Fisheries and Aquatic Resources of the Quinsam River System

A Review of Existing Information

Prepared for
BC Hydro
Burnaby, B.C.

Prepared by
D. Burt and Associates
Nanaimo, B.C.

July 2003

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Cover:

Morning mist on the Quinsam River

(October 21, 1999, instream flow transect 106, Reach 1, 3.0 m^3/s)

ABSTRACT

B.C. Hydro is in the process of developing a Water Use Plan (WUP) for the Campbell River system that is consistent with Provincial WUP guidelines. This consultative process includes provincial and federal agencies, First Nations, and other interested parties. The objectives of the WUP will be to provide a flow management strategy that addresses the life history needs of salmonids, power generation requirements, and other user interests. The Quinsam River system is a component of the Campbell River WUP due to storage and diversion of a portion of its flows to the Campbell River system.

The objectives of this report were to aid the WUP process by providing a review of existing aquatic and fisheries information on the Quinsam River system, and by identifying data gaps in this knowledge base. Topics covered in this review included Quinsam River hydrology, water quality, water temperature, habitat characteristics, salmonid life histories, fish distribution, fish abundance, enhancement and stocking activities, and commercial and sport harvests. To further assist future research, the literature were compiled into an annotated bibliography.

The most significant data gaps relevant to development of a WUP for the Quinsam River were found to include the following:

1) The pre-regulation (natural) flow regime of the Quinsam River is unknown due to an absence of pre-project flow gauging.
2) The effects of flow regulation and water abstraction on the habitat and life history stages of Quinsam River salmonids have never been examined.
3) There are numerous bedrock falls in the reaches below Lower Quinsam Lake that cause fish passage problems at low flows (and some also at high flows), however, there has been no rigorous examination of fish passage flow requirements at these obstructions. The current licence stipulation to provide 1.7 m^3/s below Lower Quinsam Lake for fish passage is based on poorly documented information collected in 1957.
4) Previous biophysical assessments on the Quinsam River are dated or reconnaissance in nature, and do not adequately describe habitat by today’s standards.
5) Previous fish sampling on the Quinsam River system has primarily provided presence/absence information and thus the abundance and distribution of rearing salmonids is poorly understood.
6) Summer water temperatures in the Quinsam River annually exceed the general provincial guidelines for the protection of aquatic life, however, no studies have been undertaken to examine water temperatures in relation to the species/life stage specific criteria outlined in the water temperature guidelines. In addition, there has been no long-term temperature monitoring in reaches above Middle Quinsam Lake to examine both the extent of temperature issues in these reaches, and the influence of water storage and diversion on downstream temperatures.

Other data gaps, although not directly pertinent to the WUP process, include a poor understanding of the distribution of spawning above the hatchery, a lack of information on the quantity of spawning and rearing space, and limited information on habitat and fish use in tributaries.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACKNOWLEDGEMENTS

Much of information presented in this report was from obscure archives, or resided in digital form on various agency computers. Without these data the scope of this report would have been greatly diminished, and I am extremely grateful to all those who assisted by bringing this information forward. In particular, appreciation is extended to staff of Quinsam River Hatchery, with special thanks to Dave Ewart for providing various digital files and for patience during numerous telephone interviews, to Jim Van Tine for the same and for historic Quinsam River files, and to Shannon Anderson for assistance in retrieving reports from the hatchery library. I would also like to thank Sue Lehmann of DFO, Vancouver for providing data on salmon exploitation rates.

Among staff from the Ministry of Environment, Lands and Parks, I am indebted to Rick Axford for supplying data and knowledge on steelhead, Lloyd Erickson for providing information on Quinsam Coal environmental monitoring activities, Joyce DeProy for retrieving and photocopying reports from the Ministry's library, and Ray Billings (Vancouver Island Hatchery) for information on the cutthroat population in Upper Quinsam Lake. Thanks is also extended to Stu Hawthorn of the Ministry of Fisheries, Victoria for locating and forwarding historic Resource Analysis Branch reach cards and maps.

Lastly, I would like acknowledge the cooperation from staff of TimberWest Forest Ltd., in particular Gary Lawsen and Dave Lindsay for providing fisheries reports undertaken by TimberWest.

PREAMBLE

The data gaps and recommendations outlined in this report were drawn up at the beginning of the WUP process and were the basis of WUP sponsored studies that were initiated in the fall of 1999. Thus, the reader should be aware that many of the data gaps identified in this report have since been addressed by these studies. The final report for the WUP studies is anticipated in the fall of 2003 (Todd Hatfield, Solander Ecological Research, pers. comm.).

1. INTRODUCTION

B.C. Hydro is in the process of developing a Water Use Plan (WUP) for the Campbell River system and its associated diversion watersheds (of which the Quinsam is one) that is consistent with Provincial WUP guidelines (see lwbc.bc.ca/water/wup/). This consultative process includes provincial and federal agencies, First Nations, and other interested parties. The objectives of the WUP will be to provide a flow management strategy that addresses the life history needs of salmonids, power generation requirements, and other user interests (Compass Resource Consultants et al. 2000). In order to develop an effective WUP, it is important to have sufficient information on the fish and fish habitat resources of the Quinsam River, its hydrology, and current hydroelectric operating regime. This report reviews available literature on the fish and fish habitat resources of the Quinsam River, and represents the first step in providing fisheries information for the WUP process. The intent is to provide a document that summarizes existing knowledge on fish and fish habitat, identifies where the data gaps are, and suggests the direction future studies should take to fill these gaps.

The specific objectives of the literature review are as follows:

1) Review published and unpublished literature on the nature and condition of aquatic habitat in the Quinsam River.

2) Review published and unpublished literature pertaining to the biology and life history of salmonids using this river system.

3) Summarize existing data on the hydrology and water chemistry of the Quinsam River system (pre- and post-regulation, if available).

4) Report on enhancement and stocking initiatives undertaken on the Quinsam River.

5) Present information (if any) on salmonid rearing capability estimates, smolt/adult production statistics, or escapement targets previously developed for the Quinsam River.

6) Document data gaps and compile a list of recommendations to fill these gaps.

To assist future research by agency staff or consultants, an annotated bibliography is provided near the back of this report and contains all references found pertaining to the aquatic resources of the Quinsam River system. Additionally, to ensure their availability, most of the references have been copied and bound, and are retained at the John Hart Generating Station Office.

2. STUDY AREA

The Quinsam River is located on the eastern side of Vancouver Island near the town of Campbell River (Figure 1). It is the only major tributary of the Lower Campbell River and enters the Campbell 3.4 km from its mouth. The Quinsam River has a mainstem length of 45 km (excluding lakes), a drainage area of 283 km^2, and a mean annual discharge near the mouth of 8.5 m^3/s. There are numerous lakes on the system with the 4 main ones being Lower Quinsam Lake (area 1.5 km^2), Middle Quinsam Lake (area 0.8 km^2), Upper Quinsam Lake (area 5.0 km^2), and Wokas Lake (area 0.6 km^2).[1] Major tributaries to the Quinsam River include Flintoff Creek, Cold Creek and the Iron River.

Under the British Columbia ecological classification system, the Quinsam River watershed spans 2 Ecosections, the Leeward Island Mountains (LIM) Ecosection, and the Nanaimo Lowlands (NAL) Ecosection, both of which are part of the Eastern Vancouver Island Ecoregion (Campbell et al. 1990; Ministry of Environment, Lands and Parks, and Environment Canada 1993). The LIM Ecosection is a mountainous region extending from the crest of the Vancouver Island Ranges to the Nanaimo Lowlands. The NAL Ecosection is the coastal plain located on the southeastern margin of Vancouver Island. Portions of the Quinsam watershed in the LIM Ecosection include rivers and lakes above Middle Quinsam Lake, while waterways below this point are located in the NAL Ecosection. Both Ecosections occur on the leeward side of the Vancouver Island Ranges which produces a rainshadow resulting in much lower precipitation than in coastal areas adjacent to the Pacific Ocean. Climate in the NAL Ecosection tends to be milder with lower snow depths than in the LIM Ecosection, and soils are less weathered (leached) and become dry in the summer.

Hydroelectric facilities on the Quinsam River include a storage dam at the outlet of Wokas Lake, a diversion dam 1 km further downstream (47.4 km from the mouth), and a diversion canal (Figure 1). These structures were constructed in 1956 and put into service in 1957 (BC Hydro 1998). The diversion canal has a capacity of 8.5 m^3/s and a length of 1.8 km. When the diversion is open, water is carried from the diversion headpond to Gooseneck Lake. From here it drains through Snakehead Lake and Miller Creek and then to Lower Campbell Lake where it provides additional electrical generation at the Ladore and John Hart Generating Stations. An overview of these facilities, including technical and engineering aspects is provided in the Campbell River Field Facility Guide (BC Hydro 1998).

[1] Stream lengths and lake areas used in our report were calculated using GIS software (QUIKMap) and 1:20,000 scale digital TRIM maps. These sometimes differ from those reported in the literature but are generally believed to be more accurate due to digital mapping tools which were not available in earlier works.

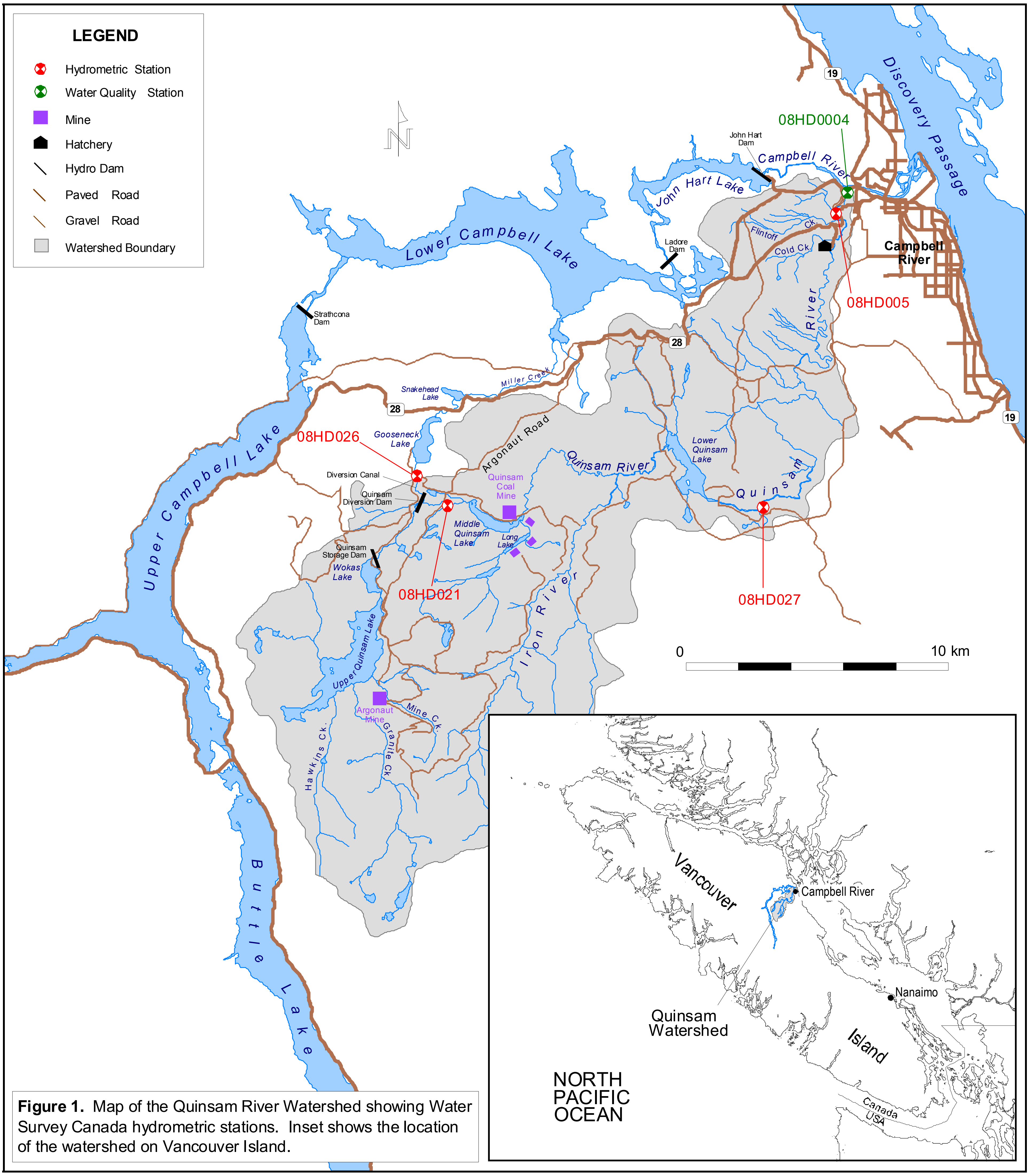

Figure 1. Map of the Quinsam River Watershed showing Water Survey Canada hydrometric stations. Inset shows the location of the watershed on Vancouver Island.

[Spacer page for back side of Figure 1]

Land-based developments in the Quinsam Watershed include logging, mining, gravel removal, agriculture, and urban development. Most of the watershed is zoned as woodland with a smaller portion in the lower valley zoned as Agricultural Land Reserve (ALR). Woodland tenures are held by TimberWest Forest, MacMillan Bloedel, and the Province of B.C. (Crown land) (Quinsam Coal Ltd. 1980). Current logging activities are located in areas below the Quinsam River Diversion Dam, and involve harvest of second growth timber (Gary Lawson, TimberWest, Oyster River Division, pers. comm.). Due to previous logging, and the huge Sayward fire which swept through the area in 1938, as well as a smaller fire in 1952, most of the watershed is comprised of second growth timber, although some old growth is still present in the upper watershed (Quinsam Coal Ltd. 1980). Mining operations within the drainage are currently conducted by Quinsam Coal Limited and involve open pit and underground coal mining in the Middle Quinsam Lake area (initiated in 1987). Historically, there has also been periodic mining of iron ore (beginning in the 1950's) in the Upper Quinsam Lake area (Eastwood 1984). Gravel operations in the valley include a number of pits, primarily on the west side of the lower Quinsam Valley adjacent to Highway 28. Agriculture and urban developments are located in the lower portion of the Quinsam Watershed.

3. HYDROLOGY

Water Licence

The hydrologic regime of the Quinsam River has been regulated since 1957 when BC Hydro's Quinsam River Storage and Diversion Dams were put into service. The water licence for these facilities include the following conditions (BC Hydro 1998; Atkins and Anderson 1994):

<u>Quinsam River Storage Dam</u>

- A maximum storage of 12.3 million m^3 per annum (10,000 acre-feet) in Wokas/Upper Quinsam Lakes.
- A minimum storage of 0.6 m above the 361.65 m elevation in Wokas/Upper Quinsam Lakes. This lowermost 0.6 m (2 ft) of drawdown is reserved for augmenting low flows for fisheries purposes.

<u>Quinsam River Diversion Dam</u>

- Maximum allowable diversion of 148 million m^3 per annum (120,000 acre-feet).
- A minimum flow of 0.28 m^3/s (10 cfs) for the Quinsam River immediately upstream of Middle Quinsam Lake year round (for fisheries purposes).
- 1.70 m^3/s (60 cfs) to be maintained immediately below Lower Quinsam Lake from February 1 – May 31, and from September 1 – November 15 (for adult salmonid migrations).

The requirement of maintaining 1.7 m^3/s below Lower Quinsam Lake during adult salmonid migrations was the result of passage problems that occurred in 1957 under flows of 0.8–1.0 m^3/s. Observations at the time found that coho were able to ascend the falls below Lower Quinsam Lake when flows reached 1.6–1.7 m^3/s (DFO 1957). Details of these and other fish passage issues are provided in Section 6.2.1.

Points of measurement for the minimum flow requirements include immediately upstream of Middle Quinsam Lake for the 0.28 m^3/s minimum, and immediately below Lower Quinsam Lake for the 1.70 m^3/s minimum. For the first 30 years of project operation it was impossible for BC Hydro to accurately monitor whether or not it was meeting its licence agreements since the only flow gauging station on the river was located near the mouth (station 08HD005). In addition, flows on the diversion were crudely gauged by means of a paper strip chart recorder. In recent years these deficiencies have been rectified with the installation of additional flow gauging stations (Data Collection Platforms or DCPs). These include DCPs above Middle Quinsam Lake (installed in 1993), in the diversion canal, and below Lower Quinsam Lake (installed in 1997). Table 1 lists active flow gauging stations on the Quinsam River, while map locations are shown in Figure 1.

Table 1. Stream gauging stations on the Quinsam River and their period of record.

DCP Station	Location	Latitude/Longitude	Years Of Record	Remarks
08HD026	Quinsam Diversion Canal	49E56'36"N 125E30'29"W	1997–2000	Regulated; diversion canal flows; prior to 1997 a paper strip chart recorder was used
08HD021	Quinsam River at Argonaut Bridge	49E55'53"N 125E30'33"W	1993–2000	Regulated
08HD010	Quinsam River Below Quinsam Lake	Unknown	1957–62, 68–70	Regulated; recorded by DFO; unpublished data*
08HD027	Quinsam River Below Lower Quinsam Lake	49E55'47"N 125E20'16"W	1997–2000	Regulated
08HD005	Quinsam River near Campbell River	52E01'45"N 125E17'55"W	1956–2000	Regulated

* Water Survey Canada has not published the data from this site due to quality uncertainty.
Source: Water Survey Canada (contact: Lynne Campo, Environmental Canada, 604-664-9324)

Flow Characteristics

Post-project flow characteristics of the Quinsam River can be reliably quantified near the mouth due to long term monitoring at this location (station 08HD005). The newer stations (08HD0021, 08HD027) provide further quantification of flow characteristics at these points, however, averages generated from these stations will be less certain until more years of data become available. Assessment of flow conditions prior to hydro development was undertaken by BC Hydro as part of the Water Use Planning (WUP) process. This involved reconstructing mean daily flows from the diversion and adding these to DCP station data for their various periods of record. It should be noted that there may be some inaccuracies in these results due to storage/release patterns at Wokas Dams, although total annual discharge would be unaffected by this facility.

