 2. Summer flows out of Cultus Lake are reduced to maintain water levels suitable for recreation. High water temperatures have been reported in the summer. Winter flows are stable and flood flows are moderated by storage in the lake.*

LIUMCHEN CREEK

LICENSED WATER DEMAND

Stream number 00-0600-020-040

Tributary to the Chilliwack River

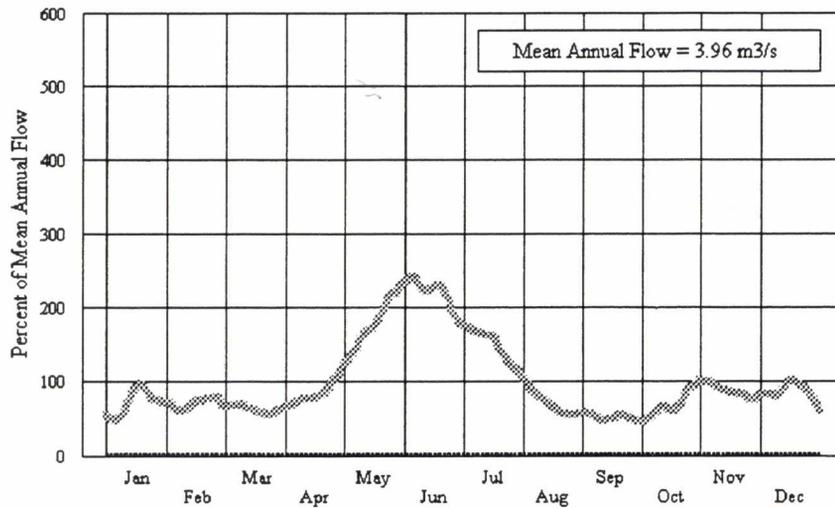
Drainage Area = 64.4 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	100,000 g/d	5.26	5.26	5.26
Industrial	21,000 g/d	1.10	1.10	1.10
Conservation	0 cfs			

	Feb	Aug	Sep
MEAN STREAM FLOW L/S		550	530

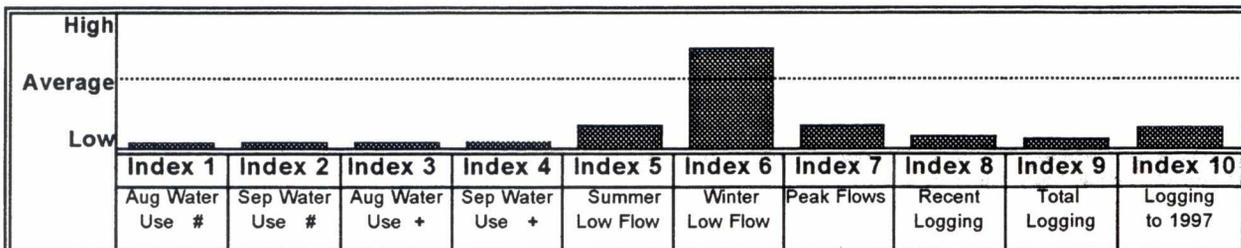
MEAN ANNUAL HYDROGRAPH

(Estimated, using Slesse Creek Station 08MH056)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

LIUMCHEN CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. The District of Chilliwack has applied for waterworks licences on Liumchen and Foley creeks. Both creeks have good quality water. Water from Liumchen alone is viewed as a short term solution to the water supply, but Liumchen together with Foley Creek and storage on Upper or Lower Foley Lake is viewed as a long term solution.

RYDER CREEK

LICENSED WATER DEMAND

Stream number 00-0600-020-050

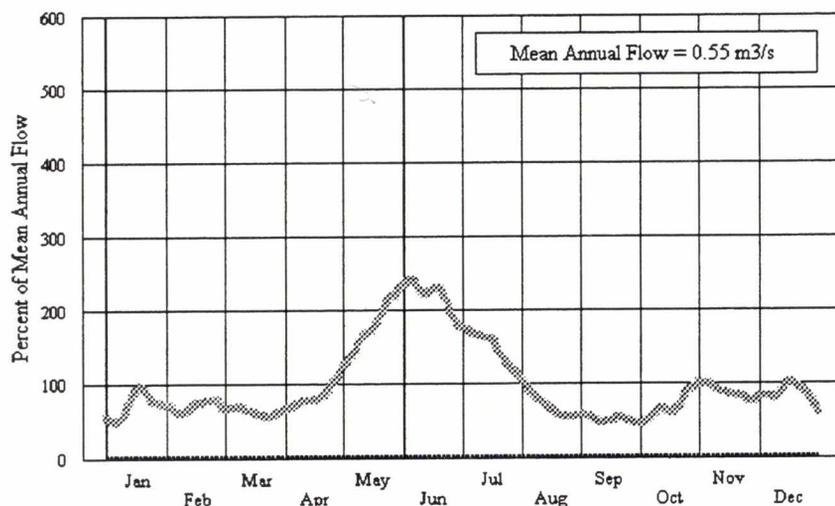
Tributary to the Chilliwack River

Drainage Area = 8.9 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	10,250 g/d	0.54	0.54	0.54
Irrigation	39 ac.ft.		5.39	2.78
Waterworks	0 g/d			
Industrial	14,000 g/d	0.74	0.74	0.74
Conservation	2 cfs			
MEAN STREAM FLOW L/S			320	210

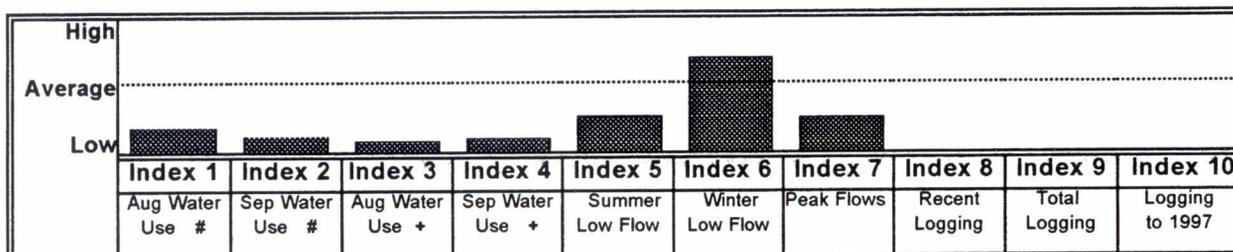
MEAN ANNUAL HYDROGRAPH

(Estimated, using Slesse Creek Station 08MH056)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

RYDER CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Urban development by the District of Chilliwack is a major threat to Ryder Creek. The district currently has no requirements for stormwater detention or retention and stormwater from the development is likely to end up in Ryder and Semihault Creeks, greatly increasing flood flows and altering the stream channels.

2. The Stream Summary Catalogue reports low flow problems in Ryder Creek and notes that DFO recommends no further withdrawals to ensure fisheries maintenance flows.

LITTLE TAMIHI CR.

LICENSED WATER DEMAND

Stream number 00-0600-020-070

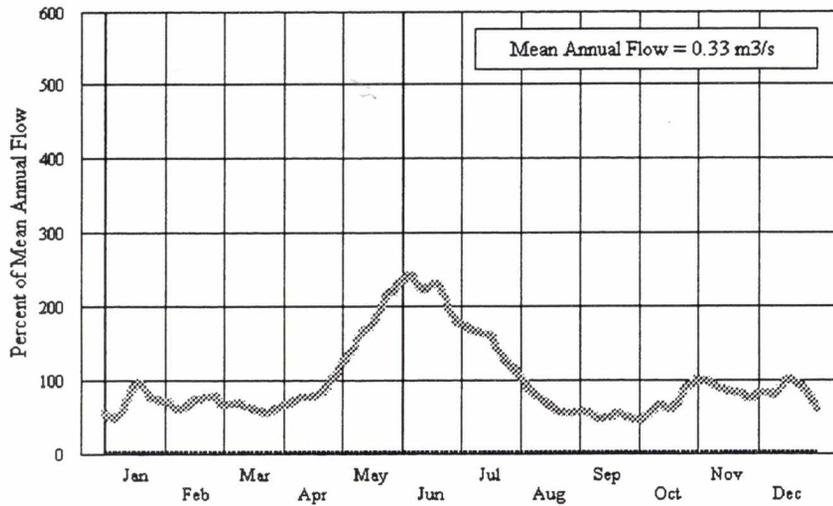
Tributary to the Chilliwack River

Drainage Area = 5.3 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			190	120

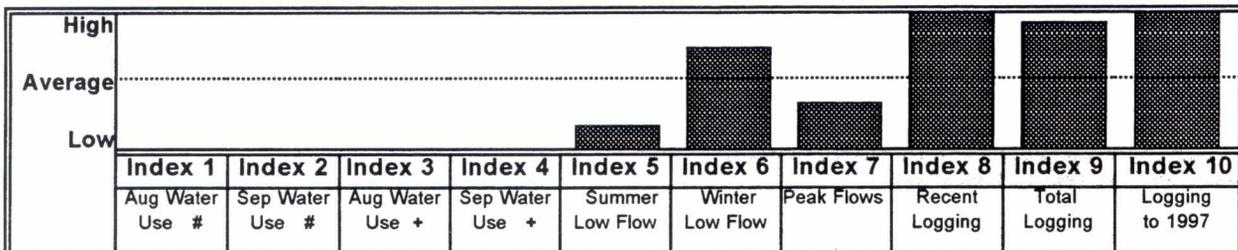
MEAN ANNUAL HYDROGRAPH

(Estimated, using Slesse Creek Station 08MH056)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

LITTLE TAMIHI CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. The Stream Summary Catalogue reports that glaciers in the United States help maintain unusually high flows during the late summer in Little Tamihi Creek. However, winter low flows are rated as more severe than average.

2. Approximately 48% of the watershed has been logged; no additional logging is being proposed in the present 5 year plan.

TAMIHI CREEK

LICENSED WATER DEMAND

Stream number 00-0600-020-090

Tributary to the Chilliwack River

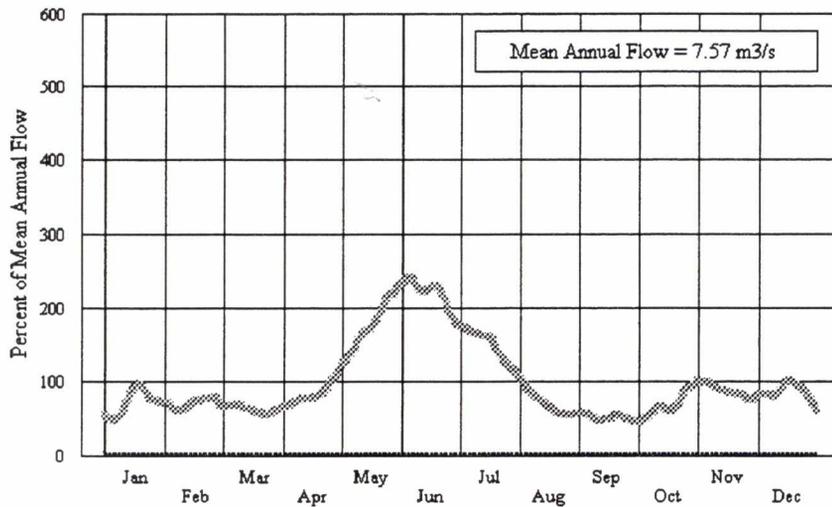
Drainage Area = 123.0 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	22,300 g/d	1.17	1.17	1.17
Irrigation	277 ac.ft.		38.3	19.8
Waterworks	4,000 g/d	0.21	0.21	0.21
Industrial	278,000 g/d	14.6	14.6	14.6
Conservation	140 cfs			

	Feb	Aug	Sep
MEAN STREAM FLOW L/S		4,460	2,850

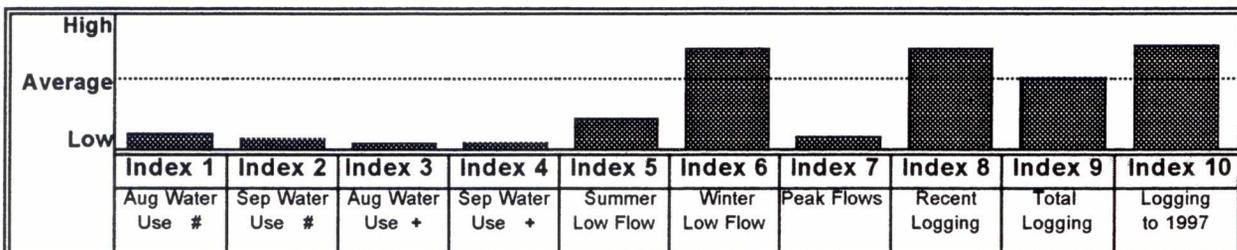
MEAN ANNUAL HYDROGRAPH

(Estimated, using Slesse Creek Station 08MH056)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

TAMIHI CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. The Stream Summary Catalogue reports that glaciers in the United States help maintain unusually high flows during the late summer in Tamihi Creek. However, winter low flows are rated as more severe than average.

THURSTON CREEK

LICENSED WATER DEMAND

Stream number 00-0600-020-115

Ungauged

Tributary to Chilliwack River

Drainage Area = 3.8 km²

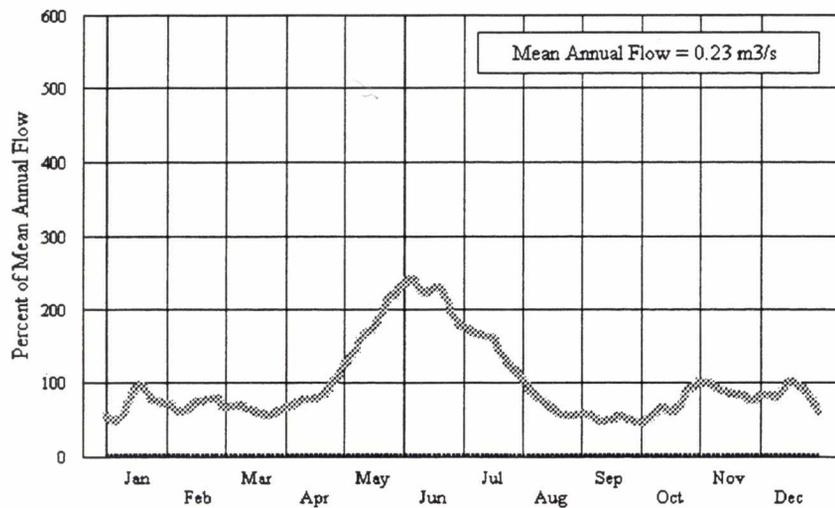
Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	2,000 g/d	0.11	0.11	0.11
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

Feb Aug Sep

MEAN STREAM FLOW L/S	Feb	Aug	Sep
		140	90

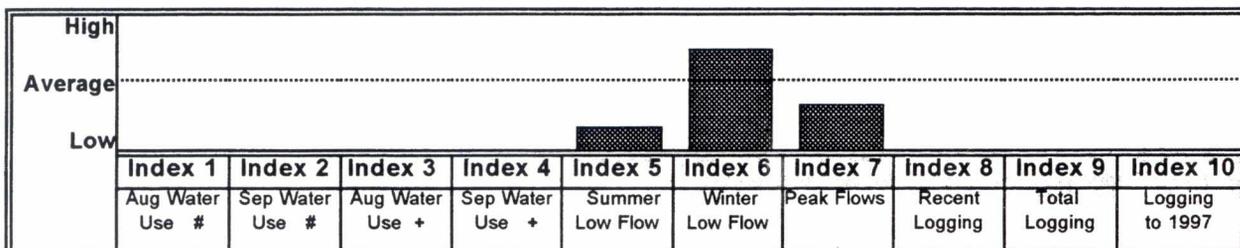
MEAN ANNUAL HYDROGRAPH

(Estimated, using Slesse Creek Station 08MH056)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

THURSTON CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Thurston Creek is a groundwater fed stream that maintains a reasonably constant flow. However, winter low flows are rated as being much lower than average.