Table 2 summarizes selected mean annual parameters for active gauging stations on the Quinsam River and the diversion canal. As mentioned above, flow statistics for the Lower Quinsam Lake station (08HD027) should be regarded as preliminary as they are based on only 4 years of data (1997–2000). Data from the Quinsam Diversion (08HD026, DCP and paper strip chart records) indicate an average abstraction of 1.82 m^3/s from the Quinsam River, with a mean daily diversion ranging from 0 to 8.8 m^3/s. The effect of this abstraction on flows below the diversion, is a reduction in mean annual discharge (MAD) by amounts of 40.6% at Argonaut Bridge (08HD021), 14.9% below Lower Quinsam lake (08HD027), and 17.8% near the Quinsam mouth (08HD005)[2]. Table 2 also shows the mean 30-day summer low flow for the period of record. In fisheries circles, this parameter is typically called the Critical Period Stream Flow (CPSF) because it represents an extended period during the growing season when low flows can constrain the amount of salmonid rearing habitat having a direct influence on the number of juveniles that survive the summer. CPSF for the Quinsam River are indicated to be 0.539 m^3/s at Argonaut Bridge, 0.856 m^3/s below Lower Quinsam Lake, and 2.00 m^3/s near the mouth.

There have been other attempts to estimate pre-project hydrology parameters using modelling techniques. For example, Comptroller of Water Rights files show an estimated pre-regulation mean annual discharge of 11.9 m^3/s (Lough et al. 1993)[3]. This is higher than the MAD given in Table 2 (10.41 m^3/s), which may be due to differences in the approach or years used in the estimate by the Comptroller of Water Rights.

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[2] Values are the converse of % NMAD, e.g., 100% - 59.4% = 40.6% (station 08HD021).

[3] No river location was given for this estimate, but presumably it refers the Quinsam River near its mouth.

Table 2. Summary of selected flow parameters for the Quinsam Diversion and the 3 active DCP stations on the Quinsam River.

DCP Station	Flow Parameters in m^3/s and as a % of Natural MAD (NMAD) for the Period of Record								
	Natural MAD	Regulated MAD		Minimum Daily		Maximum Daily		30-day Low (CPSF)	
	m^3/s	m^3/s	%NMAD	m^3/s	%NMAD	m^3/s	%NMAD	m^3/s	%NMAD
Diversion 08HD026 (pre 1997 synthesized, 1997-2000 DCP)	–	1.82	–	0.000	–	8.8	–	0.015	–
Argonaut Bridge 08HD021 (1993-2000)	3.08	1.83	59.4%	0.356	11.6%	39.7	1289.0%	0.539	17.5%
Below LQL 08HD027 (1997-2000)	8.39	7.14	85.1%	0.376	4.5%	91.5	1090.6%	0.856	10.2%
Near Campbell R. 08HD005 (1956-2000)	10.41	8.56	82.2%	0.889	8.5%	218.0	2094.1%	2.00	19.2%

Notes:
1. Source: generated by Todd Hatfield (Solander Ecological Research, Victoria, B.C.) from the Water Survey Canada Hydat CD (data are based on mean daily discharge for the periods of record shown in column 1). Pre 1997 data for the diversion (08HD026) were based on a paper strip chart recorder maintained in the diversion following construction.
2. MAD refers to Mean Annual Discharge.
3. Natural MAD was obtained by adding diversion flows (station 08HD026) to the regulated flows.
4. CPSF refers to Critical Period Stream Flow, which is the mean 30-day low flow during the fish growing period, i.e., when water temperatures are $ 7EC.

Mean monthly discharge for the Quinsam River at the 3 active gauging stations are presented in Figure 2. In the charts of Figure 2, the top of the light shaded bars indicate regulated flows, while the top of the dark shaded bars show naturalised flows (i.e., if all water were allowed to pass down the Quinsam River), and the dark shaded region between shows the mean monthly diversion. The hydrographs also include natural MAD, CPSF, and licence requirement flows. At the Argonaut Bridge station (Figure 2A), water diversion has substantially reduced flows during the months of November to June (mean diversion rates range from 37% of available flow in June to 71% in April). Flow reductions at this station are less dramatic in July and August while in September and October very little water is diverted. At the station below Lower Quinsam Lake (08HD027) and the one near the mouth (08HD005), flow reductions follow a similar pattern but represent a smaller proportion of the naturalised flow due to water inputs from tributary sources (Figures 2A and B).

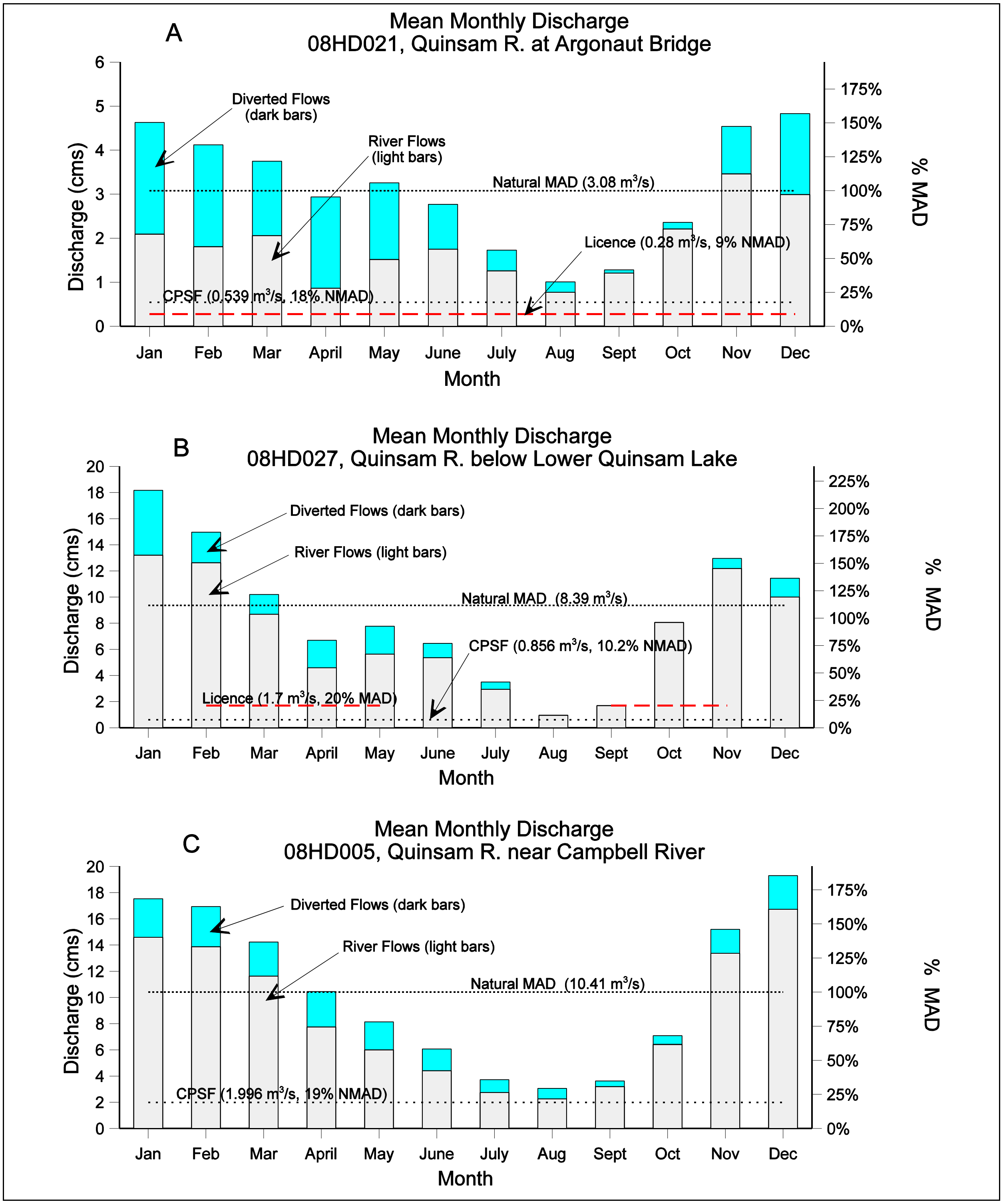

Figure 2. Mean monthly discharge for the Quinsam River, and with the addition of discharge from the Quinsam Diversion. Graph A: Argonaut Bridge; Graph B: below Lower Quinsam Lake; Graph C: near Campbell River. Also shown are CPSF, natural MAD, and licence flow requirements (note: licence requirements only apply to 08HD021 and 08HD027).

The patterns of monthly discharge shown in Figure 2 are typical of Vancouver Island streams, with highest flows during late autumn and winter and lowest flows during late summer. In the case of the Quinsam River, mean monthly flow is lowest in August for all 3 stations.

It should be pointed out that for certain months the mean flows at the Lower Quinsam Lake station (08HD027) are higher than the station near the mouth (08HD005) (e.g., January, June, and October). This is due to the shorter period of record for the Lower Quinsam Lake station (4 years versus 45 years for 08HD005) with above average flows for these months.

Mean daily discharge for the Quinsam River in 1997 and 1998 are provided for the Argonaut Bridge station in Figure 3, and for the station below Lower Quinsam Lake in Figure 4. Again, diversion flows were included as they indicate the flow levels without the diversion. These 2 stations are also pertinent to the water licence, which states that a minimum of 0.28 m^3/s be maintained in the river immediately below the diversion at all times, and 1.70 m^3/s be maintained immediately below Lower Quinsam lake from February 1 – May 31, and from September 1 – November 15. For the Argonaut Bridge station (Figure 3), mean daily flows remained above the licence requirement for both years, however, the pattern of abstraction was radically different between the 2 years. In 1997 (graph A) diversion was substantial from January to the end of April and left inriver winter flows only slightly greater than the licenced amount. Little or no diversion occurred throughout the remainder of 1997. In 1998 (graph B), the diversion regime was the reverse of 1997, with abstraction from May to the beginning of July, and again during November and December. As in 1997, when water was being diverted, inriver flows were generally only slightly greater than the licence requirement.

At the station below Lower Quinsam Lake (Figure 4), the mean daily hydrographs for 1997 and 1998 are similar to the Argonaut Bridge station but with greater water volumes due to tributary inputs such as the Iron River and others. Because of the greater flows at this station, water abstractions have a smaller influence on the mean daily hydrograph, however, abstractions can still be significant if they occur during low flow periods. An example is the diverted flows during May and June in 1998 (Figure 4B). Another feature indicated by Figure 4 is that inriver flows during September dropped below the licence requirement in both 1997 and 1998. In 1998, the sudden increase in flow on September 8-9 at Argonaut Bridge station, and subsequent flat flow regime (Figure 3B), suggest water was released at the Wokas Lake Storage Dam in order to meet the 1.70 m^3/s flow requirements below Lower Quinsam Lake in 1998 (until autumn freshets arrived in mid November).

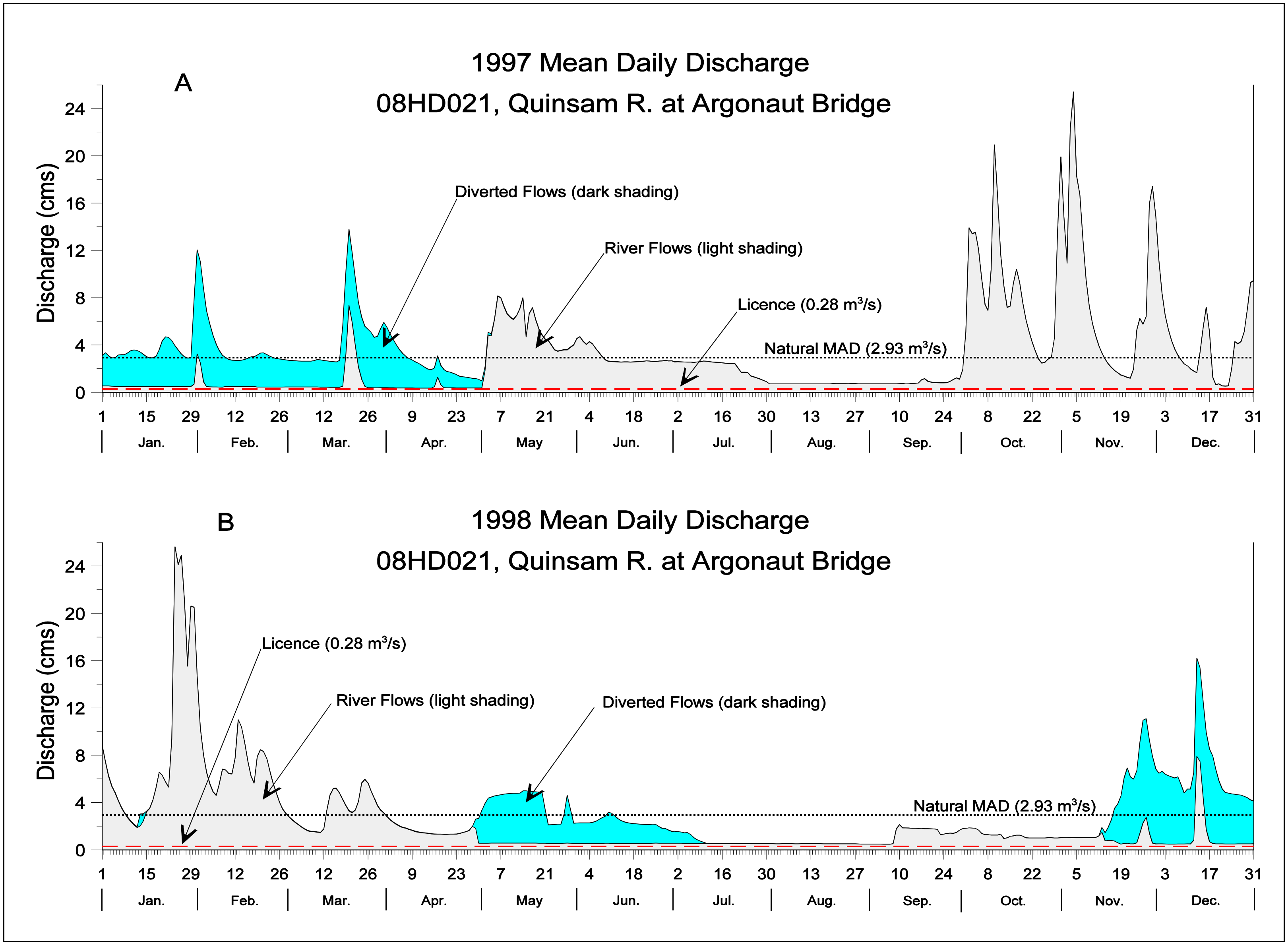

Figure 3. Mean daily discharge at Argonaut Bridge in 1997 (Graph A) and in 1998 (Graph B). Diversion flows are also shown to indicate the flow regime if all water were allowed to pass down the Quinsam River.

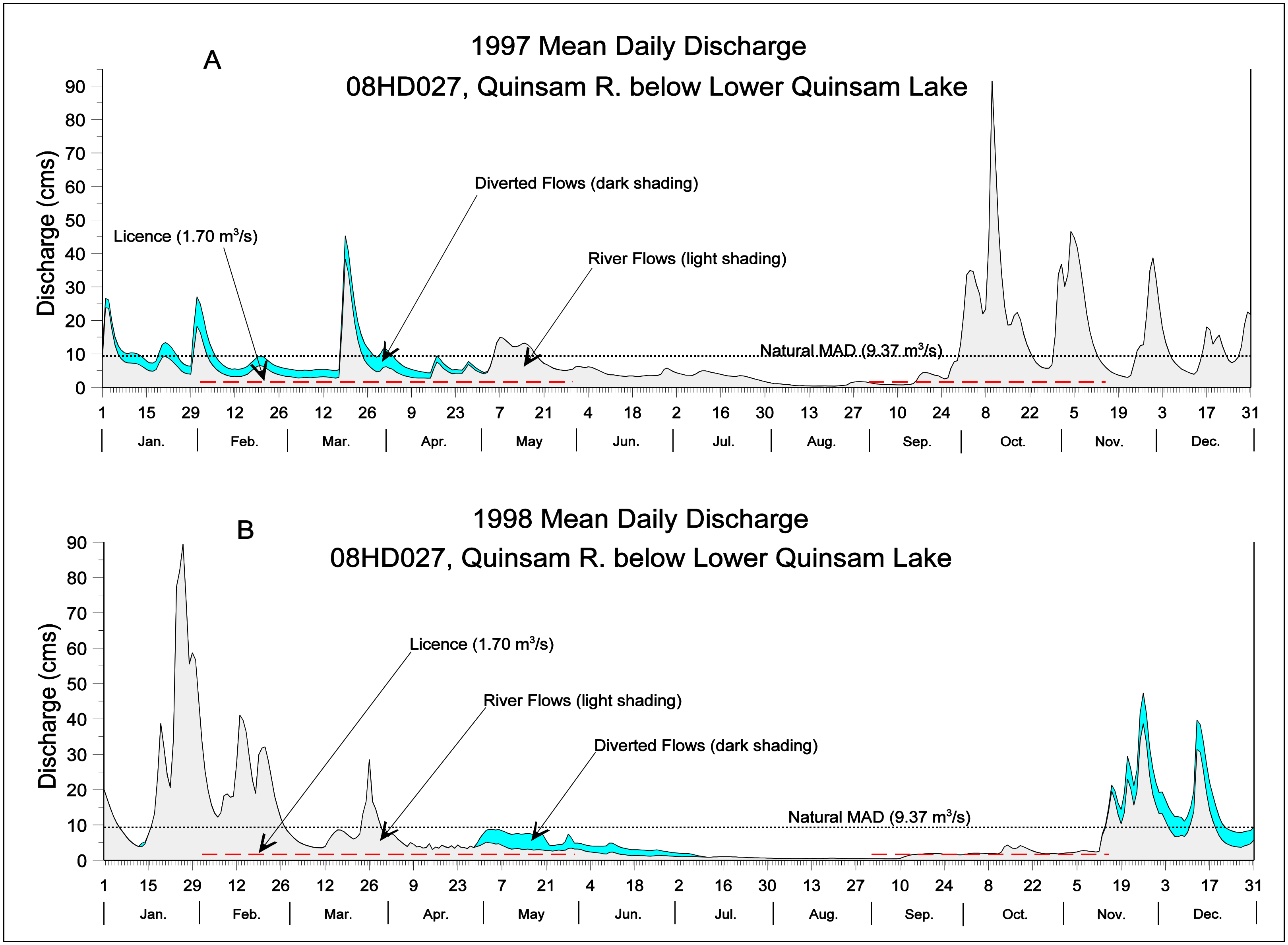

Figure 4. Mean daily discharge below Lower Quinsam Lake in 1997 (Graph A) and in 1998 (Graph B). Diversion flows are also shown to indicate the flow regime if all water were allowed to pass down the Quinsam River.

Synopsis of BC Hydro Operational Effects on Quinsam Hydrology

The effects of the Wokas Storage Dam and the Quinsam Diversion on the hydrology of the Quinsam River system can be summarized as follows:

1) A reduction in annual total discharge due to diversion (MAD reduced by roughly 41% at Argonaut Bridge, 15% at Lower Quinsam Lake outlet, and 18% at the mouth).

2) An alteration of seasonal flow patterns due to both diversion and storage facilities (generally a reduction in mean monthly flows from November to June; sometimes flow augmentation by releases at Wokas Dam in order to meet the minimum flow requirements of the water licence).

3) Unnatural changes in flow (ramping) when Wokas Dam and Quinsam Diversion facilities are opened or closed (ramping is generally performed over a 4 hour period; effects are most pronounced in reaches between Wokas Dam and Upper Quinsam Lake).

4) Increased fluctuation in water levels of Wokas and Upper Quinsam Lakes due to storage and drawdown at Wokas Dam.

4. WATER QUALITY AND TEMPERATURE

Water Quality

The Quinsam Watershed has received extensive water quality monitoring since the mid 1980's, primarily due to concerns stemming from development of the Quinsam Coal Mine (Redenbach 1989, 1990). Monitoring has also been conducted due to potential effects from forest fertilization (Lindsay 1987) and from Quinsam Hatchery effluents (Munro et al. 1985). The most consistent long-term monitoring is from Environment Canada's ENVIRODAT station number 08HD0004 located about 500 m from the Quinsam mouth (see Figure 1 for location).

Water quality of the lakes and rivers of the Quinsam system is typical of East Coast Vancouver Island. Characteristics include low concentrations of dissolved ions (nutrient-poor), exceptional clarity (high transparency), and low productivity (oligotrophic) (Kangasniemi 1989; MacIsaac and Stockner 1985). pH is also typical of the area and remains alkaline throughout most of the year, although slightly acidic conditions can occur during periods of rain or snowfall. The low nutrient levels have been attributed to weather-resistant parental rock, low rates of chemical weathering and leaching of soils, combined with high flushing rates of lakes and streams (Kangasniemi 1989; MacIsaac and Stockner 1985). As a consequence of these characteristics, primary production (i.e., phytoplankton and periphyton) is also low and considered to be nutrient limited. There is, however, disagreement in the literature as to whether nitrogen or phosphorus is the limiting nutrient. For example, nitrogen was reported to be the limiting nutrient by Munro et al. (1985) for the lower Quinsam River, and for Quinsam and Long Lakes (MacIsaac and Stockner 1985), whereas phosphorous was reported as the limiting nutrient by Lindsay (1987), Redenbach (1989, 1990), and by Lough et al. (1993).

The range of various water quality parameters, as measured near the mouth (station 08HD0004), are provide in Table 3. Parameters shown include suspended and dissolved particulates, and nutrient indices (metal concentrations are also available but not included). Ranges are based on biweekly or weekly measurements for the period 1986 – 1998. For comparative purposes, water quality criteria are also shown. A detailed review of Quinsam River water quality can be found in Regnier et al. (1996).

Table 3. Range of selected water quality indices for the Quinsam River near the mouth (station 08HD0004, 1986–1998) and MELP Approved Water Quality Criteria.

Parameter	Minimum	Maximum	Median	Timing	Water Quality Criteria
Turbidity	0.05	73	0.9	Min: typically late summer Max: typically winter storms	Drinking water: maximum increase of 1 NTU when background # 5 NTU; maximum increase of 5 NTU when background # 50 NTU; maximum increase of 10% when background > 50 NTU. Aquatic life: maximum increase of 8 NTU in 24 hrs and mean increase of 2 NTU over 30 days when background # 8 NTU; maximum increase of 8 NTU when background is between 8 and 80 NTU; maximum increase of 10% when background $ 80 NTU
Filterable Residue (TDS)	47	202	86	Min: ? (small data set) Max: ? (small data set)	Drinking water: 500 mg/L (aesthetics)
Non-Filterable Residues (suspended solids)	5	119	5	Min: ? (small data set) Max: ? (small data set)	Aquatic life: maximum increase of 25 mg/L in 24 hrs and mean increase of 5 mg/L over 30 days when background # 25 mg/L; maximum increase of 25 mg/L when background is between 25 and 250 mg/L; maximum increase of 10% when background > 250 mg/L.
Nitrate/Nitrite-N	0.002	0.961	0.140	Min: typically summer Max: typically winter storms	Drinking water (Nitrate): 10 mg/L Aquatic life: (Nitrate): 200 mg/L and average of 40 mg/L
Total Dissolved N	0.01	1.10	0.21	Min: typically summer Max: typically winter storms	
Total Phosphorus	0.002	0.64	0.02	Min: typically spring-summer Max: typically Sept-Nov	

Parameter	Minimum	Maximum	Median	Timing	Water Quality Criteria
pH	7.1	8.3	7.6	Min: typically winter Max: typically summer	Drinking water: 6.5 to 8.5 Aquatic life: 6.5 to 9.0 unless background levels are otherwise (e.g. bogs)
Alkalinity	12.0	54.3	29.0	Min: typically winter Max: typically late summer	

Notes:
1. Range of values are from ENVIRODAT station 08HD0004 available from Environment Canada (contact person: Lynne Campo, Environmental Data Applications, 604-664-9324).
2. Approved Water Quality Criteria from MELP (1998), updated August 24, 2001 and from Guidelines for Interpreting Water Quality Data (RIC 1998).

Human activities within the watershed that have elicited water quality concerns include the development of the Quinsam Coal Mine, forest fertilization practices, and effluents from the Quinsam Hatchery. Operations of BC Hydro's storage and diversion facilities have been relevant to these concerns in that they influence river discharge, which in turn, affects dilution ratios.

During the Quinsam Coal Mine approval process in the 1980's, substantial focus was placed on the potential impacts of open-pit mining on water quality. The main concerns related to settling pond discharges, and their potential to carry acidic effluents, elevated nutrients levels (mainly nitrogen but also phosphorous), metals, and suspended sediments to the Quinsam River (Quinsam Coal 1980; Kangasniemi, 1989). Coal mining operations commenced in 1987 and several pits were established, however, Quinsam Coal subsequently switched to underground mining techniques, although open pit methods are still planned for coal seams close to the surface. The main concern from underground operations is from fracturing of surface rock, which would allow groundwater to seep into the mine site and become contaminated (Lloyd Erickson, MWLAP, Nanaimo, pers. comm.). To minimize or prevent mining impacts, a number of operational procedures were adopted by Quinsam Coal Ltd. (Quinsam Coal 1980). Also, in order to protect aquatic life, wildlife, aesthetics, irrigation, drinking, and recreation, specific water quality objectives were established for the Quinsam River by MWLAP (Kangasniemi 1989). Initial post-project monitoring in the receiving waters of the Quinsam Coal Mine effluent found most water quality indices to be within established guidelines with the exception of iron, and occasional exceedances in phosphorous, nitrogen, dissolved zinc, and acid indicators (conductivity, sulphate, hardness) (Redenbach 1989, 1990). More recent monitoring has found a substantial increase in sulphate (an acid drainage indicator) in the receiving waters. For example, values in Long Lake are frequently around 200 mg/L in the hypolimnion (bottom layer) and 15–20 mg/L in the epilimnion (surface layer) (note: 100 mg/L is the MWLAP maximum criterion for aquatic life). Values in Middle Quinsam Lake are elevated (peak at 15–20 mg/L at the outlet) but not as severe, probably due to more thorough mixing of bottom and surface layers, shallower depths, and higher inlet flows (Lloyd Erickson, MWLAP, Nanaimo, pers. comm.). An increase in sulphate and certain other parameters has also been detected near the mouth (station 08HD0004). Regnier et al. (1996) reviewed water quality parameters at this station for the period 1986–1995 and found an increasing trend in calcium, hardness, conductivity, magnesium, sodium, sulphate, and strontium, although few exceeded the Quinsam River water quality criteria. Again, the most notable change was in sulphate, which increased by 3–4 times between 1988 and 1994. At present, the exact source of the sulphate is unknown but rider seams (edge of the coal seams) are suspect. Concern over elevated sulphate levels led MWLAP to undertake bioassay testing on fish and fish eggs, however, to date, no significant effects have been found (L. Erickson, MWLAP, Nanaimo, pers. comm.).

The effects of forest fertilization within the watershed were examined by Lindsay (1987). Areas fertilized included private forest land (Tree Farm 68) from Upper Quinsam Lake to Middle Quinsam Lake and adjacent to Tom Brown Creek (which flows into Echo Lake, which in turn flows into the north end of Lower Quinsam Lake). Fertilizer was distributed by centrifugal spreader from a helicopter at a rate of 400 kg urea/ha, with the exception of the swampy area southwest of Middle Quinsam Lake, which received 200 kg/ha. Distribution included a minimum 10 m buffer around large streams and lakes. Fertilization was undertaken in late November during a period with numerous rainfall events. It was found that the study streams exhibited a rapid increase in nitrogen immediately following fertilization (up to 200 times ambient levels), with a return to low concentrations within days of application. Ammonia and urea concentrations returned to background levels by the following spring while nitrate levels remained slightly elevated into the spring. Phosphate levels were not affected by fertilization.

The effects of hatchery effluents on downstream water quality were examined by Munro et al. (1990) during 1978 and 1979. Although nutrient enrichment can benefit oligotrophic streams, the concern was that if concentrations of nitrogen and phosphorus were sufficiently high, the receiving waters could be degraded through decreases in dissolved oxygen, modification of benthic invertebrate communities, and development of nuisance levels of periphyton (levels that decrease the transport of gases through the substrate or that eliminate the habitat of some invertebrates and fish). In the case of the Quinsam River, concentrations of total phosphate and ammonia below the discharge outlet were indeed found to be elevated. Abundance of periphyton and benthic invertebrates were also greater, but were restricted to the region immediately below the discharge outlet (~ 60 m). Despite these effects, dissolved oxygen levels remained high during the growing season (May to October), periphyton did not attain nuisance levels, and the benthic invertebrate community demonstrated a species assemblage characteristic of enrichment rather than degradation.

Temperature

Sources of temperature data for the Quinsam Watershed include weekly to biweekly monitoring near the mouth since 1986 (Environment Canada station 08HD0004), continuous recording near the Quinsam Hatchery since 1972, and daily or spot recordings from various aquatic studies on the system (Table 4).

Daily temperature monitoring using continuous recording devices during 1983 and 1984 by Blackmun et al. (1985) and Lukyn et al. (1985a, b) indicated that lowest temperatures typically occur during the end of December through January and are frequently <l°C. Lakes are often ice covered at this time. Highest temperatures typically occur during mid July to mid August and are frequently in the range 18–21°C. Highest mean daily temperatures occurred at the outlet of Middle Quinsam Lake and were 21.8 °C in 1983 (August 12) and 23.2 °C in 1984 (August 1). The presence of lakes appeared to moderate temperature minima during winter and increase temperature maxima during summer. Iron River was substantially cooler than the Quinsam River and had a cooling effect on the Quinsam River.

Table 4. Sources of temperature data for the Quinsam Watershed.

Source	Timing	Site Location(s)	Method
Environment Canada	1986 – present	08HD0004, 500 m above mouth	weekly to biweekly, single (spot) measurements
Quinsam Hatchery	~1972 – present	Quinsam Hatchery	continuous recording devices
Blackmun et al. (1983)	Mar. 24 – Dec. 31, 1983	7 sites, various locations on mainstem and selected tributaries (including the Iron R.)	mix of continuous recording devices and daily spot measurements
Lukyn et al. (1985a)	Jan. 1 – Aug. 31, 1984	7 sites, various locations on mainstem and selected tributaries (including the Iron R.)	mix of continuous recording devices and daily spot measurements
Lukyn et al. (1985b)	Sept. 1 – Dec. 31, 1984	7 sites, various locations on mainstem and selected tributaries (including the Iron R.)	mix of continuous recording devices and daily spot measurements
MacIsaac and Stockner (1985)	June – Oct., 1984	Long and Middle Quinsam Lakes	biweekly, temperature profiles to maximum station depth
Grant, Brydges, and Tripp (1995)	Apr. 24 – Aug. 22, 1995	Small tributaries within TimberWest Forest Ltd. land tenure	single (spot) measurements per site

Temperature data collected by Grant et al. (1985) on numerous small tributaries between April 24 and August 22, 1995, found a temperature range of 9–21.5°C. The maximum (21.5°C) was recorded on a tributary to the Iron River (site 384) on August 2 and was found to be utilized by cutthroat trout.

Temperature data collected on Middle Quinsam Lake in 1984 (MacIsaac and Stockner 1985) indicated development of a strong thermocline at 6 m by late July. Epilimnion temperatures at this time ranged from 21–23°C. Subsequent wind mixing lowered the thermocline to 9.5 m with an associated decrease in surface temperatures to 17°C. Near isothermal conditions developed by late September and complete mixing by mid-October, at which time lake temperature was 11°C. Long Lake had a strong thermocline by June which was maintained at a depth of 4–6 m until early September. Epilimnion temperatures ranged from 16–20°C during this time. Near isothermal conditions (8–10°C) were attained in mid-October.

Annual water temperature regimes for the Quinsam River near the Quinsam Hatchery and below Middle Quinsam Lake are shown in Figure 5, graphs A and B, respectively. Mean daily lows in winter typically range from 1–6°C, while mean daily highs in July and August are generally around 16–22°C at the lower river site, and 18–23°C at the middle river site. It is important to note that summer temperatures frequently exceed the provincial criteria for the protection of freshwater aquatic life. For streams with unknown fish distribution, these guidelines include a maximum daily temperature of 19°C, and a mean weekly maximum temperature (MWMT) of 18°C (MWLAP 2001)[4]. These guidelines are based on maximum daily temperatures as opposed to the mean daily temperatures shown in Figure 5. Thus the frequency and extent that Quinsam water temperatures exceed the guidelines is actually greater than shown in Figure 5. To better understand these exceedances, I examined maximum daily water temperatures from the Quinsam River near Quinsam Hatchery for 1992 and 1995–98 (years with complete or near complete data sets). During these 5 years, the MWMT criteria of 18°C was exceeded for 52 – 90 days per year, and the maximum daily temperature of 19°C was exceeded on 35 – 58 days per year. Annual maximum temperature for these years ranged from 22.0°C to 24.8°C.

Oliver and Fidler (2001), the consultants who developed the MWLAP guidelines, reviewed numerous studies on the effects of water temperature on salmonid life history stages. Their conclusions were that water temperatures that exceed the optimum criteria are likely to have detrimental consequences for growth or development, disease resistance, reproductive success, and species interactions. Maximum temperatures between optimum and incipient lethal levels can lead to an impairment threshold with impacts that range from zero net growth to cumulative effects leading to death. Regarding Quinsam River summer temperatures, key points are: 1) MWMT's annually exceed

[4] The guidelines cited here for freshwater aquatic life are for streams with unknown fish distribution. The guidelines also include recommendations for streams with known fish distribution. These include ± 1°C beyond optimum temperature range for each life history phase of the most sensitive salmonid species present, and a maximum hourly rate of change of 1°C. A table of optimum temperature ranges for each species and life stage is provided in the guidelines (Table 2 in MWLAP 2001). The distribution of Quinsam River salmonids is sufficiently known, as is life history timing, for a comparison of Quinsam River temperatures with the species/life stage guidelines, however such an investigation was beyond the scope of this review.

the optimum level (18°C) for an extended period (July through August or longer), 2) maximum daily temperatures also exceed the threshold for positive growth (19°C) for extended periods, and 3) during peak thermal periods, maximum daily temperatures sometimes approach or attain incipient lethal levels or thermal temperature tolerance thresholds for various species and life stages (Tables 2, 3, 4, and 5, in Oliver and Fidler 2001). Thus, the probability is high that temperature regimes on the Quinsam River are impinging on salmonid production. This should be addressed by an investigation of Quinsam River temperature regimes during specific life stage periods and results compared with species/life stage criteria outlined in MWLAP (2001) and Oliver and Fidler (2001).