BORDEN CREEK

LICENSED WATER DEMAND

Stream number 00-0600-020-120

Ungauged

Tributary to Chilliwack River

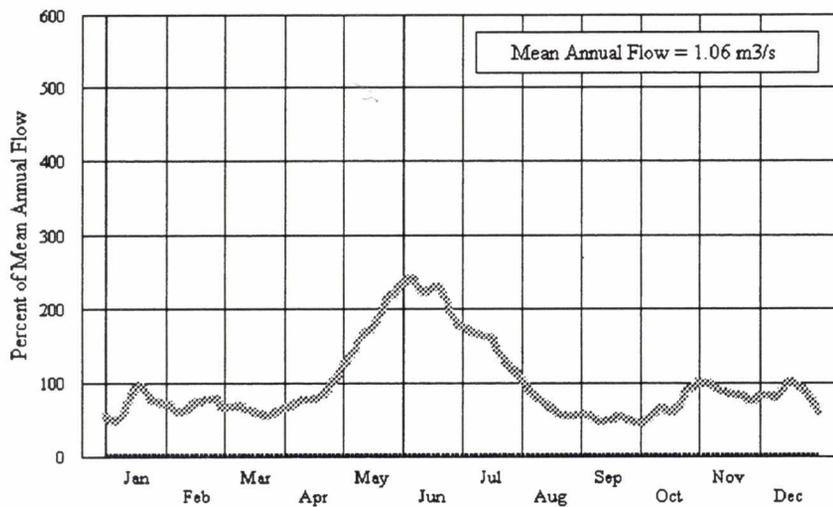
Drainage Area = 17.3 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	4 ac.ft.		0.55	0.29
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

	Feb	Aug	Sep
MEAN STREAM FLOW L/S		630	400

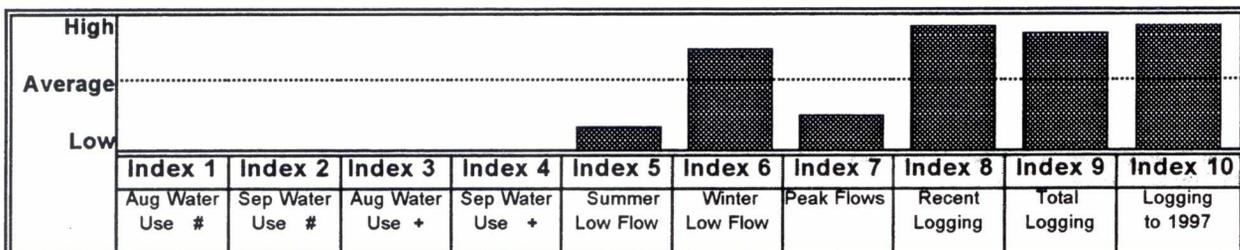
MEAN ANNUAL HYDROGRAPH

(Estimated, using Slesse Creek Station 08MH056)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

BORDEN CREEK

SUMMARY NOTES AND RECOMMENDATIONS

- 1. Approximately 38% of the Borden Creek watershed has been logged and 3% is proposed to be logged, according to the present 5 year plan.*
- 2. Borden Creek has winter low flows lower than average.*

SLESSE CREEK

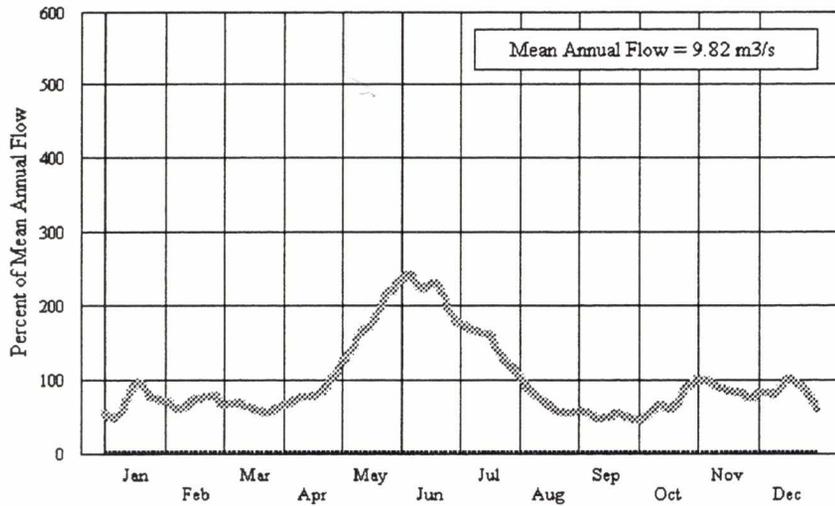
LICENSED WATER DEMAND

Stream number 00-0600-020-130
 Water Survey of Canada Station 08MH056
 SlesseCreek near Vedder Crossing
 Records 1957 to 1990
 Drainage Area = 162 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

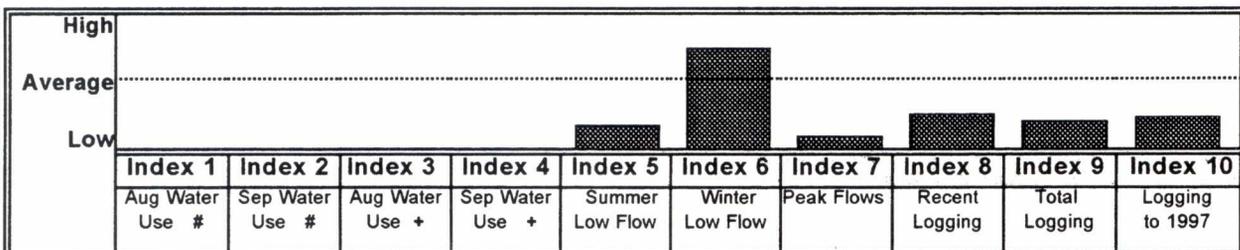
	Feb	Aug	Sep
MEAN STREAM FLOW L/S	6,640	6,920	5,180

MEAN ANNUAL HYDROGRAPH



SENSITIVITY INDICES

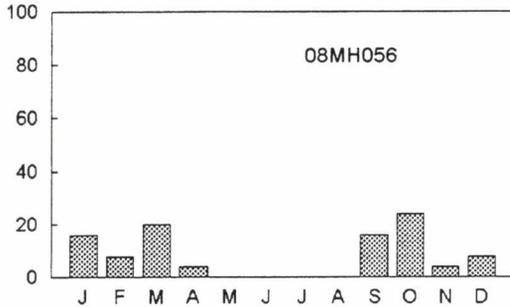
The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



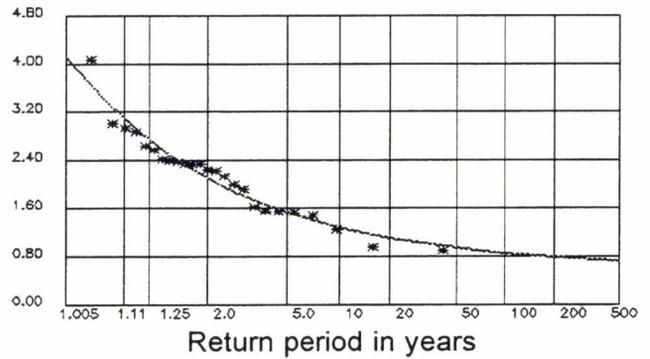
Water use as a proportion of the 7 day low flow
 + Water use as a proportion of the mean monthly flow for the same month

7 DAY LOW FLOWS

*Distribution , by month, of
7 Day Low Flow (in percent)*



*7 Day Low Flow Frequency Curve
(Flow in m³/s)*



Return period	2 years	10 years	20 years	50 years	100 years
7 Day Low Flow	2.10 m ³ /s	1.24 m ³ /s	1.10 m ³ /s	0.93 m ³ /s	0.85 m ³ /s
Annual Flood	52 m ³ /s	75 m ³ /s	83 m ³ /s	94 m ³ /s	103 m ³ /s

SUMMARY NOTES AND RECOMMENDATIONS

1. Slesse Creek is an unstable, active stream. It is the major gravel source to the upper Chilliwack River, partly as a result of large failures which contribute gravel to the river. These failures mostly are a result of road construction and clearcutting in the watershed. A moratorium has been placed on further logging. Several options have been discussed to reduce gravel supply to the Chilliwack River; they include the construction of a berm or a debris basin.

FOLEY CREEK

LICENSED WATER DEMAND

Stream number 00-0600-020-160

Tributary to Chilliwack River

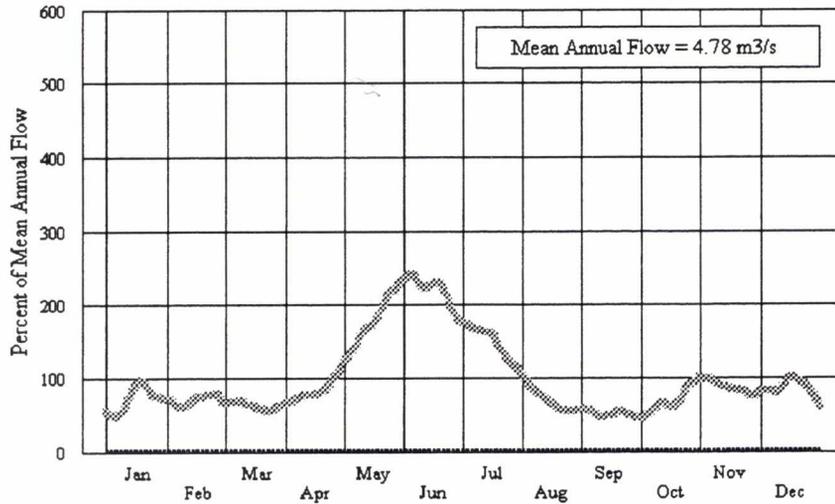
Drainage Area = 77.7 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

	Feb	Aug	Sep
MEAN STREAM FLOW L/S		2,820	1,800

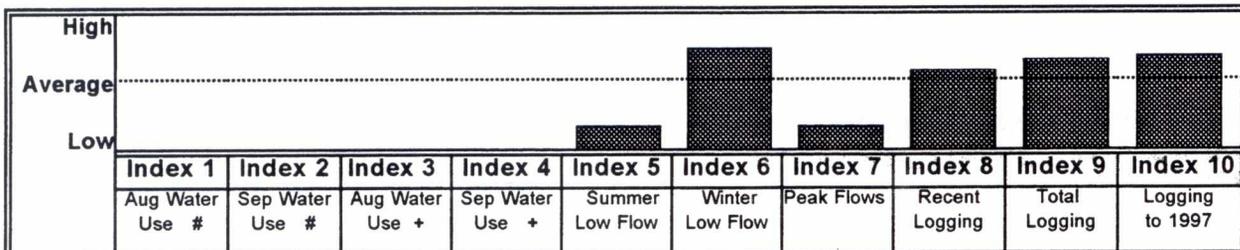
MEAN ANNUAL HYDROGRAPH

(Estimated, using Slesse Creek Station 08MH056)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

FOLEY CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. The District of Chilliwack has applied for waterworks licences on Liumchen and Foley creeks. Both creeks have good quality water. Water from Liumchen alone is viewed as a short term solution to the water supply, but Liumchen together with Foley Creek and storage on Upper or Lower Foley Lake is viewed as a long term solution.

NESAKWATCH CR.

LICENSED WATER DEMAND

Stream number 00-0600-020-170

Ungauged

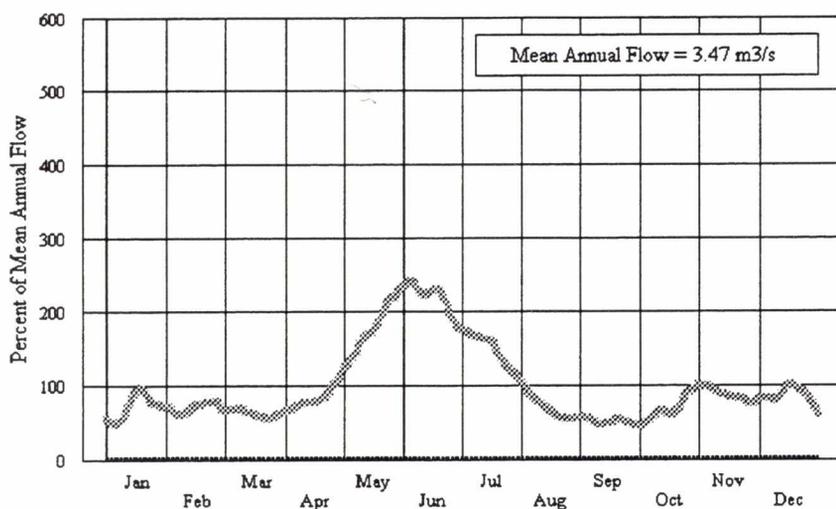
Tributary to Chilliwack River

Drainage Area = 56.4 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			2,050	1,310

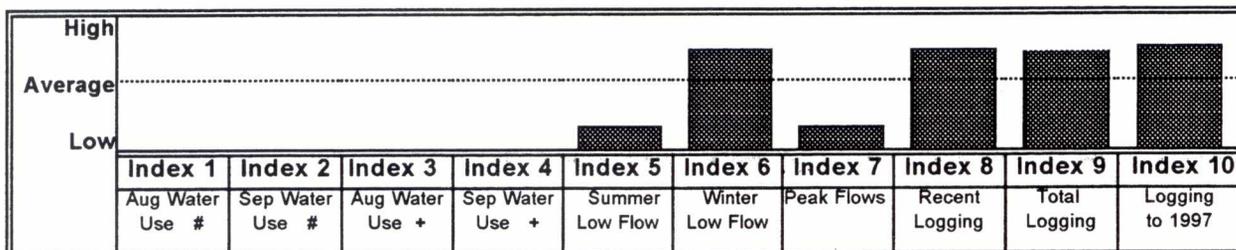
MEAN ANNUAL HYDROGRAPH

(Estimated, using Slesse Creek Station 08MH056)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

NESAKWATCH CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Winter low flows in Nesakwatch Creek are rated as more severe than average. There are no water licences on the creek. Approximately 18% of the watershed has been logged and 2% more is planned for by the present 5 year plan.