The growing season for rearing salmonids, has been defined in the literature as the period with water temperatures greater than 7°C, and is often termed G7 (Symons 1979; Ptolemy and Tredger 1997). In Figure 5, G7 is the period above the 7°C dashed line. In the lower river (graph A), temperatures above 7°C occur on average from March 27 to November 15, suggesting a growing season of 234 days for this portion of the river. For the upper river (graph B), temperatures were above 7°C in 1984 from March 29 to October 29, suggesting a growing season of 216 days. The significance of growing season length is that there is a positive relationship between its duration and the size rearing fish achieve by the end of the growing season (Symons 1979; Ptolemy and Tredger 1997). In addition, fish entering the winter at a larger size tend to smolt at an earlier age and to have better freshwater survival. From this, one could speculate that salmonids rearing in the lower river have a survival advantage over those using the upper river, however, the picture is incomplete without knowledge of other factors that influence freshwater survival (e.g., food abundance, habitat quality, and the degree of competition for food and space).

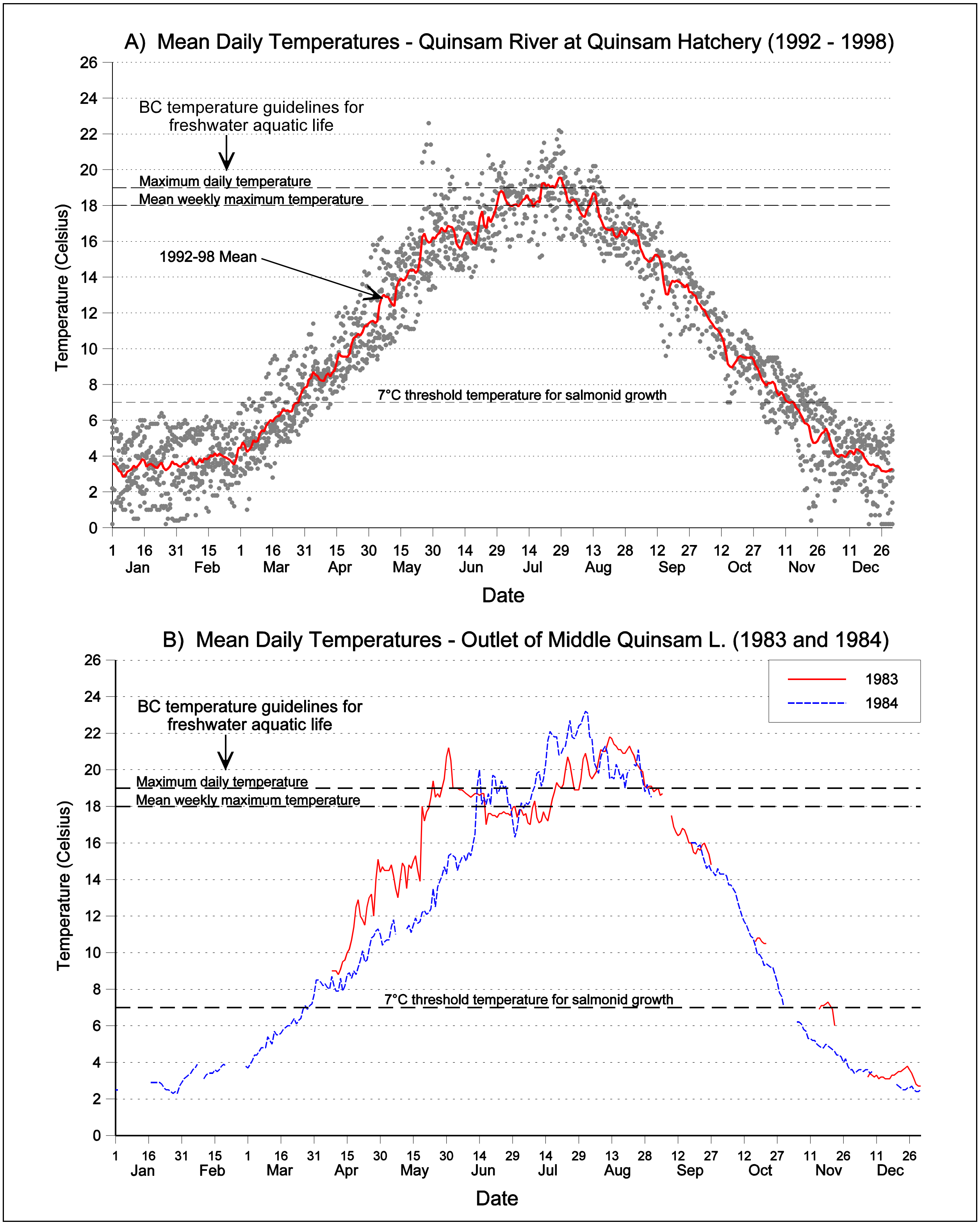

Figure 5. Quinsam River water temperatures. Graph A: mean daily temperatures near the Quinsam Hatchery for 1992 to 1998 (from D. Ewart, Quinsam Hatchery); Graph B: mean daily temperatures below Middle Quinsam Lake for 1983 and 1984 (from Blackmun et al. 1983; Lukyn et al. 1985a,b).

5. FISH HABITAT

The extent and nature of fish habitat in the Quinsam River system was examined in the 1970's and 1980's, primarily in response to the Quinsam Coal development. The most rigorous of these early studies was by DFO in July 1977 (Lawseth 1979). This survey was conducted by foot and covered stream reaches from the Quinsam Diversion Dam to the confluence with the Campbell River, as well as the lower 3.5 km of the Iron River. Other surveys were mainly reconnaissance in nature (e.g. Quinsam Coal Ltd. 1980; Norecol 1983; Hawthorn 1984; Resource Analysis Branch 1983), and recorded data according to point and reach cards developed by the Resource Analysis Branch (RAB) in the 1970's (see Chamberlin 1980; Belford and Chamberlin 1980). The following subsections describe the various river and lake reaches of the Quinsam system based on these surveys. Tributaries are included where data were available. A summary of the data can be found in Tables 5 (stream reaches) and 6 (lake reaches). Reach boundaries are shown in Figure 6 and are based on a helicopter overflight conducted on March 3, 1983 by the Resource Analysis Branch of the Ministry of Environment[5]. This overflight identified 13 river reaches and 5 lake reaches along the Quinsam mainstem. Length and area data indicated for these reaches in Tables 5 and 6 was determined by myself by digitizing on 1:20,000 TRIM maps using GIS software.

Mouth to Lower Quinsam Lake (Reaches 1 to 5)

The 1983 RAB helicopter overflight partitioned the Quinsam River from its mouth to the Lower Quinsam Lake outlet into 5 reaches. The overflight was also used to access points within each reach in order to complete RAB reach cards (digital copies of the reach cards were obtained from Stu Hawthorn, Ministry of Fisheries, Victoria, B.C.).

Reach 1 is a relatively long reach (10.4 km) with channel features that include frequent confinement by valley walls, an average width of 20 m, and a gradient of 0.7% (Table 5). Substrates are dominated by gravels and larges (40% each). This reach has the greatest abundance of spawning gravels of the 5 reaches in this section, although other authors have noted that gravel quality has been degraded by excessive amounts of fines (Lawseth 1979; Hirst 1991). Lawseth (1979) indicated that unstable banks in this reach appear to be a major source of siltation. He identified 6 large clay banks at the top of this reach that exhibited considerable erosion.

Reaches 2 and 3 have many similar characteristics including a low gradient (0.3%), and a high proportion of fines in the substrates (reach cards indicate a predominantly compact clay bottom with only

[5] Instream flow studies conducted by D. Burt and Associates in 1999 and 2000 validated the RAB reach breaks, although some lumping of reaches was done in order to reduce the number of reaches for statistical purposes.

patches of gravel). The main differences between the two reaches are that in Reach 2 the valley is narrower and the channel becomes more confined (entrenched), and diminishes from 20 m to 15 m in average width.

In Reaches 4 and 5 the valley remains narrow and the channel entrenched as in Reach 3, however, the channel width reverts back to about 20 m. The main change from previous reaches is that the gradient has significantly increased, and continues to increase with upstream progression (1.0% in Reach 4 to 1.4% in Reach 5). The gradient increase is associated with a switch to much larger substrates, dominated by larges in Reach 4 and bedrock in Reach 5. Reach 5 is also notable for its numerous cascades and small falls which are reported to be partial barriers to anadromous fish migrations (discussed in Section 6.2).

Lower Quinsam Lake (Reach 6)

Lower Quinsam Lake has a length of 3.50 km, an area of 145.3 ha, and a maximum depth of 22m. It is the second largest lake on the Quinsam River system (next to Upper Quinsam Lake).

Lower Quinsam Lake Inlet to Middle Quinsam Lake Outlet (Reaches 7 to 12)

Reach 7 extends from the fan at the Lower Quinsam Lake inlet to 1.7 km upstream. In this reach the channel flows through a wide valley and was reported to have an average width of 20 m, a gradient of about 0.5%, and substrates dominated by gravels (Table 5). Quinsam Coal (1980, Appendix IV) reported that this reach provides good spawning potential with numerous 10–50 m long gravel beds.

In Reach 8 (length ~ 1.7 km) the valley becomes narrower, the gradient increases to 1.3%, and the channel width reduced to 10 m. Substrates were indicated to be similar to the previous reach with gravels being the dominant category. The Iron River enters at the top of this reach. This reach was also reported to offer excellent spawning potential (Quinsam Coal 1980, Appendix IV).

In Reach 9 the valley opens up again. The channel was reported to average 20 m in width, to have a low gradient (0.8%) with marshy areas, and to have substrate material composed mainly of silt (Table 5). Quinsam Coal (1980, Appendix IV) showed no spawning habitats within this reach (probably due to lack of gravel), however, the reach probably offers rearing potential.

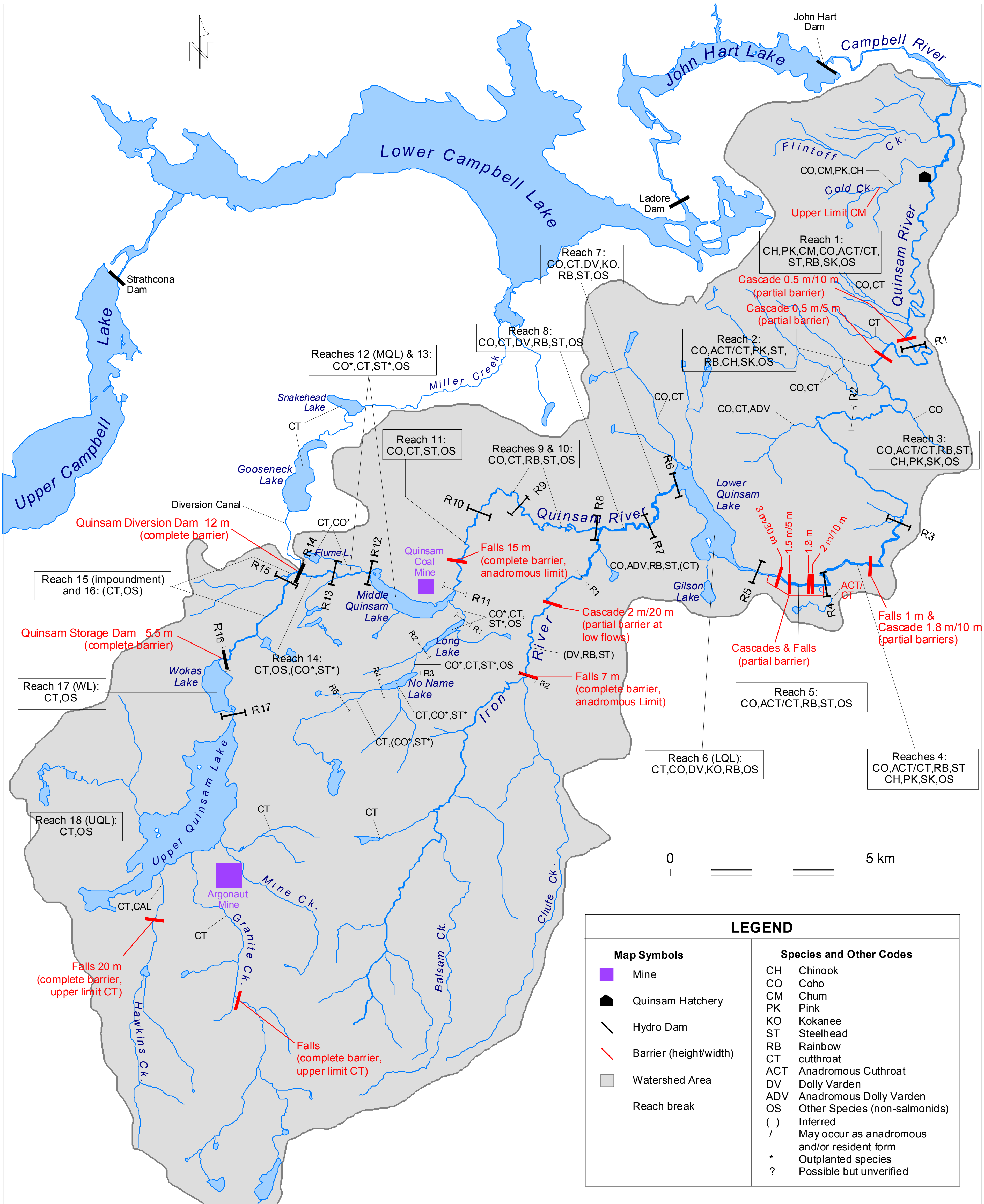

Figure 6. Map of the Quinsam River Watershed showing obstructions, and distribution of salmonid species.

[Spacer page for back side of Figure 2]

In Reach 10 the valley width, channel width, and gradient were reported to be similar to the previous reach, but substrates become coarser (mainly gravels and cobbles). Norecol (1983) rated fish habitat potential in this reach as moderate with suitable spawning and rearing areas in the lower half of the reach.

In Reach 11 the channel features change dramatically. The river flows through a canyon with an average width of 15 m, and the gradient increases to about 3.5% (Table 5). The flow character becomes mainly fast flowing riffles with numerous cascades, each 50–60 m long and 4–5 m high (Hirst 1991). Substrates were mainly cobbles and boulders, with isolated patches of gravel. The lack of spawning gravel was indicated to limit the spawning potential of this reach, while high water velocities constrained available rearing habitat. The best rearing habitat within this reach was indicated to occur within a short section immediately below the outlet of Middle Quinsam Lake (Norecol 1983).

Middle Quinsam Lake (Reach 12)

Middle Quinsam Lake has a length of 2.7 km and an area of 75.3 ha. This lake is very shallow with a maximum depth of 15 m and much of it less than 6 m in depth. This shallowness, combined with relatively high water clarity, was found to result in a euphotic zone that extends to the bottom during the summer. Much of the shoreline is rocky with submerged logs from previous timber harvest activities. The most important fish rearing areas are believed to be the eastern end and the western third of the lake, where aquatic vegetation is more abundant.

Middle Quinsam Lake Inlet to Quinsam Diversion Dam (Reaches 13 and 14)

Reach 13 is a 1.1 km section of the mainstem immediately above Middle Quinsam Lake. The channel in this reach flows through a wide valley, and was found to have a width of about 15 m, and a gradient averaging 0.8%. The flow character was dominated by slow-moving riffles and glides. Excellent spawning gravels were found to occur in this reach, while an abundance of large woody debris (LWD) cover provided high quality rearing habitat for resident cutthroat and outplanted coho (Hawthorn 1984).

Reach 14 is also about 1.1 km in length and is demarcated at its top end by the Quinsam River Diversion Dam. In this reach the channel is confined by a narrower valley and the gradient increased to 1.7%, but the average width was found to remained at about 15 m. The predominant habitat type was riffles, and substrates were mainly cobbles and gravels. During survey of this reach in 1983, it was found that 50% of the banks were failing (Norecol 1983). Norecol ranked fish habitat potential within this reach as low, however, no explanation was provided for this poor ranking.

Quinsam Diversion Dam Impoundment (Reach 15)

This reach is a small lake created by the 12 m Quinsam Diversion Dam at km 47.4. It has an area of 1.2 ha and a length of 0.4 km.

Reach 16 - Quinsam Diversion Impoundment to Quinsam Storage Dam (Reach 16)

Reach 16 is the 3.0 km stream section between the top of the diversion impoundment and the storage dam at the outlet of Wokas Lake. The channel flows through a narrow valley, and was indicated to have an average width of 10 m, and gradient of 2%. Substrates were comprised of cobbles and large gravels. Fish habitat potential of this reach (spawning and rearing) was not covered in the literature.

Upper Quinsam and Wokas Lakes (Reaches 17 and 18)

Water levels in Wokas and Upper Quinsam Lakes are controlled by the 5.5 m high storage dam located at the outlet of Wokas Lake (km 50.8). The 2 lakes are connected by a narrows at km 52.6 which also forms the reach break between the 2 lakes. Wokas Lake (Reach 17) has an area of 61.0 ha, a length of 1.8 km, and a maximum depth of 34 m. Upper Quinsam Lake (Reach 18) is the largest lake on the Quinsam River system. It has an area of 504.2 ha, a length of 6.6 km, and a maximum depth of 48 m.

Iron River

Review of the 1:20,000 map of the middle Quinsam River drawn up by Norecol (1983, map 1), suggests 3 reaches for the Iron River. Reach 1 includes the stream section from the Iron River mouth upstream for 2.6 km. Within this reach the river has an unconfined channel as it flows across the broad valley of the Quinsam mainstem. Digitizing on 1:20,000 TRIM maps indicated an average gradient of 1.2% for this reach. Previous reconnaissance surveys have described this reach as having an average channel width of 30 m, with frequent braids, and numerous gravel bars strewn with woody debris (Quinsam Coal 1980; Norecol 1983). Bed material was reported to be comprised of mainly gravels and cobbles. Quinsam Coal (1980, Appendix IV) observed 3 main spawning beds within this reach, the largest of which was a 100 m long bed near the mouth.

In reach 2 the river channel becomes confined within a canyon and the width reduced to about 10 m. Substrates were indicated to be mainly cobbles and boulders (Norecol 1983, map 1). Digitizing on 1:20,000 TRIM maps indicated an average gradient of 2.3% for this reach. On the Norecol map, this reach is reported to contain a 7 m falls near its top end which forms a complete barrier to anadromous fish migrations. However, there is some confusion as to the location of this barrier since some reports (Hooton and Carswell 1981; Carswell et al. 1986) show a barrier several kilometres further upstream (above the Chute Creek confluence). In our Figure 6 this falls is shown in the location indicated by Norecol (1983). The spawning and rearing potential of this and Reach 3 was not examined in the literature.

Reach 3 includes the rest of the Iron River above the 5.4 km point (18.2 km of stream). No biophysical data were found for this reach.

Long Lake Subbasin

The Long Lake subbasin empties into the southeastern end of Middle Quinsam Lake. Norecol (1983) subdivided this subbasin into 6 reaches. Reach 1 is the 0.7 km long outflow stream connecting Long Lake and Middle Quinsam Lake. This creek was examined on foot by Water Management Branch in September 1984 (Hawthorn 1984). The stream was found to flow through a marshy area at its mouth, however, above this the channel became more defined with numerous patches of spawning gravel. At approximately 150 above the mouth a log jam was encountered with a gravel berm on its upstream side, which caused the creek to flow underground at this point (low flow barrier). Near the Long Lake outlet the gradient increased and substrates become dominated by cobbles and boulders with only isolated patches of gravel. At the Long Lake outlet a heavy accumulation of debris was found but was thought to provide good rearing cover and not to impede fish passage. Norecol (1983) reported an average channel width of 5 m and gradient of 2.8% for this reach. Overall, the creek was believed to provide good rearing opportunities, with some spawning potential at its lower end. Rearing habitats included protected areas behind boulders and beneath undercut banks.

Long Lake (Reach 2) is a long narrow body of water (length 1.25 km, width 110 m, area 13.9 ha) with a mean depth of 7 m and a maximum depth of 22 m. Limnology surveys conducted on the lake in 1984 (MacIsaac and Stockner 1985) indicated an average euphotic zone depth of 9 m, and thus, unlike Middle Quinsam Lake, the euphotic zone only extends to the bottom in shallower regions of the lake. Long Lake is known to provide rearing habitat for colonized coho and resident cutthroat trout.

Reach 3 was assigned to the 0.8 km creek connecting No Name Lake and Long Lake. Norecol (1983) described this creek as sinuous with an average channel width of 5 m and an average gradient of 1.9%. In the upper half of this reach, the valley became narrower and the gradient slightly greater than the lower half. With the increased gradient the substrates also became more coarse, i.e., a bed composed predominantly of large gravel became mixed with a range of sizes up to the boulder category. The upper portion also had accumulations of woody debris which were lacking in the lower half. This reach was thought to provide moderate to high potential for both spawning and rearing phases of salmonids (resident cutthroat and outplanted species).

No Name Lake (Reach 4) has an area of 14.0 ha, length of 1.0 km, and maximum depth of 18 m. Macrophyte growth is restricted to shallow areas along the margin of the lake, particularly along the north shore and at the eastern end.

The inlet stream for No Name Lake was subdivided into Reaches 5 and 6. The boundary between the 2 reaches was placed about 1.0 km upstream of No Name Lake. Reach 5 was indicated to have a channel width of 3 m and bed material composed of mostly fines. Little information was available for Reach 6 (3.1 km long) other than the presence of beaver dams.

Flume Lake Subbasin

The Flume Lake subbasin drains into the north side of the Quinsam River about 250 m upstream of Middle Quinsam Lake. Norecol (1983) designated Flume Lake Creek as Reach 1 and Flume Lake as Reach 2. Flume Lake Creek is a 1.2 km long waterway that flows through a 100–200 m wide wetland. The stream only occasionally forms a distinct channel, has a low gradient (average 0.7%), and a bottom composed of silt and organic debris. Flume Lake (Reach 2) is a small shallow body of water (6.1 ha, 0.4 km long, 8 m maximum depth) with a flat shoreline, and marshlands at its east and west ends. Substrates are almost exclusively silts (Hawthorn 1984). Although this subbasin had little spawning habitat, its source lake, outlet stream, and associated wetlands provide excellent rearing habitat for coho fry outplanted by Quinsam Hatchery.

Table 5. Habitat characteristics of the Quinsam River and some of its tributaries.

Reach	Reach Starting Point (km)	Reach Length (km)	Valley Flat to Channel Width Ratio	Channel Width (m)	Reach Gradient (%)	Dominant Habitat Types	Substrate Categories (% F/G/L/R)	Comments
Quinsam River Mainstem								
R1	0.00	10.43	2–5	20	0.7	riffle/run/pool	2/4/4/T	
R2	10.43	6.90	2–5	20	0.3	pools	8/1/1/T	Spawning gravel in patches
R3	17.33	5.08	0–2	15	0.3	runs/pools	7/2/1/0	Spawning gravel in patches
R4	22.41	3.69	0–2	20	1.0	riffles	1/2/7/T	
R5	26.10	1.91	0–2	20	1.4	riffle/pool/casc	0/1/3/6	Numerous cascades
R6*	28.01	3.10						Lower Quinsam Lake
R7	31.11	1.72	N/A (fan)	20	0.5	pools/riffles	2/7/1/0	Good spawning potential
R8	32.83	1.68	2–5	10	1.3	riffles/pools	2/7/1/0	Good spawning potential
R9	34.51	3.42	$10	20	0.9	pools	9/1/0/0	Poor spawning potential
R10	37.93	1.90	$10	20	0.8	glides/pools	2/4/4/0	Spawning and rearing potential in lower half
R11	39.83	2.69	0–2	15	3.5	fast flowing riffles	0/1/7/2	Canyon, numerous chutes and falls, low spawning and rearing potential, anadromous barrier at 15 m falls
R12*	42.52	2.67						Middle Quinsam Lake
R13	45.19	1.12	$10	15	0.8	slow moving riffles/glides	2/8/0/0	Extensive and good quality spawning and rearing habitat
R14	46.31	1.08	2–5	15	1.7	riffles	1/3/6/0	Failing banks common, low rearing/spawning potential
R15*	47.39	0.42						Diversion Dam impoundment
R16	47.81	2.97	0–2	10	2.0	riffles	1/3/6/T	
R17*	50.78	1.81						Wokas Lake
R18*	52.59	6.56						Upper Quinsam Lake
Total-Rivers Only		44.59						
Total		59.15						
Iron River								
R1	0.00	1.51	$10	30	1.2	riffles/pools	1/5/4/0	Spawning potential
R2	1.51	3.83	0–2	10	2.3	riffles	1/3/6/T	Canyon, 7 m barrier falls at top of reach
R3	5.34	12.83						
Total		18.17						
Long Lake Drainage								
R1	0.00	0.72	5–10	5	2.8	boulder controlled riffle–pool sequences	½/7/T	Good rearing potential, some spawning potential in lower end
R2*	0.72	1.25						Long Lake
R3	1.97	0.76	0–5	5	1.9		1/3/6/T	Good spawning and rearing potential

Reach	Reach Starting Point (km)	Reach Length (km)	Valley Flat to Channel Width Ratio	Channel Width (m)	Reach Gradient (%)	Dominant Habitat Types	Substrate Categories (% F/G/L/R)	Comments
R4*	2.73	0.86						No Name Lake
R5	3.59	1.04	$10	3			9/1/0/0	
R6	4.63	3.06						Beaver dams present
Total-Rivers Only		5.58						
Total		7.69						
Flume Lake Drainage								
R1	0.00	1.16	$10		0.7		Fines and organic debris	Flows through marsh, no spawning potential, good rearing potential
R2*	1.16	0.42						Flume Lake
Total		1.58						

Sources: Norecol (1983), Hawthorn (1984), Hirst (1991), Resource Analysis Branch (1983 reach cards)
Notes:
1. Asterisk (*) beside a reach number indicates a lake reach.
2. In the column "Dominant Habitat Types," habitat categories include pools, glides, riffles, and cascades.
2. In the column "Substrate Categories," the percentage of Fines (F), Gravels (G), Larges (L), and bedRock (R) are rounded to the nearest 10%, and expressed as an integer (when less than 5%, T for trace is indicated). In some cases only dominant/subdominant categories were provided in the literature (no percentages). Particle sizes are from the Wentworth scale (Anon. 1995).
3. Lake distances are from inlet to outlet.

Table 6. Physical characteristics of lakes in the Quinsam River system.

Name	Area (hectares)	Length (km)	Max. Depth (m)	Percent Littoral Zone	Previous Surveys
Lower Quinsam Lake	145.3	3.50	22	49%	1958,76
Middle Quinsam Lake	75.3	2.67	15	75%	1958,76,78,80
Long Lake	13.9	1.25	22	25%	1958,86
No Name Lake	14.0	1.00	18	32%	
Flume Lake	6.1	0.41	9	79%	1984
Quinsam Diversion Impoundment	1.2	0.42	Unknown	Unknown	
Wokas Lake	61.0	1.81	34	33%	1976,78
Upper Quinsam Lake	504.2	6.56	48	32%	1975,76,78
Gooseneck Lake	84.1	2.21	38	9%	1956,75
Snakehead Lake	22.2	0.91	9	78%	1985

Notes:
1. Length and Area were determined using GIS software (QuikMap) on 1:20,000 TRIM maps.
2. Lake lengths are longest dimension (as opposed to Table 6 which are from inlet to outlet, i.e., "blueline").
3. Maximum depth, percent littoral zone, and survey years are from Resource Analysis Branch (1983).

Data Gaps

Previous habitat surveys on the Quinsam River system have largely been reconnaissance in nature, and as such, have been limited to providing only baseline biophysical data for the different reaches (e.g., confinement, channel width, gradient, substrate). Some key habitat questions that remain unaddressed by previous studies are listed below. Items 1 and 2 are important to the WUP process, while items 3 and 4 are more important to fisheries management.

1) What is the effect of regulated flows and current operating regimes for Quinsam Diversion and Storage Dams on the quantity and quality of fish habitat? Studies that address this question typically require measurement of hydraulic parameters (width, depth, and velocity) in relation to stream discharge, which are then linked with changes in the amount of rearing and or spawning habitat.

2) Previous studies are dated (15 or more years ago), and biophysical characteristics and fish potentials may have changed since these surveys were conducted (e.g., past disturbances may have stabilized, or new disturbances incurred).

3) Previous studies have not identified the localities and extent of degraded habitats (although Lawseth [1979] provided some insights). In recent years documentation of degraded habitats has been the focus of the Province's Watershed Restoration Program (WRP), and new assessment procedures have been layed out for this type of habitat inventory (Johnston and Slaney 1996).

4) What are the actual quantities (m^2) of spawning and rearing habitats in the different reaches of the Quinsam River? This kind of empirical data can greatly assist in establishing appropriate escapement targets, rearing habitat seeding rates, and the setting of stocking rates for outplanting programs. It can be used to assess limiting factors (bottlenecks) to freshwater production (example spawning habitat vs rearing habitat limitation), and to predict smolt production if rearing habitat were seeded to capacity.

6. FISH RESOURCES

The Quinsam River system supports a variety of salmonid and non-salmonid fish species. Anadromous salmonids include all 5 species of salmon (chinook, coho, pink, chum, and sockeye salmon), as well as steelhead and sea-run cutthroat trout and Dolly Varden char. Resident salmonids include rainbow and cutthroat trout, kokanee, and Dolly Varden char. Non-salmonids present in the system include coastrange sculpins, threespine sticklebacks, and lamprey. Table 7 lists these species with their scientific names and abbreviation codes.

Table 7. Common and scientific names of fish species found in the Quinsam River system.

Common Name	Abbre-viation	Scientific Name	Comments
Anadromous Salmonids:			
Chinook Salmon	CH	*Oncorhynchus tshawytscha*	
Coho Salmon	CO	*Oncorhynchus kisutch*	
Pink Salmon	PK	*Oncorhynchus gorbuscha*	
Chum Salmon	CM	*Oncorhynchus keta*	
Sockeye Salmon	SK	*Oncorhynchus nerka*	
Steelhead Trout	ST	*Oncorhynchus mykiss*	Anadromous form of *O. mykiss*
Sea-run Cutthroat Trout	ACT	*Oncorhynchus clarki*	Anadromous form of *O. clarki*
Sea-run Dolly Varden	ADV	*Salvelinus malma*	Anadromous form of *S. malma*
Resident Salmonids:			
Rainbow Trout	RB	*Oncorhynchus mykiss*	Resident form of *O. mykiss*
Cutthroat Trout	CT	*Oncorhynchus clarki*	Resident form of *O. clarki*
Kokanee Salmon	KO	*Oncorhynchus nerka*	Resident form of *O. nerka*
Dolly Varden	DV	*Salvelinus malma*	Resident form of *S. malma*
Non-Salmonids:			
Coastrange Sculpin	CAL	*Cottus aleuticus*	Resident in fresh and brackish waters
Threespine Stickleback	TSB	*Gasterosteus aculeatus*	Resident in fresh, brackish, & marine waters
Pacific Lamprey	PL	*Lampetra tridentata*	Anadromous
Lamprey (species uncertain)	L	*Lampetra* spp.	Possibly *L. ayresi* (anadromous) or *L. richardsoni* (resident)[1]

[1] Downstream trapping on the Quinsam River regularly captures at least 2, possibly 3 species of lamprey. The larger sized ones are *L. tridentata*, while the smaller ones are either or both of *L. ayresi* or *L. richardsoni*, but have not been keyed out (Rob Bell-Irving, Quinsam Hatchery, pers. comm.).

6.1 Life History Information

The following are life history synopses for fish species inhabiting the Quinsam River system. For each species, the timing of life history stages are summarized in Table 8 (p. 37). Information sources for anadromous species included annual monitoring of upstream migrating adults (1973–1998), and downstream migrating juveniles (1988–92, 1996-98), both of which are enumerated at the counting fence located 300 m above the Quinsam Hatchery (files supplied by D. Ewart, Quinsam hatchery). Information on the life history timing of resident species was not well documented, and the author relied on recent work on neighbouring Campbell Lake streams by MWLAP personnel (MELP 1998-99). These surveys involved monthly snorkel swims from February 1998 to May 1999 on Fry Creek, Greenstone Creek, and the Campbell River below Strathcona Dam (other streams were surveyed but were excluded because they are further up the Campbell Watershed with higher elevations and colder temperature regimes). The MWLAP surveys also included inspection of redds to determine the developmental state of incubating eggs or alevins.

Other sources of information included interviews with Quinsam Hatchery staff (Dave Ewart and Jim Van Tine) who have worked on the Quinsam River system for many years, and with Vancouver Island Hatchery staff (Ray Billings) who have conducted previous studies on the system. Lastly, general texts such as Scott and Crossman (1973) and Groot and Margolis (1991) were sometimes consulted.

Because the timing of life history events is crucial to Water Use Plan development, Table 8 was reviewed by hatchery staff (Dave Ewart, Jim Van Tine) to ensure the best accuracy with data at hand.

Chinook Salmon

Adult chinook salmon destined for the Quinsam River begin arriving in the Campbell River about mid-August (Burt and Burns 1995). The timing of migration into the Quinsam River is influenced by the timing of fall rains, which cause an increase in Quinsam River flows (Andrew et al. 1988). Migration into the Quinsam River usually occurs from late September to mid November, with a peak at the end of October (Dave Ewart, Quinsam Hatchery, pers. comm.). Spawning takes place from the beginning of October to mid-November (Table 8). Eggs hatch during January and February and alevins remain in the gravel until approximately early April, after which they emerge as free swimming fry (Dave Ewart, Quinsam Hatchery, pers. comm.). The duration of fry rearing is variable and ranges from migration soon after emergence, to rearing in the river for 2 to 3 months before migrating as smolts. This rearing strategy, albeit a variable one, is typical of ocean-type chinook, whereby emigration to sea occurs during the first summer of life, usually within 3 months after emergence (as opposed to stream-type chinook which rear for a summer and winter, or longer, prior to migration to sea)[6]. Chinook that migrate from the Quinsam as fry are believed to continue down to the Campbell River estuary where they continue rearing until smoltification. Aging of adult scales has indicated that some chinook (proportion unknown) rear for a full summer and winter before smolting (as in stream-type chinook), however, it is believed that the overwintering occurs in the estuary as opposed to the stream. This belief is based on the absence of one year old smolts in downstream trapping captures (Dave Ewart, Quinsam hatchery, pers. comm.).

The timing of the fry out-migration is typically from about mid-April to the end of June, while smolts migrate from about mid-May to mid-July (Table 8). This timing is variable between years and is influenced by water temperatures during the winter (warmer temperatures accelerate the onset of migration; colder temperatures delay it). For example, annual trapping records indicate a migration onset ranging from April 4–May 7, and its completion from June 7–July 18 (Quinsam Hatchery files from Dave Ewart).

Coho Salmon

Adult coho salmon migrate into the Quinsam River from mid-September till the end of December (Table 8). Migration is often triggered by an increase in Quinsam River flows from autumn rainfall. Early migrating coho hold in the Campbell, and move quickly into the Quinsam River when the rains start (Dave Ewart, Quinsam Hatchery, pers. comm.). Late migrating coho typically move directly from the estuary to the Quinsam River without little or no holding in the Campbell River. Coho spawning begins about mid-October and is usually over by mid-December, but can extend until mid-January in some years. The eggs hatch from January to February, and the alevins remain in the gravel for about 2 months before emerging as free-swimming fry in late March to early April (Dave Ewart, Quinsam Hatchery, pers. comm.). Like chinook, the rearing strategy adopted by coho fry is variable. Some fry migrate from the Quinsam during their first spring/early summer, but most rear for one summer and winter, and migrate from the Quinsam the following spring as 1-year-old smolts. A small portion of the coho population also remains in the river for an additional summer and winter, and emigrate as 2-year-old smolts the subsequent spring. There is some speculation that 2-year-old smolts may be due to rearing fish being trapped in offchannel habitats and prevented from migrating during the normal smolting period. This is based on the observation of a higher incidence of 2-year-olds among broods that experienced freshets during early spring, which may have provided fry with access to wetlands that are not normally available (Dave Ewart, Quinsam Hatchery, pers. comm.).