FOURTEEN MILE CR.

LICENSED WATER DEMAND

Stream number 00-0600-020-173

Ungauged

Tributary to Chilliwack River

Drainage Area = 2.4 km²

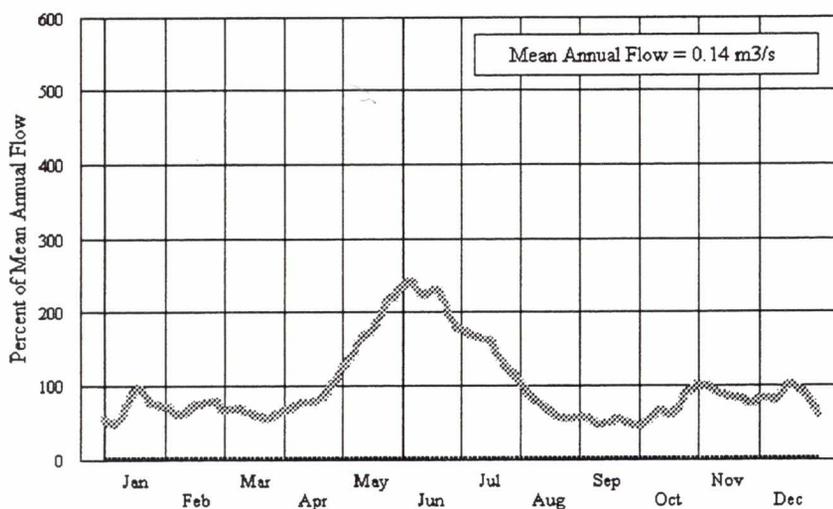
Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

Feb Aug Sep

MEAN STREAM FLOW L/S	Feb	Aug	Sep
		90	50

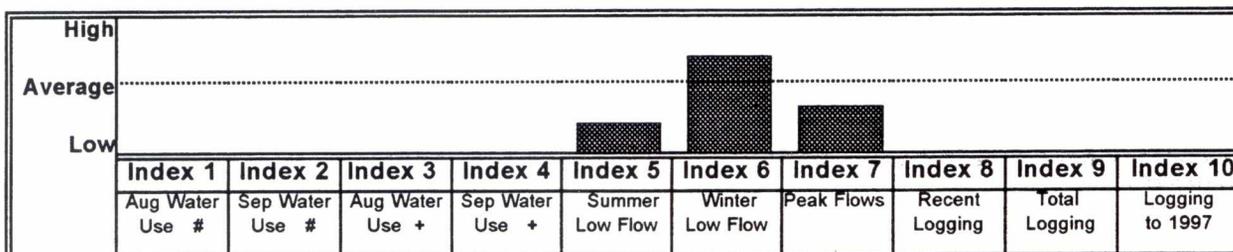
MEAN ANNUAL HYDROGRAPH

(Estimated, using Slesse Creek Station 08MH056)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

FOURTEEN MILE CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Fourteen Mile Creek flows in a former side channel of the Chilliwack River; its flow is sustained by groundwater. During floods, the Chilliwack River deposits fine sediment in the creek, burying spawning gravels. Summer and winter low flows may also limit habitat.

FIFTEEN MILE CR.

LICENSED WATER DEMAND

Stream number 00-0600-020-176
 Ungauged
 Tributary to Chilliwack River

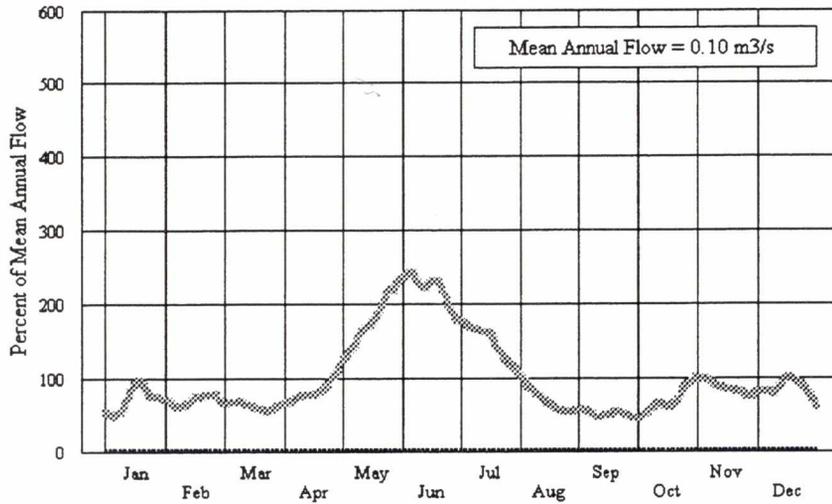
Drainage Area = 1.7 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

	Feb	Aug	Sep
MEAN STREAM FLOW L/S		60	40

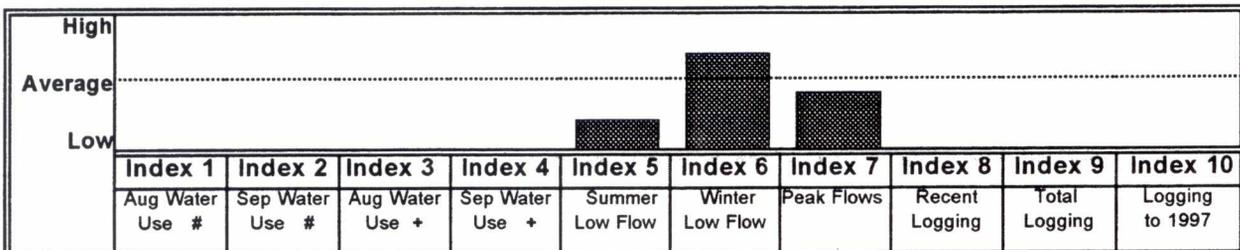
MEAN ANNUAL HYDROGRAPH

(Estimated, using Slesse Creek Station 08MH056)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow
 + Water use as a proportion of the mean monthly flow for the same month

FIFTEEN MILE CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. The Stream Summary Catalogue reports siltation and lack of flow as constraints on this creek. Winter low flows are more severe than average.

CENTER CREEK

LICENSED WATER DEMAND

Stream number 00-0600-020-180

Ungauged

Tributary to Chilliwack River

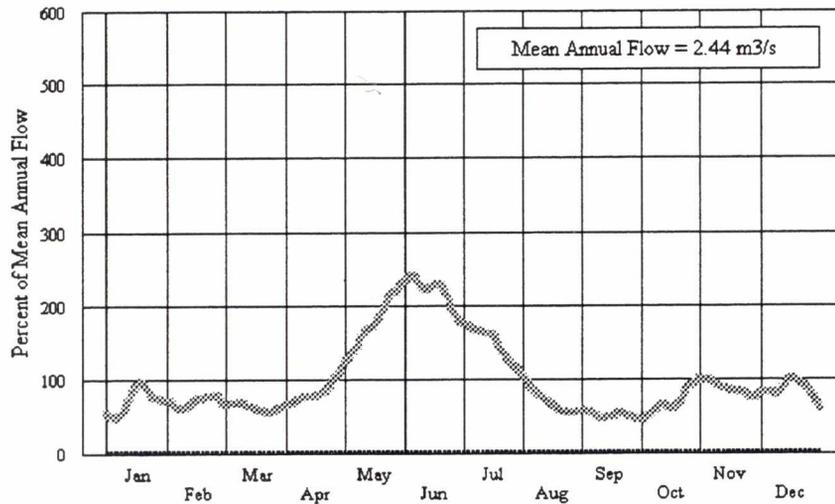
Drainage Area = 39.6 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

MEAN STREAM FLOW L/S	Feb	Aug	Sep
		1,440	920

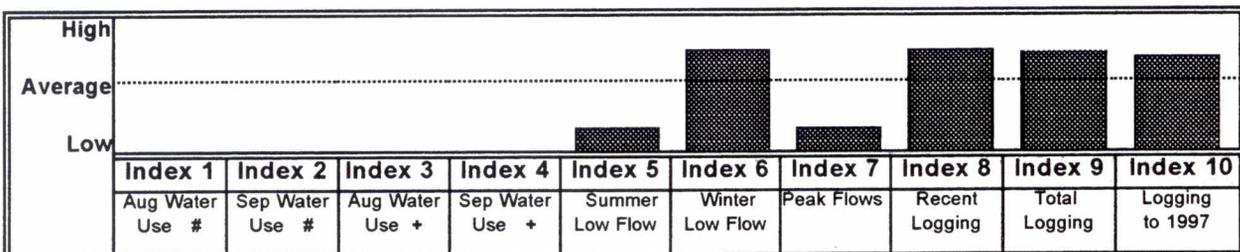
MEAN ANNUAL HYDROGRAPH

(Estimated, using Slesse Creek Station 08MH056)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

CENTER CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Approximately 18% of the watershed of Center Creek has been logged. There are no water licences, but winter low flows are more severe than average.

POST CREEK

LICENSED WATER DEMAND

Stream number 00-0600-020-200

Ungauged

Tributary to Chilliwack River

Drainage Area = 24.5 km²

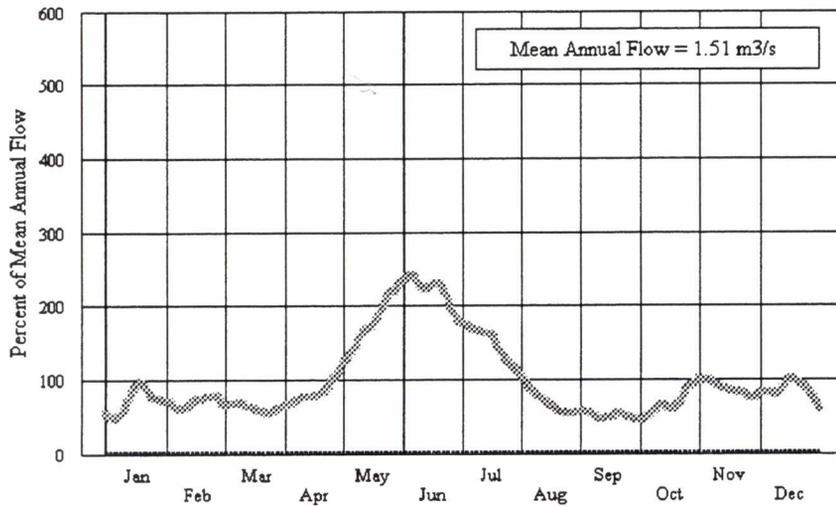
Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

Feb Aug Sep

MEAN STREAM FLOW L/S	Feb	Aug	Sep
		890	570

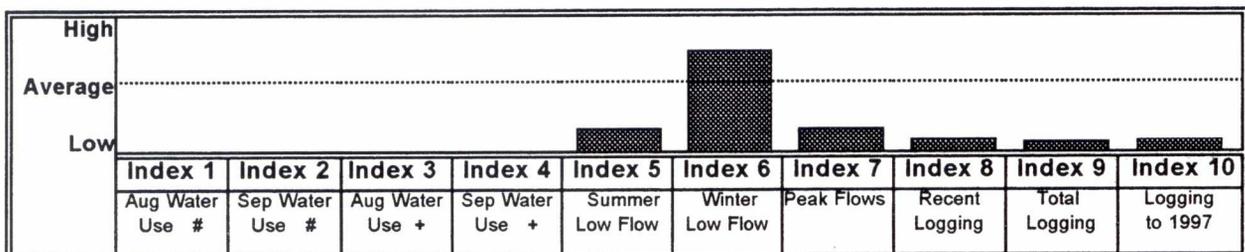
MEAN ANNUAL HYDROGRAPH

(Estimated, using Slesse Creek Station 08MH056)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

POST CREEK

SUMMARY NOTES AND RECOMMENDATIONS

- 1. There are no water licences on Post Creek, but winter low flows are more severe than average. Only 1% of the watershed has been logged.*

PALEFACE CREEK

LICENSED WATER DEMAND

Stream number 00-0600-020-240

Ungauged

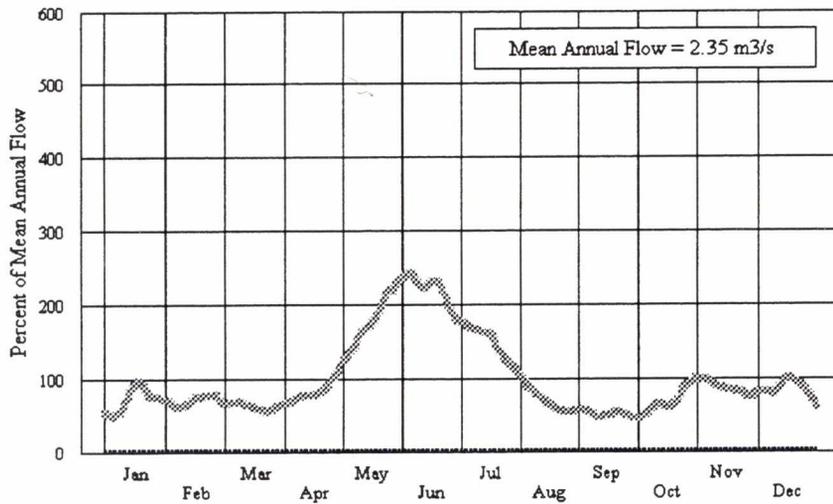
Tributary to Chilliwack River

Drainage Area = 38.2 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			1,380	880

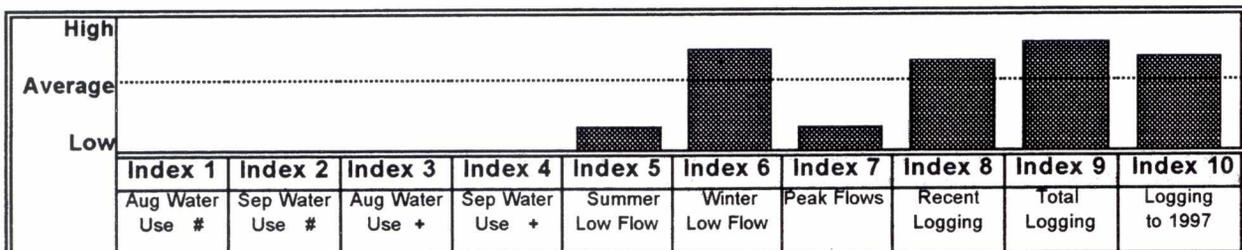
MEAN ANNUAL HYDROGRAPH

(Estimated, using Slesse Creek Station 08MH056)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

PALEFACE CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. There are no water licences on Paleface Creek, but winter low flows are more severe than average. Approximately 34% of the watershed has been logged.