[6] See Healey (1991, p 314) for a full description of distinguishing characteristics of stream- and ocean-type chinook.

The general timing of the downstream coho migration is from about mid-March to late June for fry, and from late April to late June for smolts (Table 8). These are general times as migration timing varies from year to year. For example, annual trapping records (1989–92, 1996–98) indicate a migration onset ranging from March 3 to April 27, and completion from June 16 to July 25.

The fate of juvenile coho that migrate from the Quinsam as fry is uncertain. It is possible that some take up residence along the margins of the Campbell River, or they may migrate or be displaced downstream to the estuary. It has sometimes been felt that coho that end up in the estuary as fry do not survive, however, there is mixed evidence for this conclusion (see Sandercock 1991 for a full discussion). Also, snorkel surveys by hatchery staff have regularly observed coho fry in brackish areas of the lower Campbell River (below Highway 19, northbound crossing) during the summer, and small numbers have been captured by beach seining in the estuary during winter (D. Ewart, Quinsam Hatchery, pers. comm.). These observations suggest that Quinsam River coho fry are able to survive in the estuarine environment.

Pink Salmon

Timing of life history cycles of pink salmon follows a relatively consistent pattern from year to year (Burt and Burns 1995). Adults migrate into the Campbell River from the third week in July to the third week in August. The fish hold throughout the Campbell and begin to move into the Quinsam River during the third week of August. Migration into the Quinsam peaks in the third week of September and is complete by the second week in October (Dave Ewart, Quinsam Hatchery, pers. comm.). Spawning begins in the third week of September and continues until mid-October. Fry emerge from the gravel from early March to mid-April. Unlike chinook and coho, pink fry spend little or no time rearing in the river, but migrate to sea immediately or soon after emergence. Upon reaching the Campbell River mouth, pink fry move quickly through the estuary to the marine environment. Timing of the downstream migration is generally from early March to the end of April, although the downstream trapping program has captured pink fry as early February 29 and as late as May 20.

An important feature of the pink life history is that the duration of their life cycle is typically 2 years. This tends to produce genetic separation between odd and even year runs.

Chum Salmon

Each year the Quinsam River receives a small run of chum salmon. The timing of this run is similar to the relatively large run of chum that use the Campbell River, which is described in Burt and Burns (1995). Migration of chum into the Quinsam River occurs from mid-October to mid-December and spawning commences within a few days of arrival (Table 8). Spawning occurs from mid-October to early

January. Emergence of fry from the gravel appears to occur from mid-March to mid-May (based on downstream trapping at the counting fence). Emergent chum fry behave similar to pinks, in that they emigrate from the river soon after emergence. The downstream trapping program indicates that this is typically from mid-March to early June, although the completion of migration has been variable with a range of April 22 to June 5. Upon reaching the Campbell River mouth, chum fry rear in the estuary for about a month before moving offshore (Dave Ewart, Quinsam Hatchery, pers. comm.).

Sockeye Salmon

Each year the Quinsam River receives a small run of sockeye salmon. In-migration by this species occurs from mid-August to mid-October, and spawning from mid-September to mid-October (Table 8). Downstream trapping at the counting fence suggests that emergence probably begins about mid-March, after which some of the fry emigrate from the river while others remain for a full summer and winter and migrate as smolts the following spring. The timing of the fry migration is typically from mid-March to the end of April, while smolts generally migrate from late April to early June.

It would appear that the sockeye using the Quinsam River are a river rearing population, since adults are not believed to ascend the falls below Lower Quinsam Lake (Dave Ewart, Quinsam hatchery, pers. comm.). This is based on the relatively low flows that occur during their upstream migration which likely prevents passage at these falls, and the fact that they arrive in an advanced state of ripeness. While the normal pattern for sockeye is to utilize lakes for rearing (usually for 1-3 years), it is not uncommon in British Columbia streams to have small sockeye populations with a river rearing strategy.

Another important aspect of sockeye life history is that they generally have a 4 year life cycle. Thus, like pinks, there tends to be genetic segregation among brood years.

Steelhead Trout

The Quinsam River supports a winter run of steelhead trout with an in-migration period extending from late October to mid-April (Table 8). Within this period there tends to be 3 pulses: the first occurs from late October to the end of December, the second from January to mid-February, and the third from mid-February to April. (Dave Ewart, Quinsam Hatchery, pers. comm.). Spawning takes place from the beginning of March to mid-April, and fry emerge from the gravel from late April to the end of May. Most juvenile steelhead rear in the river for 2 or 3 years and emigrate in the spring as smolts, however, some juveniles also emigrate as fry during their first spring, or as parr during their second spring. The timing of these out-migration is early April to late June for parr, and late April to late June for fry and smolts.

Lirette et al. 1985 examined scale samples from steelhead smolts enumerated at the counting for the period 1976–1981. Two-year-old smolts were typically the most abundant, followed by 3-year-olds, 4-year-olds, and then 1-year-olds. Mean smolt age (MSA) across the 6 sample years was 2.3 years.

Although the Quinsam is known as a winter run steelhead stream, a small number of summer run fish (generally less than 10) are usually captured at the counting fence during early October or November (Dave Ewart, Quinsam Hatchery, pers. comm.). These fish are distinguished from the winter run race by their dark colour which is an indication of extended time in freshwater.

Sea-Run Cutthroat Trout

The Quinsam River supports a small to moderate population of sea-run cutthroat trout. The size of this run appears to have increased in recent years, however, empirical information on abundance is not available (Dave Ewart, Quinsam Hatchery, pers. comm.). These fish arrive in the Campbell River during July and August, where they hold for the remainder of the summer (Burt and Burns 1995). In late October through mid-January, anadromous cutthroat migrate into the Quinsam River, and probably spawn during February and March (Table 8). Fry emergence likely occurs in May and June. Young rear in the river and tributaries for 2 years (predominantly) before smolt migration to the Campbell mainstem and estuary during late April to late June.

Sea-Run Dolly Varden Char

The run of anadromous Dolly Varden char to the Quinsam River is very small and poorly understood. Small numbers of adults are capture at the hatchery counting fence during their upstream migration, as well as smolts during their downstream migration. Adult Dolly Varden have also been found in Lower Quinsam Lake, and juveniles have been captured in the Iron River and one small tributary in the lower river. Because little is know of Quinsam Dolly Varden, the following description of Dolly Varden life history relies on adult and smolt fence trapping as well as information from the Keogh River population, which was investigated in detailed during the late 1970's (Smith and Slaney 1980). In-migration of Quinsam Dolly Varden occurs from mid-July to early November with spawning from late September to mid-November. Emergence probably begins in mid-March and fry may continue to emerge until June in colder tributaries. Freshwater rearing is likely to last for 2 to 4 years with fish utilizing both the mainstem and tributary habitats (in the Keogh, 3-year-olds were the dominant age of smolting). Downstream migration consists of parr and smolts, with parr migrating from about mid-March to mid-June, and smolts from mid-April to mid-June (based on Quinsam fence enumerations).

Like sea-run cutthroat, repeat spawning is common with anadromous Dolly Varden char. After spawning, the adult kelts overwinter within the river system and migrate back to the ocean in early spring. In the Keogh system, many kelts overwinter in lakes after spawning, and migrate back to the ocean from mid-March through early June. This overwintering behaviour may explain the presence of adults in Lower Quinsam Lake. Alternatively, the Dolly Varden in Lower Quinsam Lake may be a resident population. At the time of writing, I was unable to find any data that resolved this question.

Resident Rainbow Trout

Resident rainbow can occur as 2 basic types (Scott and Crossman 1973): lake-resident rainbow that spend the majority of their life in lakes and use streams for spawning and juvenile rearing, and stream-resident rainbow that conduct their entire lives in streams. Stream-resident rainbow may use larger rivers for their adult life, and smaller tributaries for spawning and juvenile rearing. The occurrence of mature rainbow in Lower and Middle Quinsam Lakes as well as the Quinsam mainstem suggests that both types occur in the Quinsam system. The life history of Quinsam rainbow is poorly understood, however MWLAP has recently conducted snorkel surveys and redd examinations in 3 Campbell Lake streams (Fry and Greenstone Creeks, and Campbell River below Strathcona Dam; MELP 1998-99), and the timing information from this work is probably appropriate for Quinsam rainbow. These surveys suggest that spawning occurs from mid-April to the end of June. Emergence probably begins about mid-June and continues through July. The fry of lake-resident spawners may migrate up or down to the associated lake soon after emergence, or by autumn, or they may remain in the nursery stream for 1–3 years before migrating to the lake (Scott and Crossman 1973). Fry of stream-resident spawners remain in the stream.

Resident Cutthroat Trout

Like rainbow trout, resident cutthroat trout can occur as both lake- and stream-resident forms (Scott and Crossman 1973). Previous studies on the Quinsam Watershed have not distinguished between the 2 forms, however, it is likely that both types occur although lake-residents appear to make up the bulk of the population. Lake-resident cutthroat depend heavily on inlet streams for spawning, but may also utilize outlet streams. The timing of life history events is not well known for resident cutthroat in the Quinsam system. Broodstock captures in Upper Quinsam Lake[7] indicated that this population spawns mainly during April (Ray Billings, Vancouver Island Hatchery, Duncan, pers. comm.). During the spawning period, adults congregated off the mouth of the spawning stream (in this case, Hawkins Creek), and made short duration excursions into the stream to spawn, and then returned immediately to Upper

[7] Upper Quinsam Lake cutthroat were examined as a potential source of broodstock for other Vancouver Island lakes because of their pure genetics (no other salmonids occur in this lake). This plan was subsequently abandoned because the fish tended to mature in 2 years under culture conditions as opposed to the preferred 3 years. Three-year-olds are preferred because of their larger size which provides a better angling experience (Ray Billings, Vancouver Island Hatchery, Duncan, pers. comm.).

Quinsam Lake. Since this is the uppermost and coldest of the main lakes, spawning may be slightly later than in the other Quinsam lakes. Recent studies on Campbell Lake cutthroat (MELP 1998-99) indicated a spawning period from early February until the end of April. Emergence was not determined precisely, but was probably in the latter half of June. Given the proximity and similar elevation of Campbell Lake, the spawning period and emergence of Quinsam cutthroat is probably similar to Campbell Lake fish and this timing is reflected in Table 8.

After emergence, fry may migrate up or down to the lake, or may remain in the nursery stream for up to 4 years before migrating to the lake (Scott and Crossman 1973). Review of juvenile cutthroat sizes from sampling by Grant et al. (1995) shows that some Quinsam cutthroat remain in the nursery stream for 1 to 2 years, and occasionally 3, before migrating to the associated lake.

Kokanee Salmon

There are early reports of kokanee in Lower Quinsam Lake (RAB reach cards), however, the author was unable to find any biological or life history timing information on these stocks in the literature. Some information was provided by the fish habitat survey conducted on the Quinsam River during fall 1999. During these surveys (October 16 and 18, 1999), the author observed kokanee in full spawning colours in reaches 8 and 9 of the Quinsam River. The fish averaged about 14 cm in length and appeared to be utilizing coarse sand and "pea" gravel for spawning. Judging by the state of ripeness and numbers of fish observed (20–30 fish per school), a substantial number of Lower Quinsam Lake kokanee spawn in the mid October period.

Data Gaps

The main data gap with respect to the life history of Quinsam River salmonids is in the uncertainty of the timing of events for the resident species (the timings provided in Table 8 rely on data from other watersheds). This may be of particular importance in Upper Quinsam Lake, where drawdown cycles may adversely affect various life history phases of the cutthroat population that resides in this lake. In addition, questions remain as to whether Lower Quinsam Lake supports a resident population of Dolly Varden char.

Another noteworthy point, is that the juvenile emergence and migration data for anadromous species could be enhanced during downstream trapping by having counting crews separate out steelhead from cutthroat parr, and by ensuring that species of lesser abundance such as sockeye, sea-run cutthroat, and sea-run Dolly Varden are not overlooked.

Table 8. Timing of freshwater life stages of Quinsam River salmonids. Adapted from Burt and Burns (1995) and B.C. Hydro (1998), and updated with information from Quinsam Hatchery records.

Species	Life Stage	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.
Chinook Salmon[1,2]	Adult Migration		x	x x x x	x x								
	Spawning			x x x P	P x								
	Incubation			x x	x x x x	x x x x	x x x x	x x x x	x x x x	x x x x			
	Rearing									E x x	x x x x	x x x x	x x x
	Juvenile Migration									F x	x x S x	x x x x	x x x
Coho Salmon[1,2]	Adult Migration		x x	x x x x	x x x x	x x x x							
	Spawning			x x	x x x x	x x x x	x x						
	Incubation			x x	x x x x	x x x x	x x x x	x x x x	x x x x	x			
	Rearing	x x x x	x x x x	x x x x	x x x x	x x x x	x x x x	x x x x	x x E x	x x x x	x x x x	x x x x	x x x x
	Juvenile Migration								F x	x x x S	x x x x	x x x	
Pink Salmon[1,2]	Adult Migration	x x x x	x x x x	x x									x x
	Spawning		x x	x x									
	Incubation		x x	x x x x	x x x x	x x x x	x x x x	x x x x	x x x x	x x			
	Rearing								E				
	Juvenile Migration								F x x x	x x x x			
Chum Salmon[1,2]	Adult Migration			x x	x x x x	x x							
	Spawning			x x	P P x x	x x x x	x						
	Incubation			x x	x x x x	x x x x	x x x x	x x x x	x x x x	x x x x	x x		
	Rearing								E				
	Juvenile Migration								F x	x x x x	x x x x	x	
Sockeye Salmon[1,2]	Adult Migration	x x	x x x x	x x									
	Spawning		x x	x x									
	Incubation		x x	x x x x	x x x x	x x x x	x x x x	x x x x	x x				
	Rearing	x x x x	x x x x	x x x x	x x x x	x x x x	x x x x	x x x x	x x E x	x x x x	x x x x	x x x x	x x x x
	Juvenile Migration								F x	x x x S	x x x x	x	
Steelhead Trout[1,2,3]	Adult Migration			x	x x x x	x x x x	x x x x	x x x x	x x x x	x x			
	Spawning								x x x x	x x			
	Incubation								x x x x	x x x x	x x x x		
	Rearing	x x x x	x x x x	x x x x	x x x x	x x x x	x x x x	x x x x	x x x x	x x x E	x x x x	x x x x	x x x x
	Juvenile Migration									x x x S	x x x x	x x x	
Sea-Run Cutthroat Trout[1,2]	Adult Migration			x x	x x x x	x x x x	x x x x						
	Spawning							x x x x	x x x x				
	Incubation							x x x x	x x x x	x x x x	x x x x		
	Rearing	x x x x	x x x x	x x x x	x x x x	x x x x	x x x x	x x x x	x x x x	x x x x	E x x x	x x x x	x x x x
	Juvenile Migration									x x x S	x x x x	x x x	

Species	Life Stage	Aug.				Sept.				Oct.				Nov.				Dec.				Jan.				Feb.				Mar.				Apr.				May.				Jun.				Jul.			
Sea-Run Dolly Varden Char[1,2,4]	Adult Migration	x	x	x	x	x	x	x	x	x	x	x	x	x																																		x	x
	Spawning								x	x	x	x	x	x	x																																		
	Incubation								x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x												
	Rearing	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	E	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Juvenile Migration																															x	x	x	x	S	x	x	x	x	x	x	x						
Resident Rainbow Trout[5,6]	Adult Migration																																																
	Spawning																																			x	x	x	x	x	x	x	x	x	x				
	Incubation	x	x																																	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Rearing	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	E	x	x	x	x	x
	Juvenile Migration																																																
Resident Cutthroat Trout[5,6,7]	Adult Migration																									x	x	x	x	x	x	x	x	x	x	x	x												
	Spawning																									x	x	x	x	x	x	x	x	x	x	x	x												
	Incubation																									x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x						
	Rearing	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	E	x	x	x	x	x
	Juvenile Migration																																																
Resident Dolly Varden Char[5,6]	Adult Migration	x	x	x	x	x	x	x	x	x	x	x	x	x	x																																	x	x
	Spawning									x	x	x	x	x	x																																		
	Incubation									x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x												
	Rearing	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Juvenile Migration																																																
Kokanee Salmon[8]	Adult Migration							x	x	x	x	x																																					
	Spawning								x	x	x	x																																					
	Incubation								x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x																		
	Rearing	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	E	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Abbreviations: E = emergence begins, F = Fry migration begins, S = Smolt migration begins, P = peak spawning,

Sources:

1 Quinsam Hatchery data files - adult enumerations at counting fence (from Dave Ewart, Quinsam Hatchery)
2 Quinsam hatchery data files - juvenile enumerations at counting fence (from Dave Ewart, Quinsam Hatchery)
3 Burt and Burns (1995)
4 Smith and Slaney (1980)
5 MWLAP data files - Campbell/Buttle Snorkel Reports, 1998-99 (from Skip Rimmer, MWLAP, Nanaimo)
6 Scott and Crossman (1973)
7 Spawning timing for Upper Quinsam Lake cutthroat (Ray Billings, Vancouver Island hatchery, pers. comm.)
8 Adult migration, spawning, and incubation are estimates by the author based on personal observation of spawning kokanee in reaches 8 and 9 of the Quinsam River on October 16 and 18, 1999.

6.2 Distribution

6.2.1 Influence of Barriers

The Quinsam mainstem and its tributaries have a number of obstructions that influence the spawning distribution of adult salmonids. The locations of known obstructions are shown as red bars in Figure 6. The associated text (also in red) indicates the nature of the obstruction (cascade or falls), its height and length, and whether it is a partial or complete barrier. Partial barriers are obstructions that slow upstream migration, either because they are difficult to ascend, or because they can only be overcome under certain flow conditions. Complete barriers are those that block ascent of a given species regardless of river flow. Some obstructions are complete barriers to certain species, but only partial barriers to others.

Table 9 lists the known obstructions on the Quinsam system and summarizes information on their passability. The upstream limit for all anadromous migrations is demarcated by the 15 m rock falls at km 41.5 on the Quinsam mainstem, and by the 7 m rock falls on the Iron River at km 5.3. There is reference in the literature of anadromous fish ascending the falls at km 41.5 (Hirst 1991), however, this seems unlikely given the height of the falls (15 m). Most fisheries assessments have indicated the 15 m falls as the upstream migration limit. Other significant obstructions in the anadromous portion of the Quinsam River include the 8 partial barriers located between kilometres 10.1 and 27.4 (Reaches 1 to 5). The latter of these (km 26.3), is believed to be a complete block to any of the heartier pink and sockeye that make it beyond obstructions below this point. Within resident sections of the Quinsam River, complete blocks to resident fish migrations exits at the Quinsam Diversion and Storage Dams.

Table 9. Summary of information on known obstructions in the Quinsam Watershed.

Obstruction	Reach	Distance From Mouth (km)	Height/Length (m/m)	Comments
<u>Quinsam River:</u>				
Cascade	R1	10.1	0.5 m/10 m	Partial barrier to pinks
Cascade	R2	13.3	0.5 m/5 m	Partial barrier; probable block to majority of pinks
Cascade (“below Grouse Nest”)	R4	24.2	1.8 m/10 m	Partial barrier; possible complete block to pinks; partial block to anadromous cutthroat
Falls (below “Grouse Nest”)	R4	24.3	1 m	Partial barrier
Cascades	R5	26.3–27.4	vary from 1.5–3 m high	1.2 km section containing series of small falls and cascades; complete block to pinks; partial block to coho, steelhead, anadromous cutthroat

Obstruction	Reac h	Distance From Mouth (km)	Height/Length (m/m)	Comments
Falls	R11	41.5	15 m	Impassable - upper limit for all anadromous spp.
Quinsam Diversion Dam	R14	47.4	12 m	Impassable - barrier for resident migrations
Quinsam Storage Dam	R16	50.8	5.5 m	Impassable - barrier for resident migrations
Iron River:				
Falls	R2	2.9	2 m/20 m	Partial barrier (obstruction at low flows)
Falls	R2	5.3	7 m	Impassable - upper limit for anadromous spp.
Other Tributaries:				
Cold Ck.	unk.	2.6	3 m	Man-made weir, complete barrier to all fish
Granite Ck.	unk.	4.9	Unk.	Impassable chutes and falls - upper limit for resident cutthroat from Upper Quinsam Lake
Hawkins Ck.	unk.	1.4	20 m/unk.	Impassable chutes and falls - upper limit for resident cutthroat from Upper Quinsam Lake

Sources:
Resource Analysis Branch (1983)
Lawseth (1979 draft)
Jim Van Tine, Quinsam Hatchery, pers. comm. (Cold Creek)

Fish passage at the 10.1, 13.3, and 24.2 km obstructions appears to become more difficult under low flow conditions, and may become insurmountable under extreme lows. This was discovered in 1957 (the year Quinsam hydroelectric facilities were put into operation), when coho and pink migrations were hindered at these obstructions during mid-October under measured flows at km 24.2 of 0.8–1.0 m^3/s (DFO 1957). Most coho and pink salmon remained below the falls at km 10.1, and the small numbers that did ascend were unable to overcome the falls at km 24.2. On October 18, the B.C. Power Commission was asked to provide additional water, and observations indicated that coho did not ascend the falls until flows reached 1.6–1.7 m^3/s (October 22). The effect of the low flow on pink spawning distribution was more uncertain since only small numbers of pink ascend beyond the falls at km 13.3 even when flows are favourable (Jim Van Tine, Quinsam Hatchery, pers. comm.). It would appear that the pink spawning area was shortened by the 3.2 km distance between the obstructions at km 10.1 and km 13.3. An unknown effect was the consequence of pinks having to spawn in depths of 15–20 cm (DFO 1957). This incident resulted in amendment of the licence agreement in 1958 to include a requirement of 1.7 m^3/s below Lower Quinsam Lake from September 1 to November 15. In 1959 the licence was again amended to include this same requirement for the period January 1 to April 30, and in 1963 this was changed to the period February 1 to May 31 (Lough et al. 1993). Hirst indicated that despite these amendments, migration problems may have occurred during 1956 to 1966 when mid- to late summer flows were often less than the licence requirement of 1.7 m^3/s below Lower Quinsam Lake.

The series of falls and cascades below Lower Quinsam Lake (kilometres 26.3 to 27.4) were examined during the habitat inventory by Lawseth (1979). The lowermost falls in the series (km 26.3) occurs in a widening of the river, and water passes over a 4.9 m bedrock falls on the left side and a 3.9 m bedrock falls with 2 steps on the right side (lower step 2.1 m, upper step 1.8 m). Lawseth felt that the left side was impassable, but that fish could negotiate the right side (with sufficient flow). The next obstruction (progressing upstream) is a 1.5 m cascade which was believed to be passable. The uppermost obstruction occurs just below the lake outlet. At this location the river is quite wide (46 m) and water again passes down either side at summer flows. On the left side there is a 3 m drop in 2 steps, the lower one being 1.2 m, and the upper 1.8 m. On the right side the river passes down a 100 m long steep cascade (15% gradient). Lawseth felt that the falls/cascades at this location posed the greatest migration obstacle of the series in this 1 km stretch of stream. At low flows ascent may be difficult due to insufficient water depths, while at high flows a velocity barrier may occur.

It appears, that to date their has been no rigorous examination of the fish passage/flow relationships that exist at the partial barriers below Lower Quinsam Lake. Given that coho, steelhead, as well as anadromous cutthroat and Dolly Varden must ascend these obstructions each year to gain access to upstream spawning grounds, it seems prudent that a more thorough investigation is warranted. Such an investigation should consider ease of passage at various flows above and below 1.7 m^3/s. The work by Griffith (1993) on the Ash River obstructions may serve as a template for this investigation.

6.2.2 Spawning Distribution

Anadromous species

The following description of the spawning distribution of anadromous salmonids is based on interviews with Quinsam Hatchery staff (Dave Ewart and Jim Van Tine), as well as historic surveys by DFO (1957), and more recent reconnaissance surveys for the Quinsam Coal development (Quinsam Coal 1980). The description starts with species that spawn lowest in the river followed by species that penetrate further upriver.

Chum salmon spawn in the lower end of the Quinsam River, primarily in the 3.6 km of river from the mouth to the counting fence located 300 m above the Quinsam Hatchery. Usually, there is a small number of chum that also migrate through the counting fence (Jim Van Tine, Quinsam Hatchery, pers. comm.). Given the poor jumping ability of chum salmon these fish probably do not migrate beyond the falls at km 10.1 or km 13.3. Small number of chum salmon also spawn in Cold Creek.

Chinook have a similar spawning distribution as chum salmon, with the most using the 3.6 km of river below the counting fence. A smaller portion of the run also spawns above the counting fence, however, the upstream extent of their utilization is uncertain. In 1997 a flood event in early October required that the counting fence be lifted, and an unknown number of chinook migrated beyond this point. Subsequent dead-pitch surveys conducted above the fence failed to find any chinook, however a helicopter survey on November 10 discovered carcasses up to the falls at km 24.2 (Dave Ewart, Quinsam Hatchery, pers. comm.). Hirst (1991) sites a 1944 DFO memo which indicates that historically some chinook migrated as far as the falls below Lower Quinsam Lake (km 26.3). These pieces of information suggests that in years with good numbers above the fence, chinook spawning may occur up to the falls at km 26.3 (Reaches 1 through 4). This said, it is worth noting that chinook have strong swimming and jumping abilities, and it is likely that if the appropriate homing cues were present they have the capability to migrate as far upstream as the 15 m falls at km 41.5.

Because pink salmon arrive in large numbers their spawning distribution is well known. The majority of pinks spawn from the mouth to the cascades at km 13.3. Small numbers also ascend this cascade and have occasionally been reported up to the falls at km 24.3. Thus pink spawning distribution can be summarized as mainly in Reach 1 with minor use of Reaches 2, 3, and the lower half of Reach 4.

Sockeye spawning distribution is poorly understood due to the small size of this run. Sockeye arrive early (with pinks) and migrate through fence. Due to the relatively low flows during their migration, and their relatively advanced stage of ripeness, sockeye probably do not ascend past the falls at km 26.3. Thus, their spawning distribution is likely from the middle of Reach 1 to either the falls in the middle of Reach 4 (km 24.3) or the cascades/falls at the bottom of Reach 5 (km 26.3).

Coho spawning occurs throughout anadromous portions of the Quinsam River, i.e., up to the 15 m falls at km 41.5, and in the lower end of the Iron River (Figure 6). Juvenile sampling suggests that coho also spawn in many of the mainstem and lake tributaries (including 1st and 2nd order tributaries), although this interpretation should be treated with caution as coho fry and parr will also colonize tributaries given suitable access and rearing habitat. Tributaries known to support coho are shown in Figure 6. This suggests a very large spawning distribution for coho that includes mainstem Reaches 1 through 10, the lower part of Reach 11, Reach 1 of the Iron River, (though they could possibly extend up to the 7 m falls in Reach 2), and a number of mainstem and lake tributaries within anadromous sections. Early studies (DFO 1957) suggest that the bulk of the coho spawning occurs from the cascades at km 13.3 to the falls at km 24.3, however, at this time very little was known of spawning activities above Middle Quinsam Lake. A question that still stands today, is the relative abundance of spawners above and below Lower Quinsam Lake, and the effect of the falls below Lower Quinsam Lake (km 27.4) on this distribution.

Steelhead trout are believed to have a similar spawning distribution as coho salmon, but with less utilisation of smaller tributaries. In the mainstem, spawning occurs from the mouth to the 15 m falls at km 41.5, and in the Iron River to the falls at km 5.3. Although steelhead are capable of ascending the lake and mainstem tributaries within anadromous reaches, there may in fact be little use of these areas. The provincial database shows that steelhead tend to spawn in streams that have a late summer wetted width of 5–7 m or greater (although exceptions occur) (Ron Ptolemy, Ministry of Fisheries, pers. comm.). This would tend to rule out many of the tributaries in the Quinsam Watershed due to their small size, which appears to be confirmed by the general absence of steelhead fry in tributary sampling (based on review of Blackmun et al. 1985 and Grant et al. 1995). As with coho, little is known of the relative abundance of steelhead above and below Lower Quinsam Lake, and the influence of the falls immediately below Lower Quinsam Lake on distribution patterns.

The spawning distribution of anadromous cutthroat in the Quinsam has not been documented, however, the Provincial database indicates that this species tends to occur in streams with late summer wetted widths of 5–7 m or less (the opposite of steelhead) (Ron Ptolemy, Ministry of Fisheries, pers. comm.). This, combined with frequent occurrence of cutthroat fry and parr in tributaries, suggests that anadromous cutthroat are utilizing the lake and mainstem tributaries within anadromous reaches of the watershed.

Sea-run Dolly Varden are another species whose spawning distribution in the Quinsam has not been examined. There are 2 tributaries where juvenile Dolly Varden have been reported: the first occurs on the west side of Reach 3, and the second is the Iron River (Figure 6). It is likely that these are progeny from anadromous adults that spawned within these 2 tributaries. It is unknown whether the Dolly Varden reported in Lower Quinsam Lake are overwintering anadromous kelts, resident stocks, or both.

Resident species

The spawning distribution of resident species has mostly been inferred from the locations of suitably sized substrates and the presence of juveniles as opposed to direct observation of spawning fish or redds.

<u>Lower Quinsam River (below Lower Quinsam Lake)</u>: Resident rainbow and cutthroat are reported to occur in the lower river below Lower Quinsam Lake (Resource Analysis Branch 1983). Oliver (1975)

conducted a inventory on August 12–13, 1975 of the river below Lower Quinsam Lake consisting of a stream walk and a snorkel survey of Reach 1 and observed that resident rainbow occurred in the lower half of Reach 1 (see Figure 6), while resident cutthroat occurred above this point. It is not known where these fish spawn but likely locations are the tributaries in the lower river.

Lower Quinsam lake: This lake supports lake-resident cutthroat and rainbow trout (Figure 6). These fish likely spawn in the tributaries draining the north end of the lake, as well as the Quinsam River above Quinsam Lake (Reach 7). Reach 7 of the Quinsam River in particular is reported to have extensive, high quality gravel beds (Lawseth 1979, Quinsam Coal 1980).

Middle Quinsam Lake Area: This lake as well as the associated Long and No-Name Lakes supports lake-resident cutthroat trout (Figure 6). Quinsam Coal (1980) indicated that cutthroat probably spawn in the outlet streams for No-Name and Long Lakes, in the Quinsam River from the inlet to the diversion dam, and possibly in the first 500 m of the Quinsam River below Middle Quinsam Lake. Quinsam Coal provided a map of these regions (Figure 13 in Quinsam Coal 1980).

Upper Quinsam River (Reach 15): A stream-resident population of cutthroat trout is reported to occur in this section of river (Figure 6). Up and downstream movement by these fish is restricted by the impassable obstructions created by Wokas Lake Storage Dam and the Quinsam Diversion Dam. Some lacustrine habitat is provided by the impoundment behind the diversion dam. Spawning by this cutthroat population likely occurs in pockets where suitably sized substrates occur.

Wokas and Upper Quinsam Lakes: These lakes support a lake-resident population of cutthroat trout (Figure 6). This population is known to spawn in lower portion of Hawkins Creek based on observation of spawning adults and redds (Ray Billings, Vancouver Island Hatchery, Duncan, pers. comm.). Juvenile cutthroat have also been captured below the barriers of Granite and Mine Creeks (Grant et al. 1995) suggesting that spawning also occurs in these streams as well. It is not known whether spawning occurs in the un-named tributary on the north side of Upper Quinsam Lake (see Figure 6).

Data Gaps

There are 3 main data gaps with respect to salmonid spawning distributions:

1) The influence of the partial barriers on spawning distribution is poorly understood, and the passability of these barrier under varying flows has not been specifically examined.
2) The relative use and distribution of spawning above the hatchery counting fence is poorly understood.
3) Spawning use in tributaries is largely unknown.

The first data gap is directly relevant to the WUP process, while items 2 and 3 or more relevant to fisheries management. With respect to item 2, there has been some mapping of pink and coho spawning locations (DFO 1957), however these are dated (1957), and only covered the area from about km 2 to the cascade at km 24.2. There was also some mapping conducted for the Quinsam Coal development (Figure 17 in Quinsam Coal 1980). On these maps, gravel beds were indicated and their probable species use identified, however, these data are dated, the locations are uncertain due to the scale of the map and lack of UTM coordinates, and species use was inferred.

6.2.3 Rearing Distribution

There have been a number of studies that have looked at the distribution of rearing salmonids in the Quinsam Watershed. Table 10 lists rearing studies that have been conducted in the Quinsam Watershed, along with their sample methods, and a synopsis of information provided. These studies provide good distribution information for coho and trout, limited information for Dolly Varden, and no data on sockeye and chinook salmon. Differences in coverage are due to the scarcity of Dolly Varden and sockeye, and the fact that most chinook emigrate from the river before rearing studies are conducted. Another problem is that information on resident trout rearing within anadromous reaches is confounded by the difficulty in separating resident progeny from the typically more abundant anadromous progeny.

Anadromous Areas

Anadromous portions of the Quinsam Watershed are used for rearing by juvenile stages of chinook, coho, and sockeye salmon, steelhead and searun cutthroat trout, and searun Dolly Varden char. Anadromous regions are also utilized by juvenile stages of resident species including rainbow and cutthroat trout, kokanee salmon, and possibly Dolly Varden char (the presence of resident Dolly Varden is unverified). The distribution of rearing species based on all sources is shown in Figure 6. Coho are the most ubiquitous, occurring in a variety of habitats ranging from large mainstem sections, to small 1st and

2nd order tributaries, to larger lakes and wetlands. Juvenile cutthroat tend to be found in the tributaries, often in association with juvenile coho salmon. Juvenile steelhead have been found rearing in the Quinsam mainstem, the Iron River, and in Cold Creek. To date, juvenile Dolly Varden have only been found in 2 streams: the Iron River and the small tributary draining from the north in Reach 3.

Resident Areas

Resident regions of the Quinsam Watershed (areas above anadromous barriers) are used for rearing by cutthroat trout, and outplanted anadromous coho and steelhead trout. These species have been found rearing in lake, marsh, and river habitats within resident reaches (Figure 6), however, they appear to have different preferences. For example, comparison of minnow trap catches by Blackmun et al. (1983) indicated that outplanted coho were more abundant in lake sites, steelhead were more abundant in river sites, and cutthroat were abundant in most sites regardless of habitat type. Coho were particularly abundant in Long and Flume Lakes, which together accounted for 79% of coho fry captured above the falls. Steelhead, were most prominent in the Quinsam mainstem between Middle Quinsam Lake and the 15 m falls. Similar coho preferences were noted in the work by Norecol (1983).

Table 10. List of juvenile rearing studies conducted on the Quinsam Watershed.