DEPOT CREEK

LICENSED WATER DEMAND

Stream number 00-0600-020-250

Ungauged

Tributary to Chilliwack River

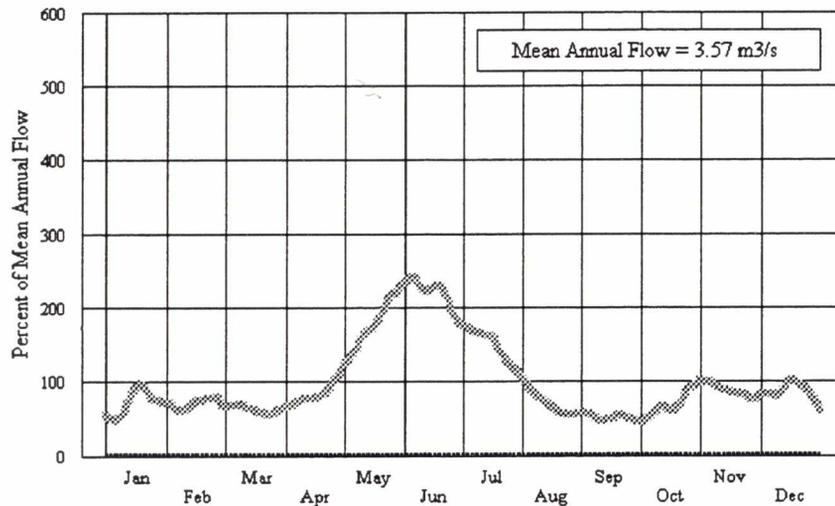
Drainage Area = 58.0 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

	Feb	Aug	Sep
MEAN STREAM FLOW L/S		2,100	1,350

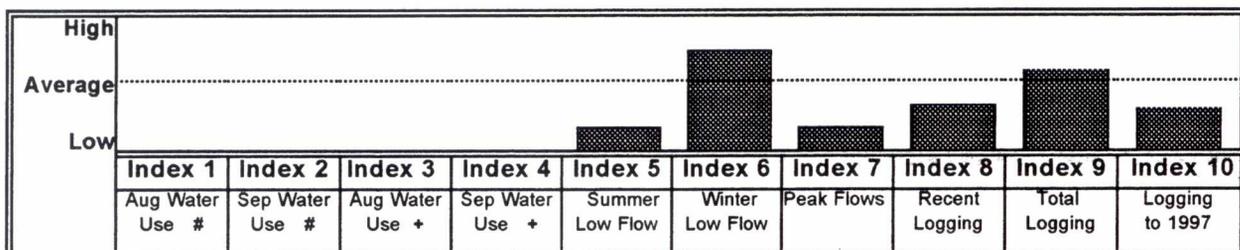
MEAN ANNUAL HYDROGRAPH

(Estimated, using Slesse Creek Station 08MH056)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

DEPOT CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. There are no water licences on Depot Creek, but winter low flows are more severe than average. Approximately 15% of the watershed has been logged.

KILGARD CREEK

LICENSED WATER DEMAND

Stream number 00-0600-050-010

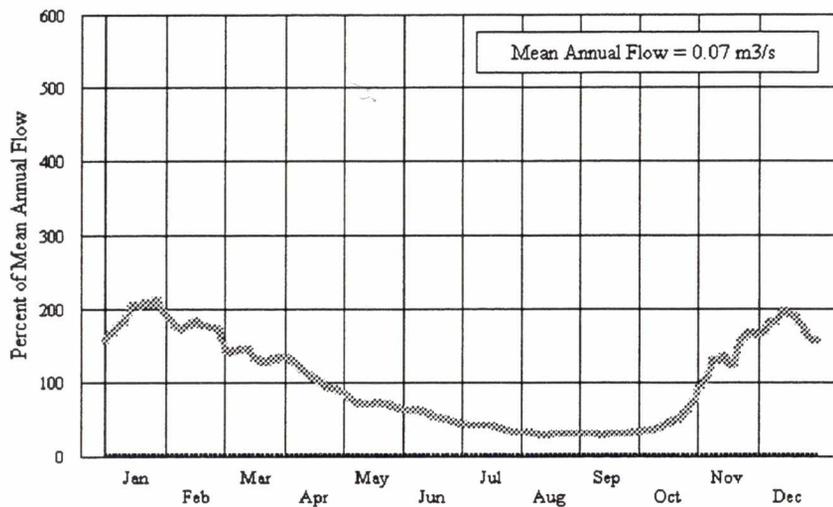
Tributary to the Lonzo Creek

Drainage Area = 2.8 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			10	4

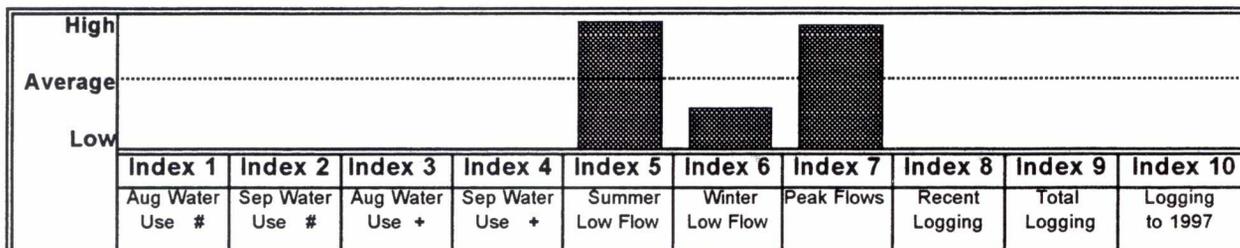
MEAN ANNUAL HYDROGRAPH

(Estimated, using Sumas River Station 08MH029)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

KILGARD CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Kilgard Creek is affected by urban development on Sumas Mountain where there is no requirement for detention or retention structures for flood flows. Siltation in the lower reaches of the creek is a concern.

2. DFO reports that riparian plantings are being made along Kilgard Creek to improve habitat.

CHILLIWACK CREEK

LICENSED WATER DEMAND

Stream number 00-0625

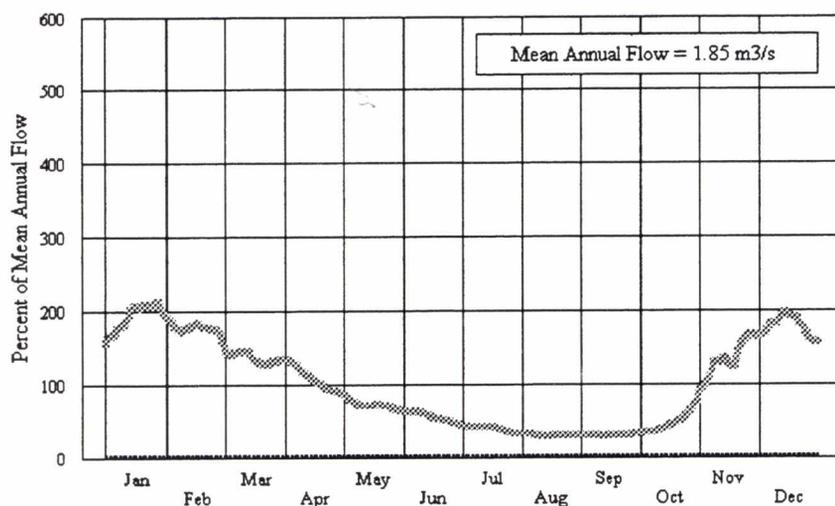
Tributary to the Fraser River

Drainage Area = 78.4 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	19,300 g/d	1.01	1.01	1.01
Irrigation	1,357 ac.ft.		187.5	96.9
Waterworks	0 g/d			
Industrial	1,517,043g/d	79.8	79.8	79.8
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			520	470

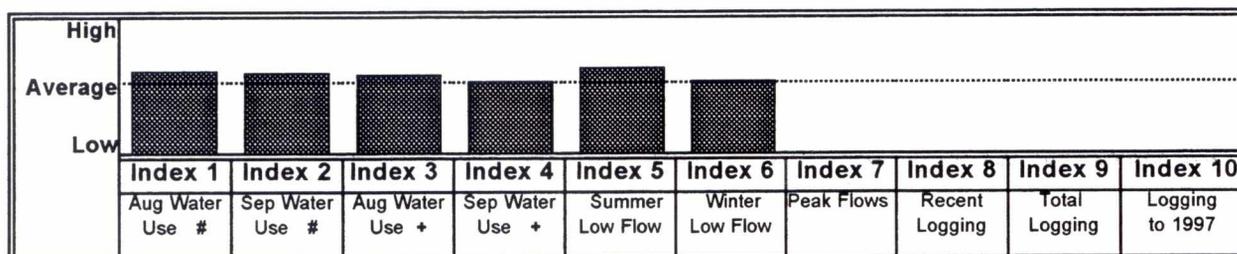
MEAN ANNUAL HYDROGRAPH

(Estimated, using Sumas River Station 08MH029)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

CHILLIWACK CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Chilliwack Creek is an old channel of the Chilliwack/Vedder River and its flow partly results from groundwater inflow. Agricultural water use affects the flow.

2. Chilliwack Creek has been enhanced upstream of Knight Road. About two kilometres of channels were excavated to improve areas where previously there were only standing pools.

ATCHELITZ CREEK

LICENSED WATER DEMAND

Stream number 00-0625-010

Tributary to the Chilliwack Creek

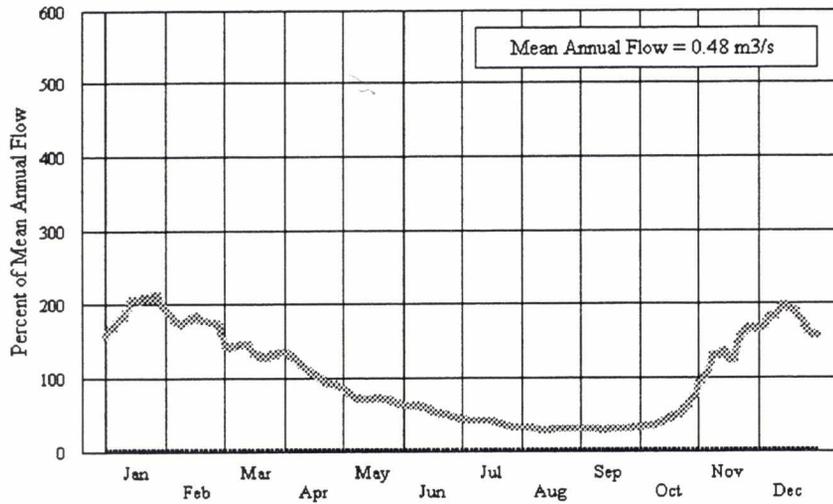
Drainage Area = 20.4 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	263 ac.ft.		36.3	18.8
Waterworks	0 g/d			
Industrial	10,000 g/d	0.53	0.53	0.53
Conservation	0 cfs			

	Feb	Aug	Sep
MEAN STREAM FLOW L/S		140	120

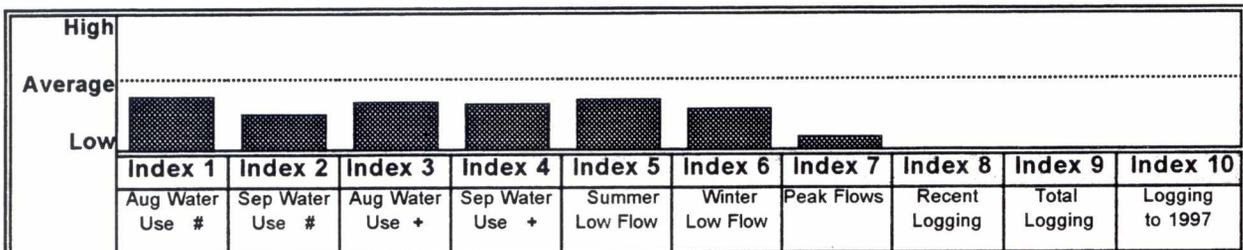
MEAN ANNUAL HYDROGRAPH

(Estimated, using Sumas River Station 08MH029)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

ATCHELITZ CREEK

SUMMARY NOTES AND RECOMMENDATIONS

- 1. The Stream Summary Catalogue reports low flow problems along this creek and notes that DFO opposes further water removals.*
- 2. Siltation from erosion of agricultural lands is reported to have affected much of the creek.*

LUCKAKUCK CREEK

LICENSED WATER DEMAND

Stream number 00-0625-030

Ungauged

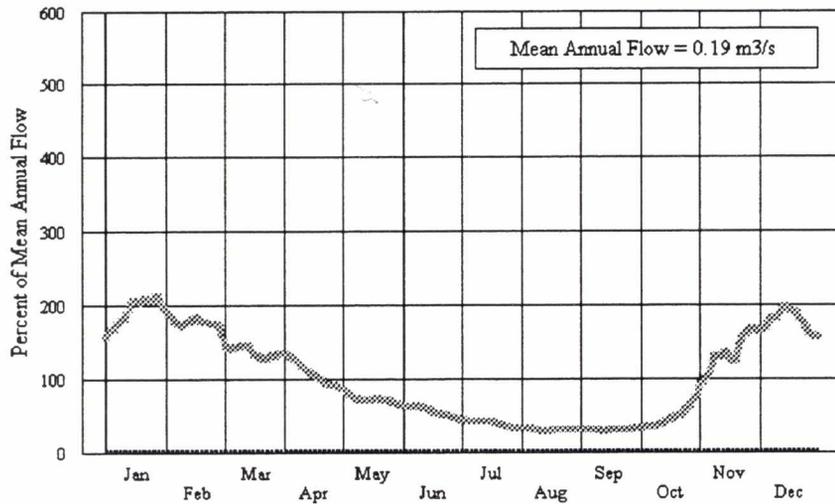
Tributary to the Chilliwack Creek

Drainage Area = 8.1 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	500 g/d	0.03	0.03	0.03
Irrigation	317 ac.ft.		43.8	22.6
Waterworks	0 g/d			
Industrial	1,500,500g/d	79.0	79.0	79.0
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			50	50

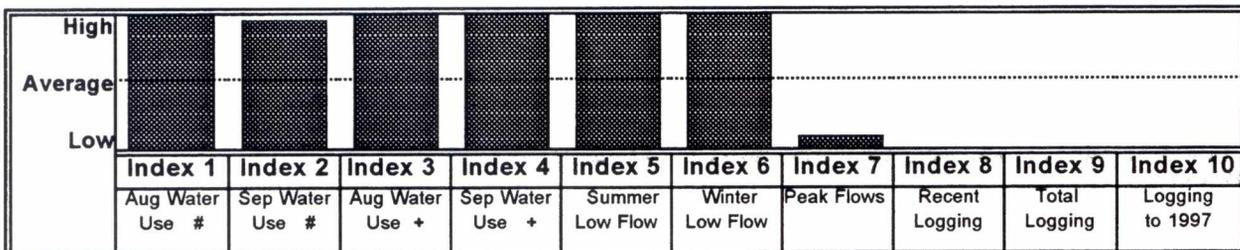
MEAN ANNUAL HYDROGRAPH

(Estimated, using Sumas River Station 08MH029)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

LUCKAKUCK CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Luckakuck Creek is an old channel of the Chilliwack/Vedder River and its flow partly results from groundwater inflow. Agricultural water use affects the flow.

2. Commercial, industrial and residential development in the Luckakuck watershed affect its hydrology. About 21% of the watershed is now effectively impervious. Both industrial and residential developments encroach on the creek and riparian vegetation has been removed in most residential areas.

SEMMIHAULT CREEK

LICENSED WATER DEMAND

Stream number

Ungauged

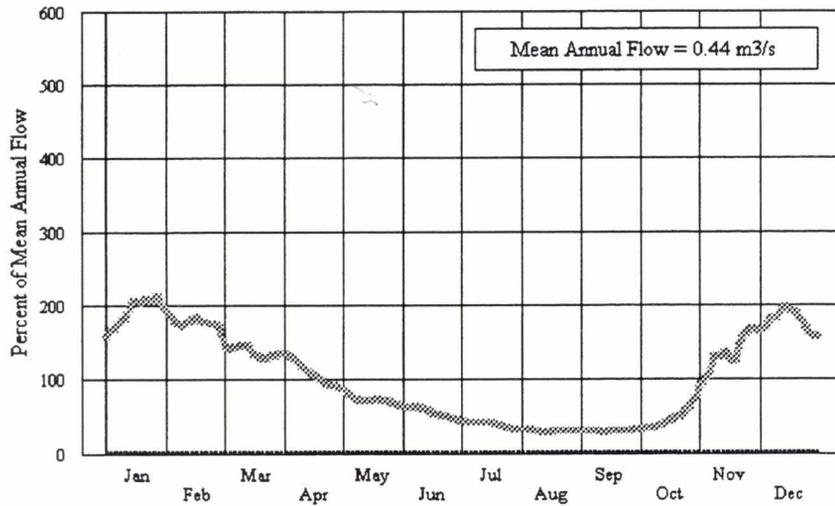
Tributary to the Chilliwack Creek

Drainage Area = 18.5 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	16,000 g/d	0.84	0.84	0.84
Irrigation	290 ac.ft.		40.0	20.7
Waterworks	0 g/d			
Industrial	4,723 g/d	0.25	0.25	0.25
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			110	120

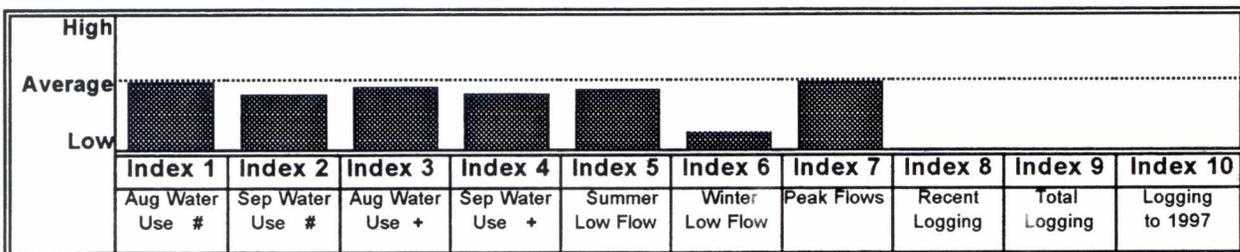
MEAN ANNUAL HYDROGRAPH

(Estimated, using Sumas River Station 08MH029)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

SEMMIHAULT CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Semmihault Creek has domestic, irrigation and industrial water demands. Summer water use and summer low flows are rated as being more severe than average.

CALKINS CREEK

LICENSED WATER DEMAND

Stream number 00-0640-020-004

Ungauged

Tributary to Semmihault Creek

Drainage Area = 3.5 km²

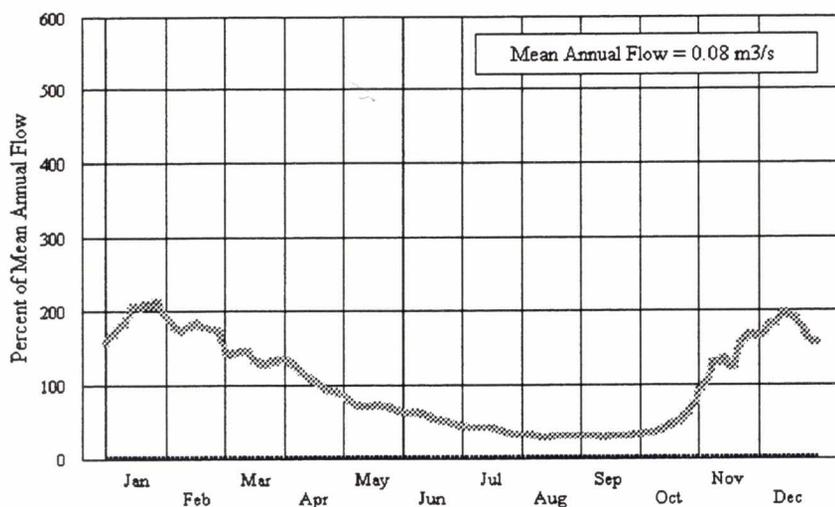
Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	1,500 g/d	0.08	0.08	0.08
Irrigation	25 ac.ft.		3.46	1.79
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			

Feb Aug Sep

MEAN STREAM FLOW L/S	Feb	Aug	Sep
		20	20

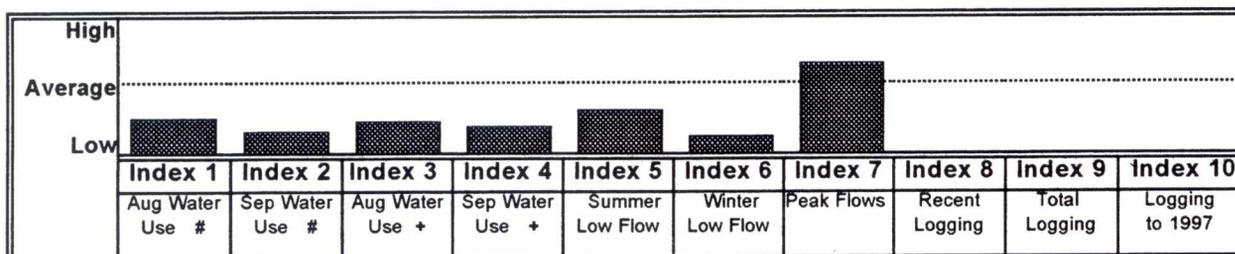
MEAN ANNUAL HYDROGRAPH

(Estimated, using Sumas River Station 08MH029)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

CALKINS CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. The Stream Summary Catalogue reports low flow problems along this creek and notes that DFO opposes further water removals.

MARBLEHILL CREEK

LICENSED WATER DEMAND

Stream number 00-0640-020-004-800

Ungauged

Tributary to Semmihault Creek

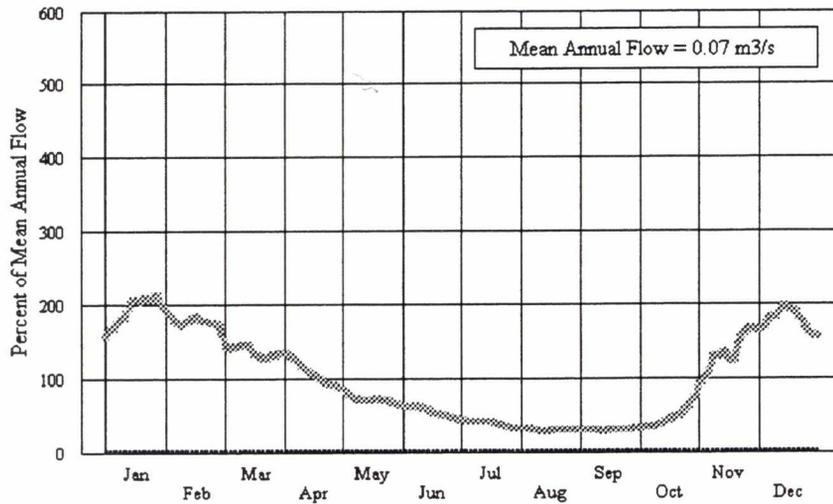
Drainage Area = 2.8 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	11,500 g/d	0.61	0.61	0.61
Irrigation	46 ac.ft.		6.36	3.28
Waterworks	0 g/d			
Industrial	1,000 g/d	0.05	0.05	0.05
Conservation	0 cfs			

MEAN STREAM FLOW L/S	Feb	Aug	Sep
		20	20

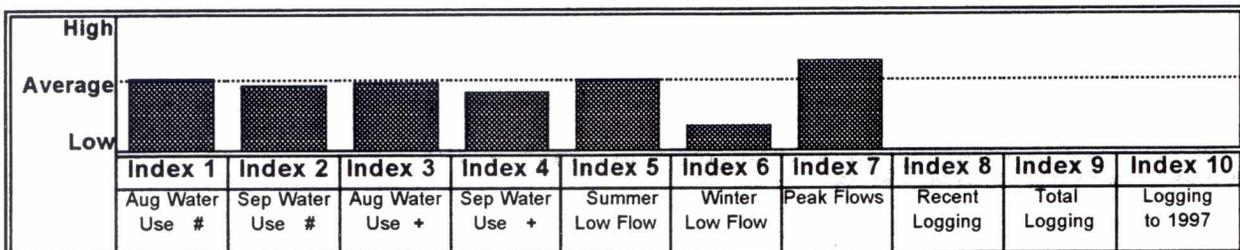
MEAN ANNUAL HYDROGRAPH

(Estimated, using Sumas River Station 08MH029)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

MARBLEHILL CREEK

SUMMARY NOTES AND RECOMMENDATIONS

- 1. The Stream Summary Catalogue reports low flow problems along this creek and notes that DFO opposes further water removals.*
- 2. Urban development on Marblehill Road has no provision for detention or retention storage.*
- 3. A licence for industrial use (fish culture) is being converted to bottling of water for export. The licence has been reduced from 3 cfs to 150,000 gallons per day and has a rider regarding future use.*

LONZO CREEK

LICENSED WATER DEMAND

Stream number 00-0600-050

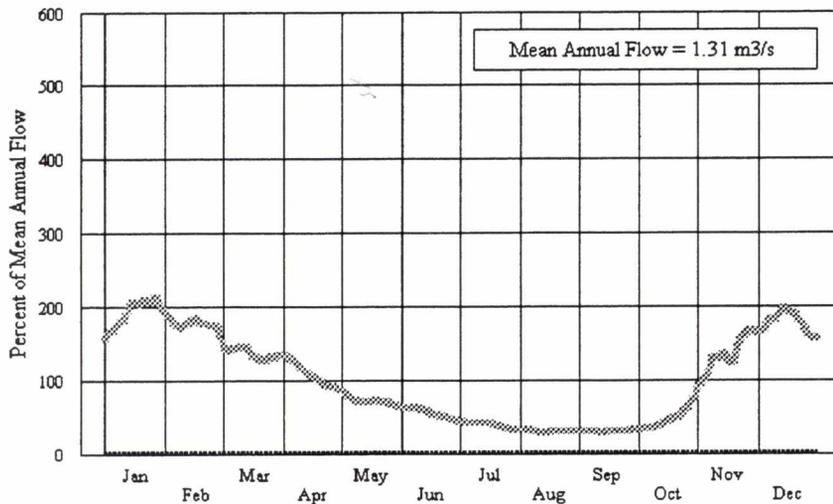
Tributary to the Sumas River

Drainage Area = 26.0 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	18,000 g/d	0.95	0.95	0.95
Irrigation	601 ac.ft.		83.0	42.9
Waterworks	0 g/d			
Industrial	1,110,500g/d	58.4	58.4	58.4
Conservation	9 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			610	670

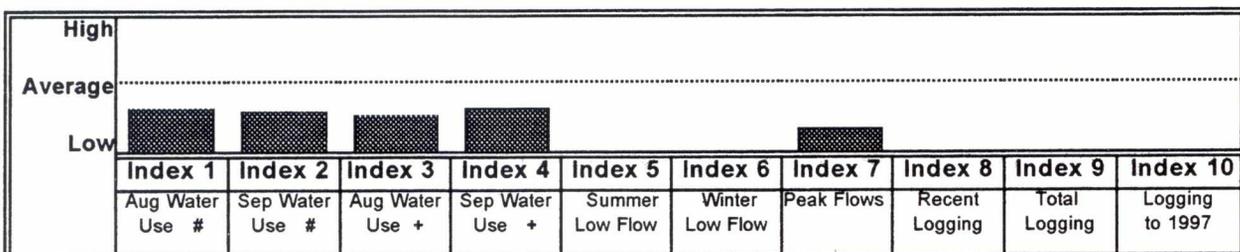
MEAN ANNUAL HYDROGRAPH

(Estimated, using Sumas River Station 08MH029)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

LONZO CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. A series of springs from the Abbotsford Aquifer provided high natural flows in Lonzo Creek. Wells for the Fraser Valley Trout Hatchery and the District of Abbotsford now withdraw water from this part of the aquifer, reducing flows in Lonzo Creek.

2. Industrial and residential development have increased the effective impervious area to about 6 % of the watershed area. Further development may begin to alter the hydrologic regime. Landfilling and other encroachments have narrowed the floodplain of the creek.

HOPE SLOUGH

LICENSED WATER DEMAND

Stream number 00-0640

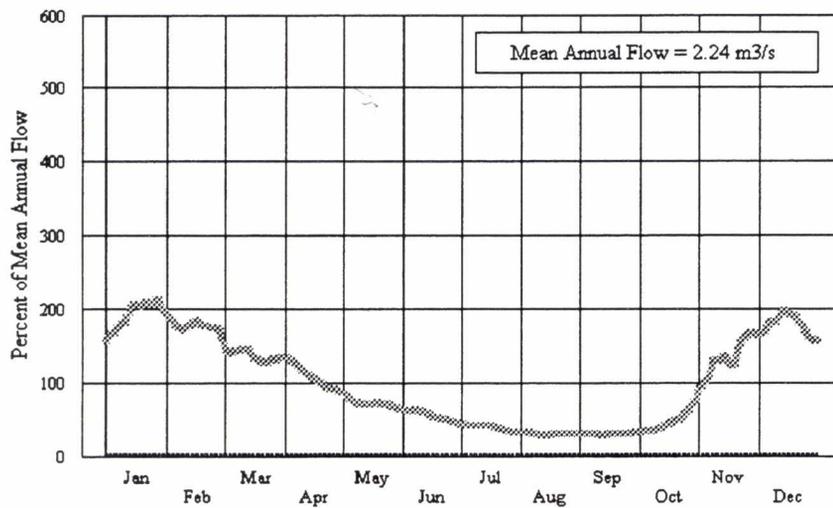
Tributary to the Fraser River

Drainage Area = 100.3 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	6,050 g/d	0.32	0.32	0.32
Irrigation	1,768 ac.ft.		244.3	126.2
Waterworks	4,700,000g/d	247.3	247.3	247.3
Industrial	162,315g/d	8.54	8.54	8.54
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			770	800

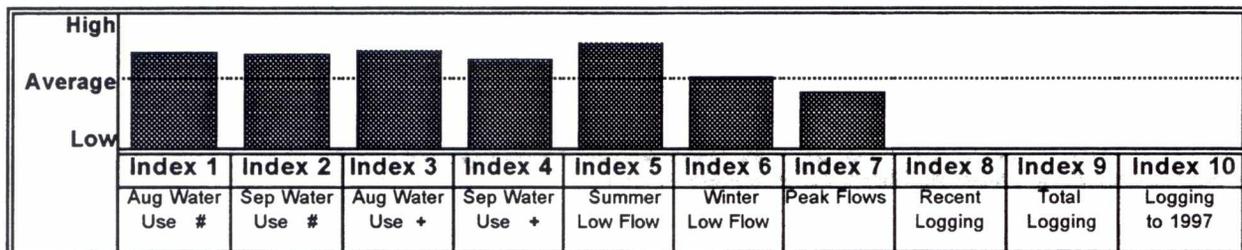
MEAN ANNUAL HYDROGRAPH

(Estimated, using Sumas River Station 08MH029)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

HOPE SLOUGH

SUMMARY NOTES AND RECOMMENDATIONS

1. As properties along Hope Slough extend to the centreline of the slough, owners often "beautify" them by removing riparian vegetation and growing lawn to the edge of the slough.

2. De Leuw and Stewart (1981) examined land and water use along the slough and concluded that there was low potential for enhancement because of degradation through clearing and dyking.

3. The Department of Fisheries and Oceans hopes that an education program for land owners will lead to restoration of riparian vegetation.

ELK CREEK

LICENSED WATER DEMAND

Stream number 00-0640-020

Water Survey of Canada Station 08MH048

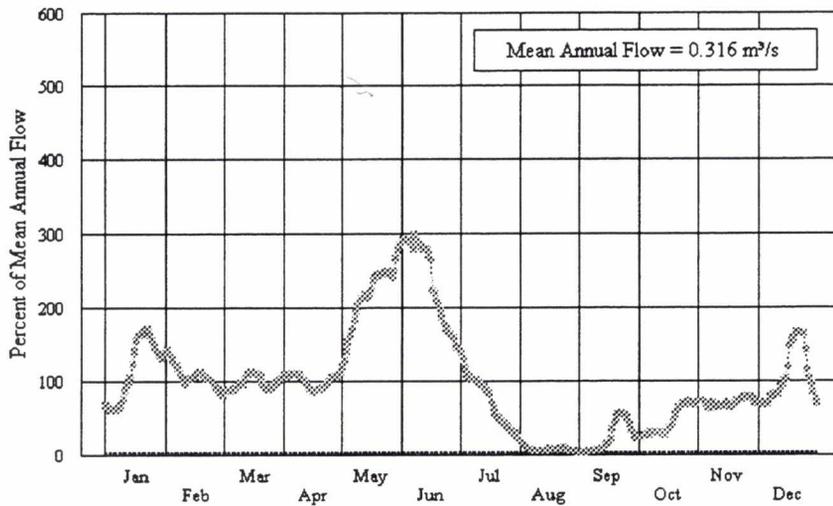
Elk Creek at Prairie Central Road

Records 1960 to 1974

Drainage Area = 11.9 km²

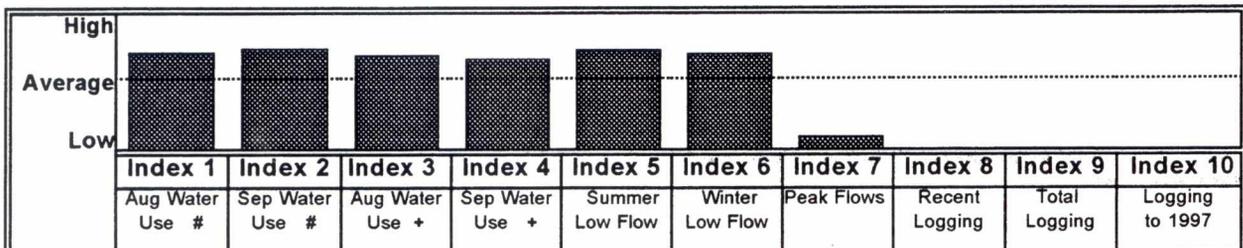
Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	3,000,000g/d	157.9	157.9	157.9
Industrial	150,000 g/d	7.9	7.9	7.9
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S		335	19	64

MEAN ANNUAL HYDROGRAPH



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

ELK CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. The District of Chilliwack operates an intake on Elk Creek. A low flow bypass is used to maintain 0.2 m³/s during spawning and 0.11 m³/s during rearing.

2. Agriculture is the main activity in the watershed. Most of the lower 4 km of the creek are in a ditch, and riparian vegetation has been removed. Riparian planting and fencing are needed to rehabilitate the creek and control cattle access. A shale trap operates about 4 km from the mouth: removal of accumulated material has caused siltation downstream.

3. The Ministry of Forests is preparing a Watershed Resource Plan for the upper part of Elk Creek.

FORD CREEK

LICENSED WATER DEMAND

Stream number 00-0640-020-020

Ungauged

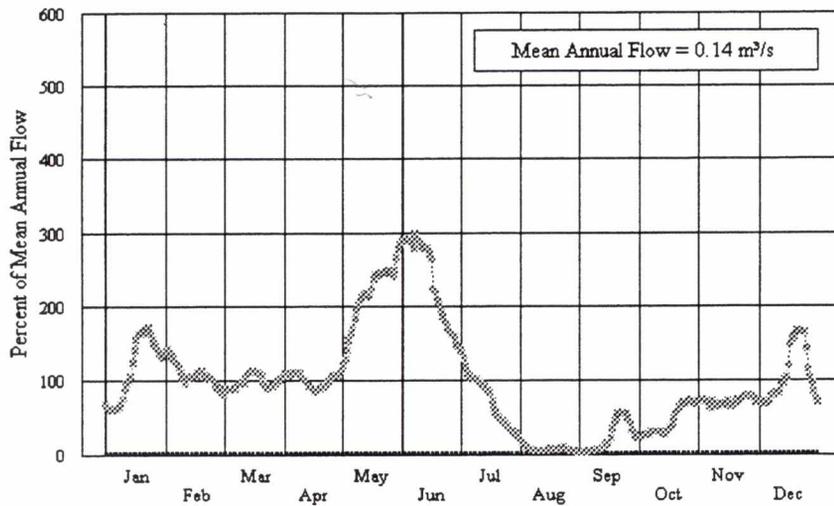
Tributary to Elk Creek

Drainage Area = 5.8 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	3,500 g/d	0.18	0.18	0.18
Irrigation	38 ac.ft.		5.25	2.71
Waterworks	0 g/d			
Industrial	11,000 g/d	0.58	0.58	0.58
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			40	40

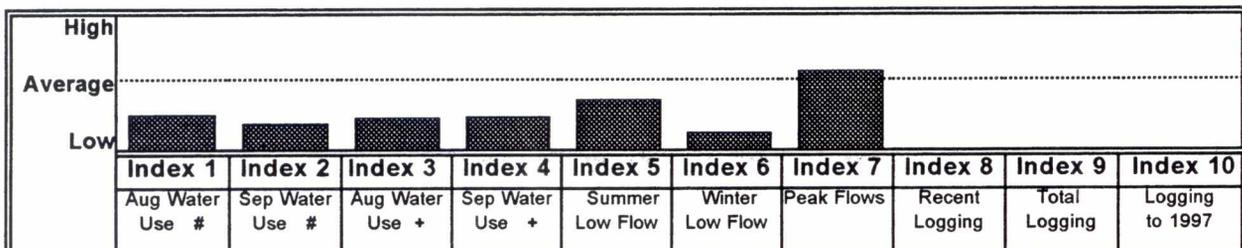
MEAN ANNUAL HYDROGRAPH

(Estimated, using Elk Creek Station 08MF048)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

FORD CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Ford Creek has domestic, irrigation and industrial water demands, but summer water use is rated as being below average.

DUNVILLE CREEK

LICENSED WATER DEMAND

Stream number 00-0640-030

Ungauged

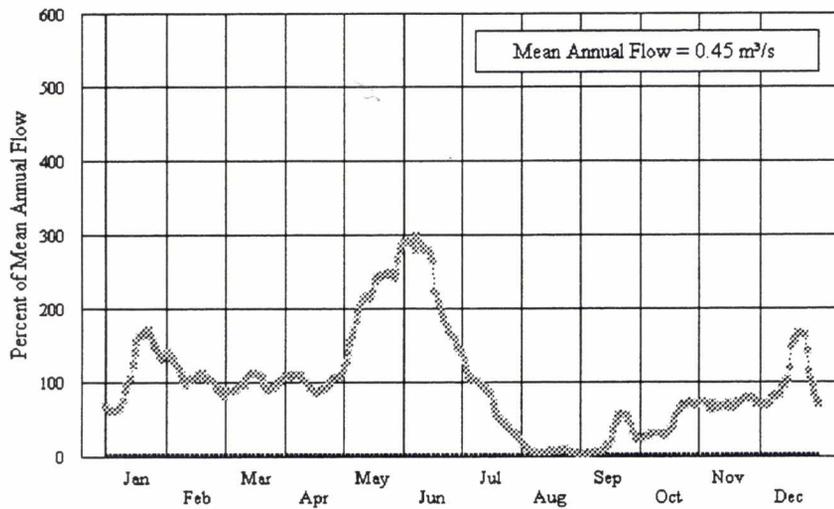
Tributary to Hope Slough

Drainage Area = 19.0 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	2,550 g/d	0.13	0.13	0.13
Irrigation	90 ac.ft.		12.4	6.43
Waterworks	1,700,000g/d	89.5	89.5	89.5
Industrial	200 g/d	0.01	0.01	0.01
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			120	120

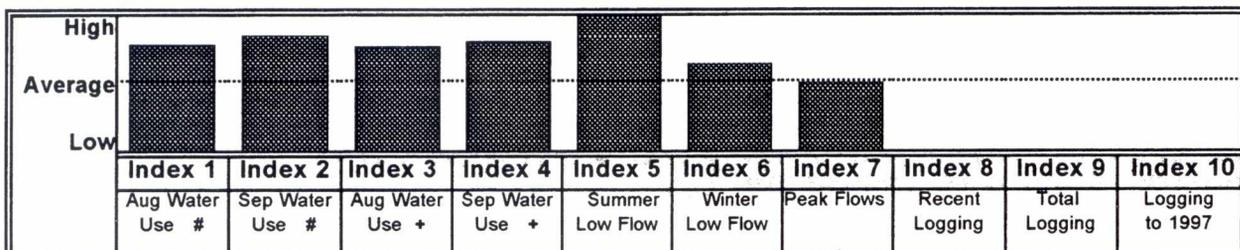
MEAN ANNUAL HYDROGRAPH

(Estimated, using Elk Creek Station 08MF048)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

DUNVILLE CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. The District of Chilliwack has a waterworks intake on Dunville Creek which has no provision for the bypass of low flows. A low flow bypass will be added during the next upgrade of the intake.

2. The Stream Summary Catalogue notes that waterworks and agricultural diversions reduce flows in the creek and that DFO opposes further water removals.

3. A debris trap in upper Dunville Creek sometimes overflows during floods and sediment is carried downstream.

NEVIN CREEK

LICENSED WATER DEMAND

Stream number 00-0640-030-005

Ungauged

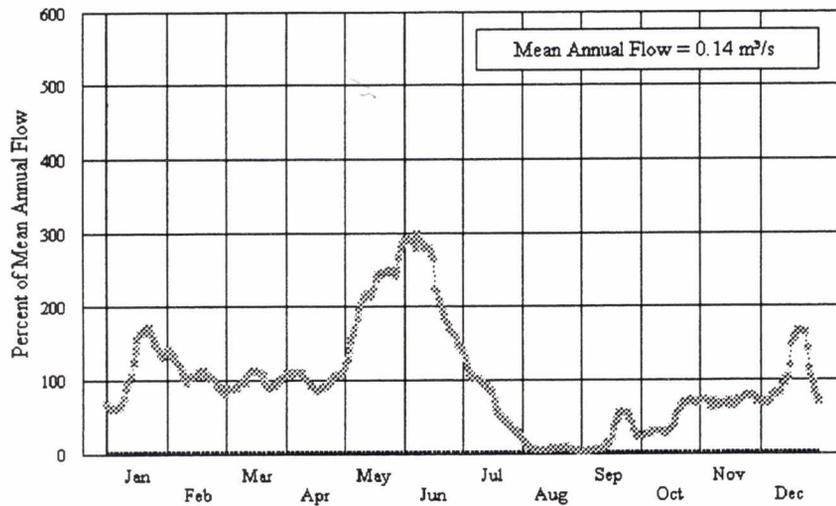
Tributary to Dunville Creek

Drainage Area = 5.8 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	1,000 g/d	0.05	0.05	0.05
Irrigation	32 ac.ft.		4.42	2.28
Waterworks	1,000,000g/d	52.6	52.6	52.6
Industrial	0 g/d			
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			40	40

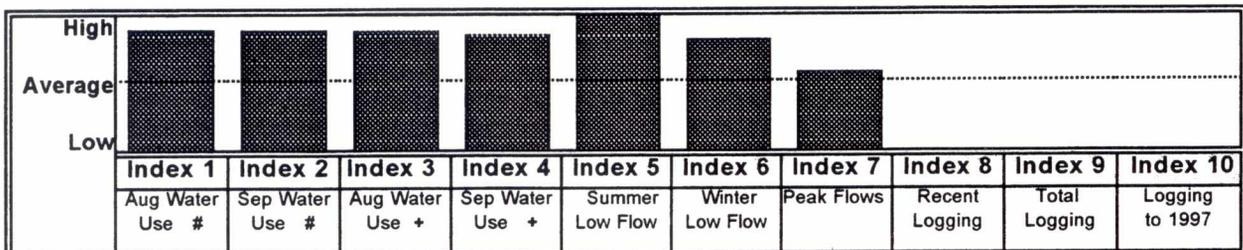
MEAN ANNUAL HYDROGRAPH

(Estimated, using Elk Creek Station 08MF048)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

NEVIN CREEK

SUMMARY NOTES AND RECOMMENDATIONS

- 1. The District of Chilliwack has a waterworks intake on Nevin Creek which has no provision for the bypass of low flows. A low flow bypass will be added during the next upgrade of the intake.*
- 2. The Stream Summary Catalogue notes that waterworks and agricultural diversions reduce flows in the creek and that DFO opposes further water removals.*

CAMP SLOUGH

LICENSED WATER DEMAND

Stream number 00-0640-010

Ungauged

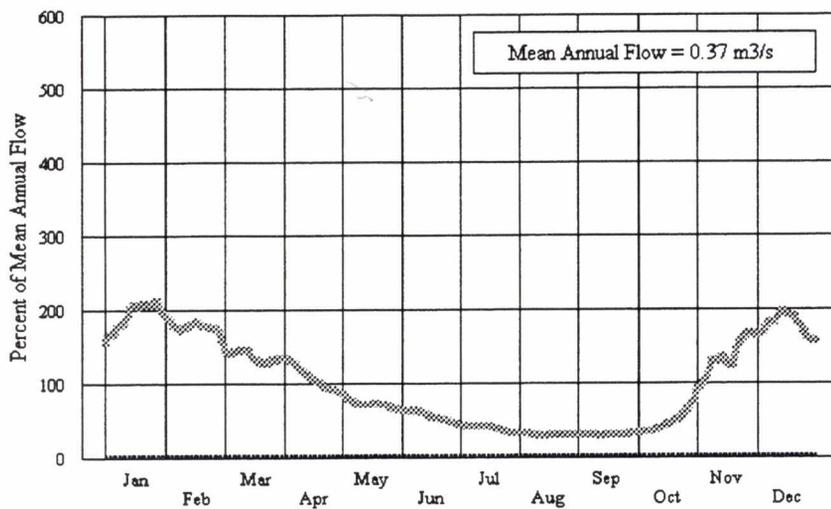
Tributary to Hope Slough

Drainage Area = 15.5 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	850 g/d	0.04	0.04	0.04
Irrigation	658 ac.ft.		90.9	47.0
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			100	100

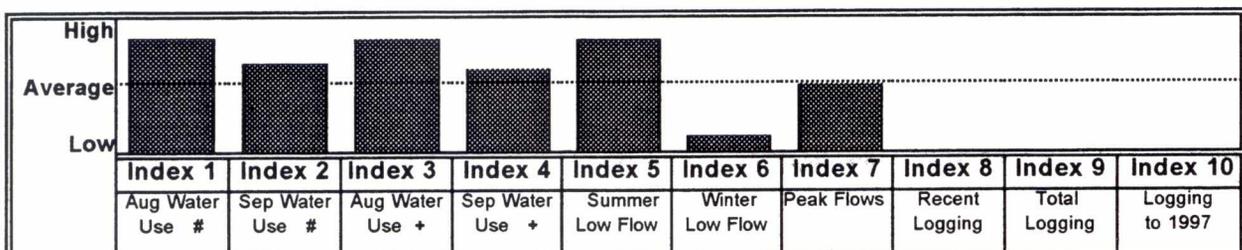
MEAN ANNUAL HYDROGRAPH

(Estimated, using Sumas River Station 08MH029)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

CAMP SLOUGH

SUMMARY NOTES AND RECOMMENDATIONS

1. De Leuw and Stewart (1981) examined land and water use along the slough and concluded that there was low potential for enhancement because of degradation through clearing and dyking.

2. The Department of Fisheries and Oceans hopes that an education program for land owners will lead to restoration of riparian vegetation.

WAHLEACH SLOUGH

LICENSED WATER DEMAND

Stream number 00-0685

Ungauged

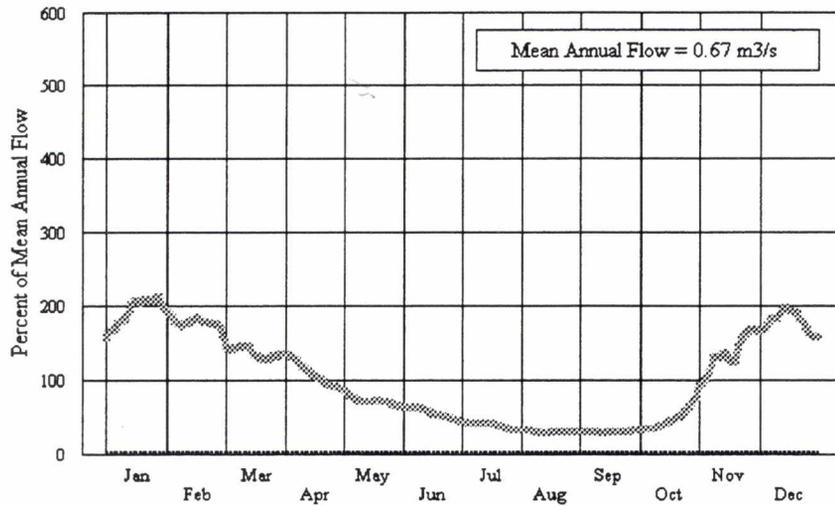
Tributary to the Fraser River

Drainage Area = 28.2 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	0 g/d			
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	0 g/d			
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			170	180

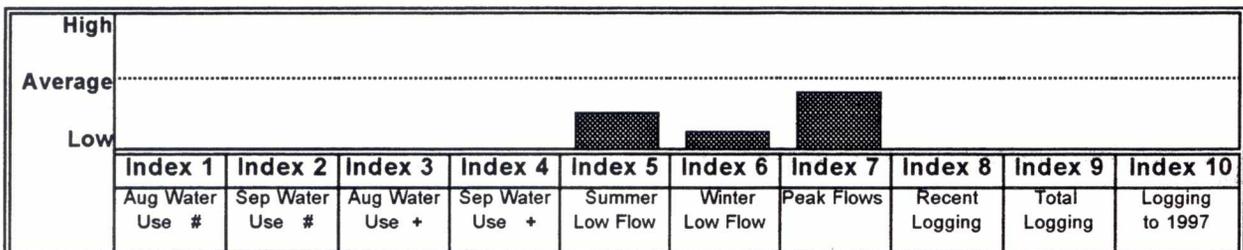
MEAN ANNUAL HYDROGRAPH

(Estimated, using Sumas River Station 08MH029)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

WAHLEACH SLOUGH

SUMMARY NOTES AND RECOMMENDATIONS

1. Wahleach Slough is very productive but sediments are deposited in the slough during Fraser River freshets. Scott Paper Ltd. has a woodlot licence on the island between Wahleach Slough and the Fraser River. As compensation for crossing the slough they have dug channels to create spawning areas.

POPCUM CREEK

LICENSED WATER DEMAND

Stream number 00-0690

Ungauged

Tributary to the Fraser River

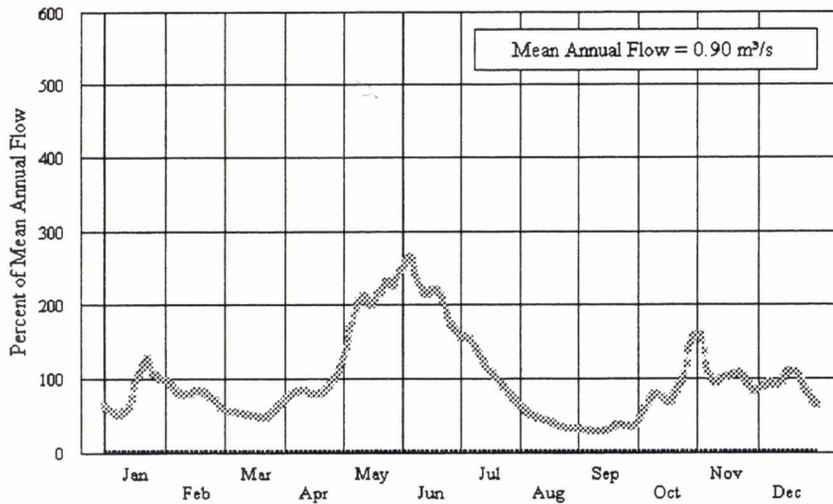
Drainage Area = 20.4 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	3,000 g/d	0.16	0.16	0.16
Irrigation	8 ac.ft.		1.10	0.57
Waterworks	0 g/d			
Industrial	3,772,044g/d	198.5	198.5	198.5
Conservation	0 cfs			

	Feb	Aug	Sep
MEAN STREAM FLOW L/S		410	340

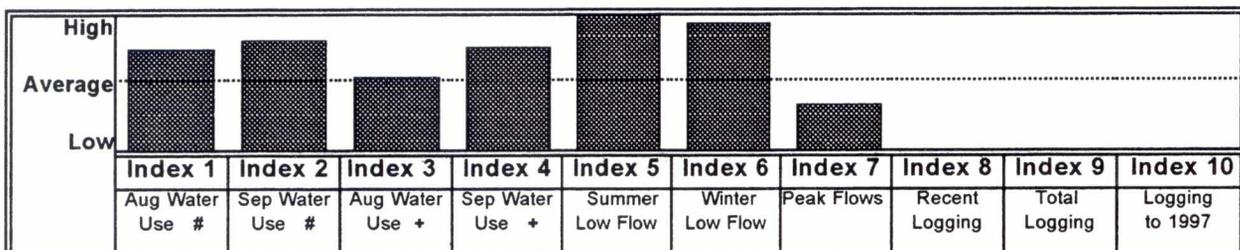
MEAN ANNUAL HYDROGRAPH

(Estimated, using Silverhope Creek Station 08MF009)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

POPCUM CREEK

SUMMARY NOTES AND RECOMMENDATIONS

1. Popum Creek has been enhanced through the Salmon Enhancement Program. Access through culverts has been improved and a fish ladder has been installed at Cheam Lake.

2. There is a golf course and urban development along the lower reaches of Popum Creek, but a 30 metre riparian corridor has been left.

WAHLEACH CREEK

LICENSED WATER DEMAND

Stream number 00-0735

Water Survey of Canada Station 08MF034

Wahleach Creek near Laidlaw (lower station)

Records 1950 to 1969

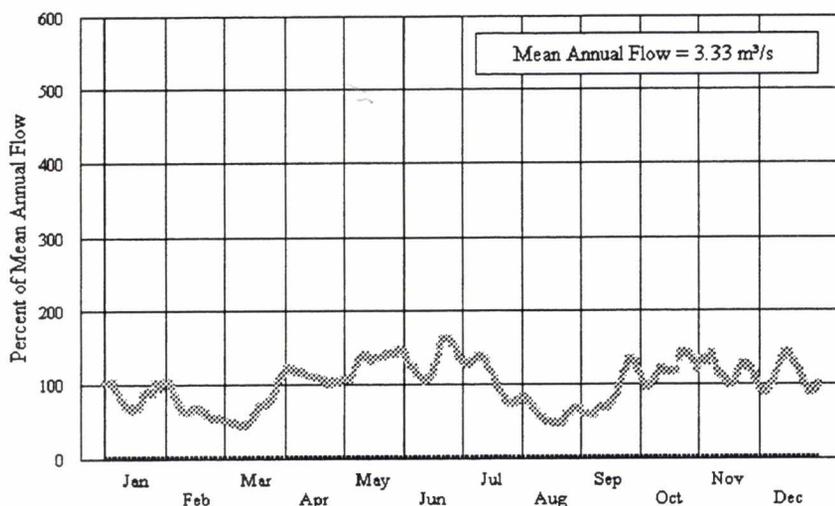
Drainage Area = 114 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	500 g/d	0.03	0.03	0.03
Irrigation	0 ac.ft.			
Waterworks	10,000 g/d	0.53	0.53	0.53
Industrial	0 g/d			
Conservation	0 cfs			

	Feb	Aug	Sep
MEAN STREAM FLOW L/S	2,340	2,530	2,960

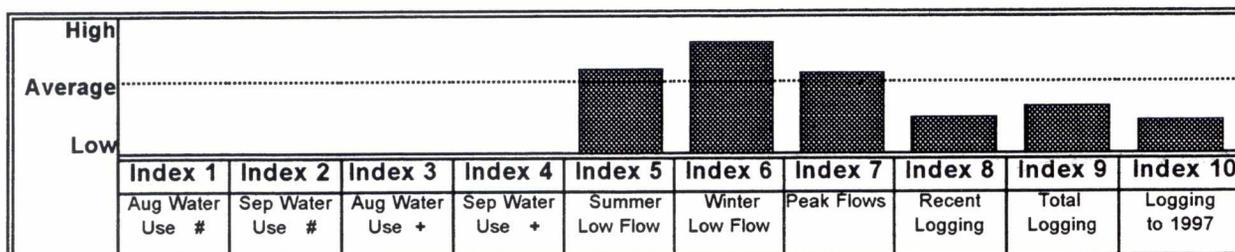
MEAN ANNUAL HYDROGRAPH

(Regulated since 1954)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.

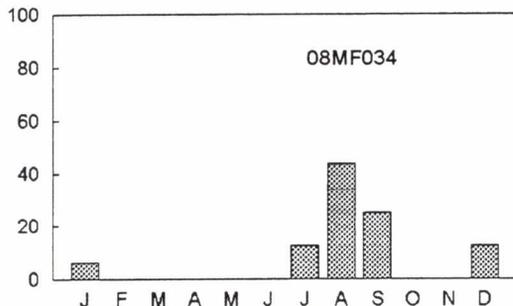


Water use as a proportion of the 7 day low flow

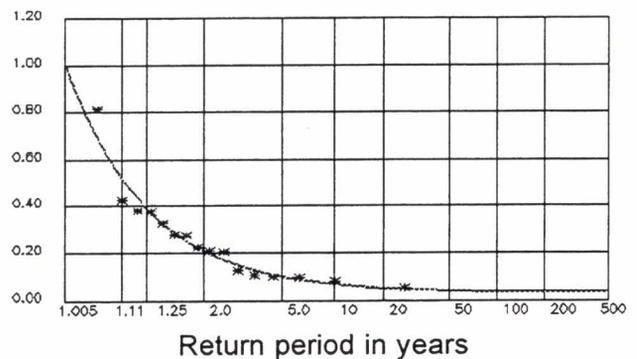
+ Water use as a proportion of the mean monthly flow for the same month

7 DAY LOW FLOWS

*Distribution , by month, of
7 Day Low Flow (in percent)*



*7 Day Low Flow Frequency Curve
(Flow in m³/s)*



Return period	2 years	10 years	20 years	50 years	100 years
7 Day Low Flow	0.206 m ³ /s	0.065 m ³ /s	0.049 m ³ /s	0.038 m ³ /s	m ³ /s
Annual Flood	32 m ³ /s	52 m ³ /s	57 m ³ /s	62 m ³ /s	66 m ³ /s

SUMMARY NOTES AND RECOMMENDATIONS

1. Unstable slopes in the Wahleach Creek watershed lead to debris flows entering the creek. In 1993 a major slide from a forestry road blocked the creek and forced it out of its channel. The Ministry of Forests removed the debris and restored the channel alignment. A major program would be required to stabilize slopes and forest roads so as to prevent further damage to the creek.

2. B.C. Hydro recently re-built their spillway at Wahleach Lake but did not incorporate any structure for releasing minimum flows. Releases are siphoned over the dam and into a spawning channel in the summer and fall.

LORENZETTA CREEK

LICENSED WATER DEMAND

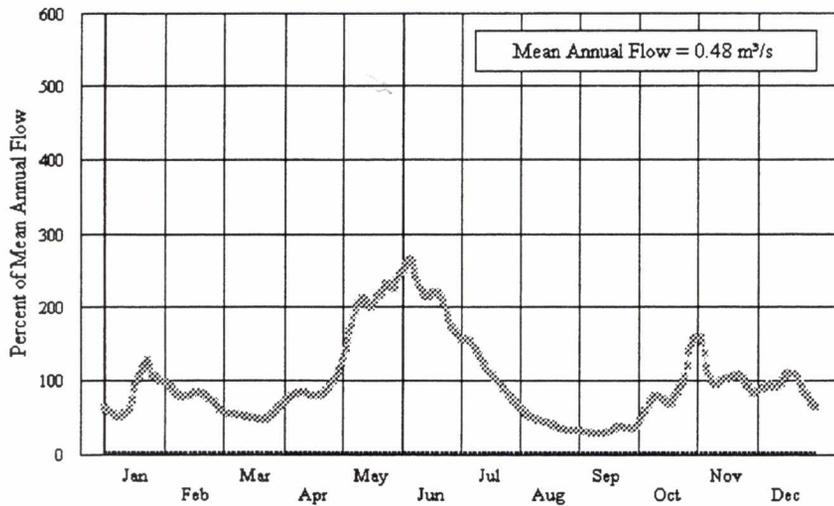
Stream number 00-0736
 Ungauged
 Tributary to the Fraser River
 Drainage Area = 11.0 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	150 g/d	0.01	0.01	0.01
Irrigation	0 ac.ft.			
Waterworks	0 g/d			
Industrial	8,898 g/d	0.46	0.46	0.46
Conservation	0 cfs			

MEAN STREAM FLOW L/S	Feb	Aug	Sep
		220	180

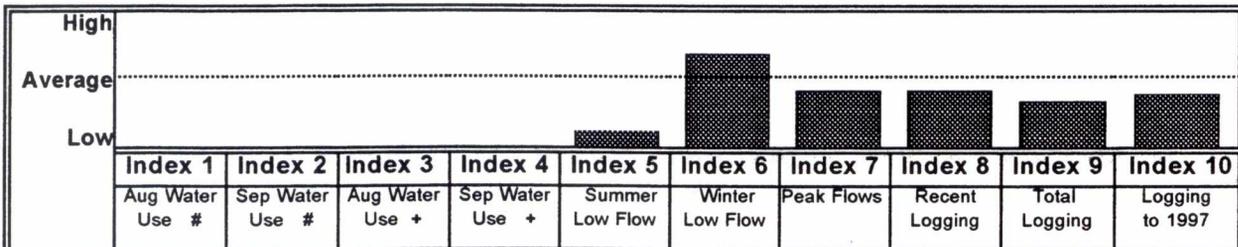
MEAN ANNUAL HYDROGRAPH

(Estimated, using Silverhope Creek Station 08MF009)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow
 + Water use as a proportion of the mean monthly flow for the same month

LORENZETTA CREEK

SUMMARY NOTES AND RECOMMENDATIONS

- 1. Lorenzetta Creek is reported to have a very flashy hydrologic regime and to move large quantities of bedload. Channel instability and flooding have resulted from sediment accumulation on its fan.*
- 2. The creek takes a bend near the head of the fan where flood flows often overtop the banks and floods a farm field. This reach was dredged and dyked in 1976-77. Gravel is still being removed from the creek under the Provincial Emergency Plan though these areas of the creek are used for spawning.*
- 3. Lorenzetta Creek is often dry during droughts because the low flows pass through the gravels in the creek bed. The Stream Summary Catalogue notes that DFO opposes further water removals from this creek to ensure maintenance flows.*

HUNTER CREEK

LICENSED WATER DEMAND

Stream number 00-0760

Ungauged

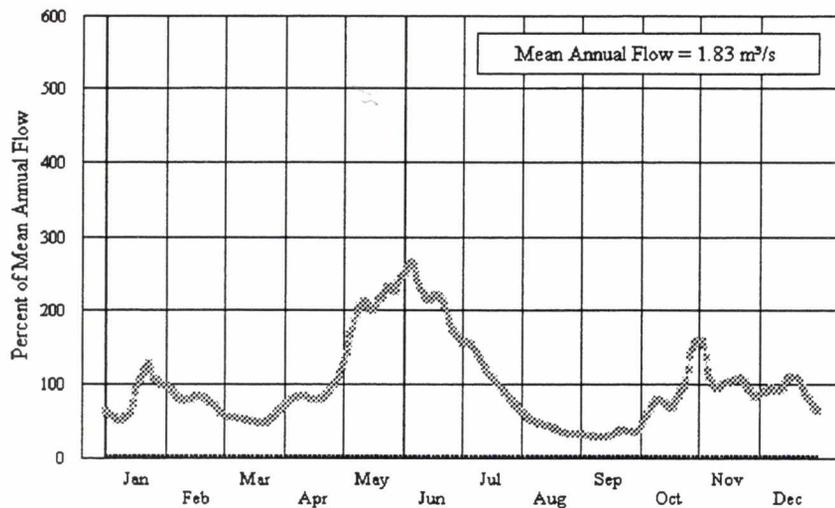
Tributary to the Fraser River

Drainage Area = 41.6 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	3,000 g/d	0.16	0.16	0.16
Irrigation	0 ac.ft.			
Waterworks	9,000 g/d	0.47	0.47	0.47
Industrial	0 g/d			
Conservation	0 cfs			
		Feb	Aug	Sep
MEAN STREAM FLOW L/S			840	680

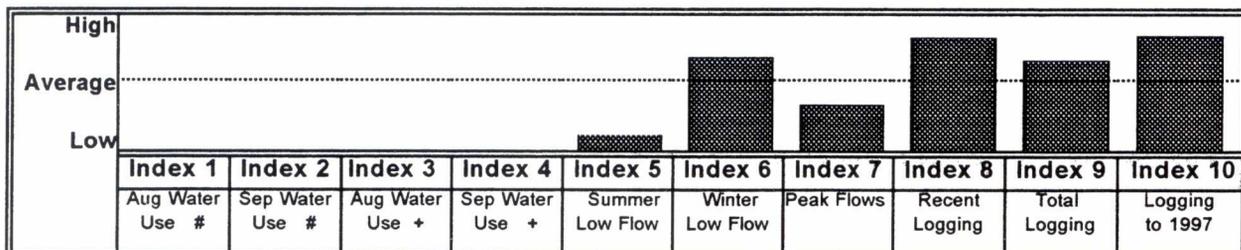
MEAN ANNUAL HYDROGRAPH

(Estimated, using Silverhope Creek Station 08MF009)



SENSITIVITY INDICES

The following bar graph shows the sensitivity of this stream relative to others in the same Habitat Management area. An index above average indicates a more severe problem; an index below average indicates a less severe problem.



Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

HUNTER CREEK

SUMMARY NOTES AND RECOMMENDATIONS

- 1. Hunter Creek has some domestic and waterworks demand. Winter low flows are a little more severe than average.*
- 2. About 16 % of the watershed has been logged and about 3% is proposed to be logged, according to the 5 year plan.*

SILVERHOPE CREEK

LICENSED WATER DEMAND

Stream number 00-0790

Water Survey of Canada Station 08MF009

Silverhope Creek near Hope

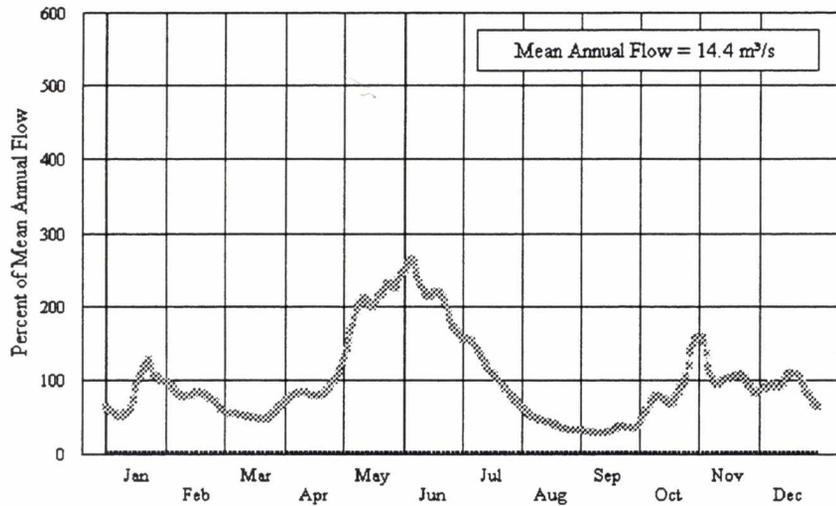
Records 1911 to 1971

Drainage Area = 350 km²

Licence Type	Total Licensed Demand	Monthly Demand L/S		
		Feb	Aug	Sep
Domestic	11,000 g/d	0.58	0.58	0.58
Irrigation	15 ac.ft.		2.07	1.07
Waterworks	26,000 g/d	1.37	1.37	1.37
Industrial	0 g/d			
Conservation	0 cfs			

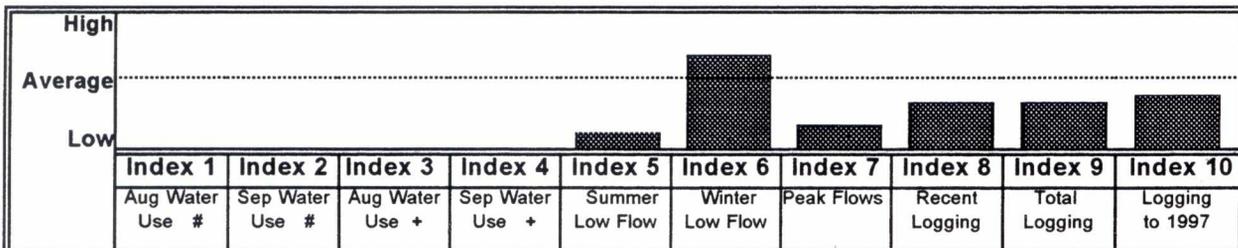
	Feb	Aug	Sep
MEAN STREAM FLOW L/S	11,300	6,630	5,380

MEAN ANNUAL HYDROGRAPH



SENSITIVITY INDICES

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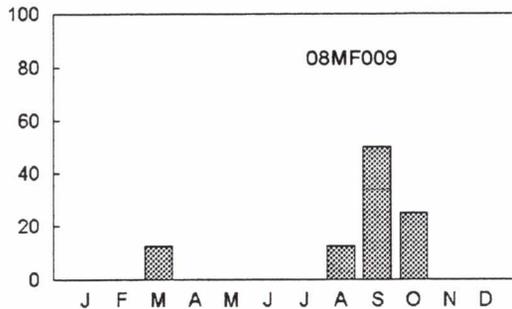


Water use as a proportion of the 7 day low flow

+ Water use as a proportion of the mean monthly flow for the same month

7 DAY LOW FLOWS

*Distribution , by month, of
7 Day Low Flow (in percent)*



*7 Day Low Flow Frequency Curve
(Flow in m³/s)*



Return period	2 years	10 years	20 years	50 years	100 years
7 Day Low Flow	2.95 m ³ /s	2.28 m ³ /s	2.10 m ³ /s	m ³ /s	m ³ /s
Annual Flood	69 m ³ /s	154 m ³ /s	198 m ³ /s	269 m ³ /s	333 m ³ /s

SUMMARY NOTES AND RECOMMENDATIONS

1. The streambed of Silverhope Creek is very mobile; about one metre of gravel has accumulated near the bridges since the 1960's. The creek has flowed along the west side of its fan since the early part of this century but it is shallowly entrenched and homes along the bank are subject to flooding and bank erosion. Some were lost in the 1984 flood.

2. The lower 3 kilometres of Silverhope Creek are used by salmon. Falls and rapids at the head of the fan prevent upstream passage, except for steelhead.