Study Period	Reference	Sites	Study Reaches	Methods	Information Provided
1976,77,78 (Aug.,Sept.)	Fish and Wildlife (1978)	4	**Anadromous Reaches:** Quinsam R. (R1–R5)	EL	Relative abundance (fish density)
1978 (June, Sept.) & 1979 (May, Aug.)	Quinsam Coal (1980a, b)	7	**Resident Reaches:** Quinsam R. (R11,R14), Long L outflow, MQL, Long L, No Name L	Streams - EL Lakes - GN	Distribution
1983 (Mar., Apr.)	Blackmun et al. (1983)	17	**Anadromous Reaches:** Quinsam R. (R2,R10), Iron R., 4 un-named tribs in lower river, Echo L outflow, LQL. **Resident Reaches:** Quinsam R. (R11), Long L outflow, Flume L outflow, MQL, Long L, No-Name L, Gentian L, and Flume L.	MT	Distribution & relative abundance
1983 (June, July)	Norecol (1983)	7	**Anadromous Reaches:** LQL **Resident Reaches:** Quinsam R. (R11, R14), No-Name L outflow, Long L outflow, Flume L outflow, MQL, Long L, Gooseneck L.	Streams - EL Lakes - LT	Distribution, specific abundance (fish density)
1995 (Apr. to Aug.)	Grant et al. (1995)	72	Sampled large number of 1st and 2nd order streams throughout anadromous and resident portions of Quinsam Watershed within TimberWest operational areas.	EL, MT, SN	Distribution

Abbreviations:

LQL = Lower Quinsam Lake
MQL = Middle Quinsam Lake
UQL = Upper Quinsam Lake

EL = electrofishing
MT = minnow trapping (gee traps)
LT = special lake traps
GN = gill netting
SN = snorkelling

6.3 Abundance

There are 3 main data sets that provide information on the abundance of Quinsam River salmonids. The first is the adult escapement data set, which has been collected annually by DFO since 1957 and provides escapement estimates for chinook, coho, pink, chum, and sockeye salmon. The second is the Steelhead Harvest Questionnaire results which have been collected by MWLAP since 1966/67 fiscal year and provide a means to monitor the abundance of adult steelhead (Smith 1999). The third is the downstream trapping data set which has been collected by DFO at the Quinsam hatchery counting fence for 1988–92 and 1996 to the present.

Escapements

Estimates of the number of adult salmon returning to the Quinsam River system have been made annually since 1957. For the period up to 1975 these were based on visual observations by local fishery officers. Since 1976, numbers of adults spawning above the hatchery have been enumerated by counting adults as they move through the fence located 300 m above the hatchery. For fish spawning below the counting fence enumeration has relied on dead-pitch surveys that incorporated mark/recapture of tagged carcasses. No attempt has been made to enumerate steelhead and anadromous cutthroat because their migration period extends beyond the time that the counting fence is operated. As a result of these changes in methodology, escapement estimates since 1976 are more reliable than those conducted before this period.

Escapements for the Quinsam River are shown in Figure 7 with actual values provided in Appendix A. Data for 1957–1972 are from the SEDS database maintained at the Pacific Biological Station (obtained from Lyse Godbout, PBS, Nanaimo). Values for 1973–1998 are mostly from Quinsam hatchery records due to errors encountered in the SEDS database (failure to include hatchery fish in some years and not others, and inclusion of jacks in some years and not others).

Annual abundance of chinook returns to the Quinsam River are shown in Figure 7. Prior to hatchery operations, the Quinsam River was not a major chinook producer, and returns ranged from about 25–75 fish annually. However, beginning with the first hatchery returns in 1977 (3 years after the first brood collection), chinook escapement to the Quinsam River increased steadily over the next 13 years with a peak of 10,330 river spawners in 1990. Through most of the 1990's chinook escapements dropped dramatically (low of 476 river spawners in 1994), however, toward the end of the decade and in 2000–2002, numbers have returned to the highs experience at the turn of the previous decade. The average annual return for the last 10 years (1993–2002) was 3,200 river spawners with another 2,100 processed at the hatchery, for a total return of about 5,300 chinook. Over the last 4 years of record (1999–2002), an average of 30% of the river escapement has spawned above the counting fence (940–2,577 adults), while the remainder have spawned below the fence (Dave Ewart, Quinsam Hatchery, pers. comm.).

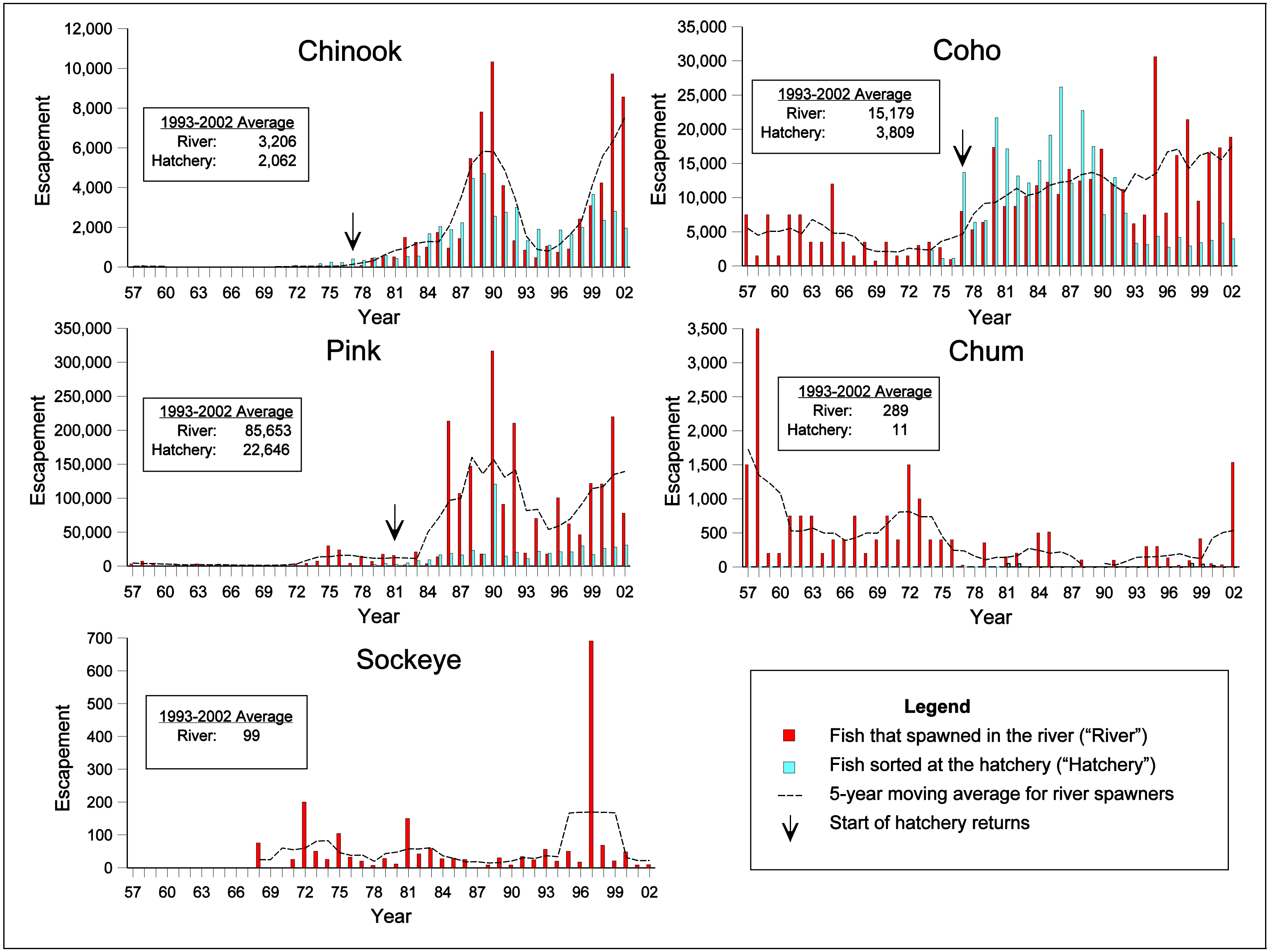

Figure 7. Annual escapement of chinook, coho, pink, chum, and sockeye salmon to the Quinsam River system. **Sources**: 1957–1975 SEDS database (supplied by Lyse Godbout, PBS); 1976–2002 Quinsam Hatchery files (supplied by Dave Ewart, Quinsam Hatchery). Note: numbers exclude jacks.

The size of natural spawning chinook escapements relative to targets are provided in Table 11. The current chinook target for the Quinsam River is 6,400 fish, with an allocation of 1,400 for hatchery brood (given an egg target of 4 million eggs), 2,000 for natural spawning below the counting fence, and 3,000 for natural spawning above the fence. These targets are based on general observations and estimates of available spawning habitat. It has been stressed by DFO, however, that spawning habitat needs better evaluation (particularly above the counting fence) to more reliably determine appropriate spawning levels, and that this could change escapement targets (Dave Ewart, Quinsam Hatchery, pers. comm.).

To date, the natural spawning chinook target (5,000 fish) has been achieved in 5 years (1988–90 and 2001, 02), however the distribution of spawners has been primarily below the hatchery counting fence and the target of 3,000 fish above the fence has not been achieved (although close in 2001 with 2,577 adults above the fence). The distribution of natural spawning is in part influenced by hatchery operations during chinook migration. Returning chinook are reluctant to enter the hatchery attraction channel where they can be sorted and spawned. As a result, the practice has been to keep the counting fence closed to prevent fish from escaping upriver. Chinook are then seined from the river and trucked live to hatchery holding ponds for sorting and processing. In years of high abundance, fish are counted and released above the fence, or are counted through the fence if river conditions permit. During flood events the fence panels must be pulled to prevent flooding and debris accumulation, and the count is lost. When this occurs, overflights and river walks are undertaken to estimate numbers above the fence (D. Ewart, Quinsam Hatchery, pers. comm.).

Table 11. Target salmonid escapements for the Quinsam River ("Total" includes brood stock requirements).

species	Target Escapement		1993-2002 Natural Spawn Average	Maximum Recorded	(Year)
	Total	Natural Spawning			
Chinook	6,400[a]	5,000	3,206	10,330	(1990)
Coho	10,000[b]	7,000	15,179	30,611	(1995)
Pink	100,000[c]	84,000	85,653	316,650	(1990)
Chum	not established		289	3,500	(1958)
Sockeye	not established		99	691	(1997)
Steelhead	600 minimum				
Searun Cutthroat					

Notes:

[a] Based on targets of 1,400 chinook for brood, 2,000 below the counting fence, and 3,000 above the fence. Above and below fence targets are “best estimates” until more information is known about the amount of habitat. The 1,400 chinook for brood is based on an egg target of 4 million eggs.
[b] Based on targets of 3,000 coho for brood and 7,000 for natural spawning in the river.
[c] Based on targets of 16,000 pink for brood and the 84,000 for the river.

Sources:
Target Escapements: salmon - Jim Van Tine and Dave Ewart, Quinsam Hatchery, pers. comm.; steelhead - Lirette et al. (1987) and Wightman (1996).

The decline in chinook escapement during the 1990's appears to have been primarily due to decreased marine survival during this period. Evidence for this is in Nagtegaal et al. (2000, Figure 12) who showed that marine survival of Campbell/Quinsam chinook to the age 2 cohort was extremely poor for the 1987–1995 brood years. For example, mean survival for the 1987–1995 brood years was 0.7% (range 0.2–1.3%), compared with a mean survival of 4.3% for the 1974–1986 brood years (range 1.2–8.8%). An increase in survival was noted for the 1996 and 1997 brood years. This pattern in marine survival parallels the chinook escapement trends shown in Figure 7 given that most Quinsam River chinook return at 3, 4 and 5 years from their brood year. The decline in Quinsam River chinook escapement during the 1990's does not appear to have been related to changes in exploitation. Nagtegaal et al. (2000, Figure 11) showed that exploitation rates did not increase, but rather declined over the 1987 to 1995 brood years. Similarly, the low escapements in the 1990's do not appear to have been related to changes in estuarine survival. During the 1990's, the estuary did not experience any further degradation, but rather has been the focus of numerous rehabilitation and enhancement projects, particularly since 1996 (Appendix A, Nagtegaal et al. 2000; Anderson and Van Tine 2002).

The decline in Quinsam River chinook in the 1990's was synchronous with abundance patterns of salmonid stocks (*Oncorhynchus* spp.) from coastal rivers of Oregon, Washington and southern BC, and evoked a number of studies to explain this phenomenon (e.g., Welch et al. 2000; Beamish et al. 2000; Koslow et al. 2002, Mueter et al. 2002). These studies correlate various ocean and climate indices (e.g., sea surface temperature, upwelling index, April flows from the Fraser, Aleutian low pressure index) with salmonid abundance. The common conclusion is that there was a shift to lower productivity in coastal waters after 1989/1990 which adversely affected the survival of juvenile salmonids during their early marine life.

Annual abundance of coho returns to the Quinsam River are shown in Figure 7. The average annual return for the last 10 years (1993–2002) is about 15,200 river spawners with another 3,800 processed at the hatchery, for a total return of about 19,000 coho. The 5-year moving average (river spawners) shows pre-hatchery escapements of around 5,000 adults in the 1950's and early 60's, around 2,500 in the late

1960's/early 1970's, and then increasing dramatically with the introduction of hatchery production in 1977. Returns in the 1990's were highly variable with some very poor years (e.g., 1993–94) and some very strong years (e.g., 1995, 1998). Hirst (1991) suggested that the decline in the 1960's and 70's was probably due to habitat degradation and heavy commercial and sport harvest. Potential habitat impairment activities sited included diversion of water by BC Hydro, logging events, and mining developments. The potential adverse effects of excessive commercial harvest was supported by work by Reinhardt and MacKinnon (1978), who calculated a catch to escapement ratio of 7.6:1 for the 1973 wild coho brood, and flagged this exploitation rate as a potential problem for conservation of coho stocks. In the 1990's the 5-years moving average remained relatively stable despite very poor marine survival during this period. This was probably due to reductions in exploitation rates beginning in 1995 and culminating in 1998 and 1999 with total closure of sensitive areas and coho non-retention in open areas (Simpson et al. 2000).

The target coho escapement for the Quinsam River has been established by DFO at 7,000 adults for river spawning and another 3,000 for the hatchery (Dave Ewart, Quinsam Hatchery, pers. comm.). These targets have been achieved or exceeded in most years, with 1993–2002 average river and hatchery escapements of 15,200 and 3,800, respectively (Table 11). Most of the river spawning occurs upstream of the hatchery counting fence.

The annual escapement of steelhead to the Quinsam River is not as well known as for salmon species. The counting fence above Quinsam Hatchery is equipped with a v-notch weir through which adult fish pass into a trap for counting and release. In the past, this trap was operated throughout the steelhead migration period, although the fence was opened during floods and periods when steelhead brood were not required. Despite the fence openings, counts nevertheless provided MWLAP with an annual index of steelhead abundance. However, during the fall and winter of 1999/2000, concern over poor steelhead returns resulted in MWLAP cutting back on steelhead brood capture in order to maximize natural spawning (some brood were captured for the living gene bank program and for smolt releases into the upper river). The fence was still operated but on a much reduce schedule of monitoring (closed) during the week and open on the weekends. As a result of this change the 1999/2000 steelhead count was not viable index of abundance. As an alternative, MWLAP conducted several snorkel swims during the migration period to estimate abundance (some snorkel swims were conducted in previous years but not on a regular basis) (Dave Ewart, Quinsam Hatchery, pers. comm.).

Steelhead Harvest Questionnaire

An alternative approach used by MWLAP to gauge the strength of steelhead stocks is through the Steelhead Harvest Questionnaire (SHQ), which is a mail survey sent to a portion of anglers who purchased a freshwater steelhead angling licence. SHQ results do not provide a direct count of steelhead escapement, but can be used to assess general trends over time (Smith 1999). Data from the SHQ are presented in Section 8 (Commercial and Sport Fisheries). At this point it is worth noting that in the early days of this program (e.g., 1968–75), there was a greater tendency for anglers to keep the steelhead they captured (as opposed to catch and release), and it is safe to say that steelhead escapements were **at least** equivalent to fish kept. Steelhead reported as kept during 1968 to 1975 ranged from 163 to 443 fish with an average of 273 (Appendix B).

With respect to a target escapement for the Quinsam River, MWLAP has tended not to specify a specific number but rather a minimum desirable level based on the number of adults required to fully seed available rearing habitat. More recently this has taken on the term of Minimum Sustainable Escapement (MSE) as per recommendations by The Committee on Protection and Management of Pacific Northwest Anadromous salmonids (1996). Preliminary estimates of a MSE for the Quinsam River steelhead were undertaken by Lirette et al. (1987) using 2 models developed by Slaney (1981). The most rigorous of the two models (model B), incorporated total dissolved solids, mean annual water temperature, boulder content in riffles, overstream cover, and quantity of riffle, run, pool and flat habitats. This model predicted a potential yield of 14,185 smolts for the Quinsam River based on habitat from Lower Quinsam lake to the confluence with the Campbell River. To this potential smolt yield, Lirette et al. (1987) applied an egg-to-smolt survival rate of 0.947%, a mean fecundity of 4,976 eggs, and a sex ratio of 1:1, to arrive at an estimated 600 adults (MSE) required to attain the modelled smolt yield (Table 11). It should be noted that this estimate does not incorporate habitat from Lower Quinsam Lake to the 15 m falls (10.4 km of stream) or the Iron River (potentially 5.3 km of stream). Also, Lirette et al. (1987) suggested that the model be refined to incorporate hydraulic features of habitat (weighted usable area based on depths and velocities).

Downstream Enumerations

Annual abundance of chinook fry and smolts combined from downstream trapping has averaged around 40,000 fish with a range of about 2,000–73,000 fish (Table 12). These results highly underestimate total chinook production from the Quinsam River since they do not include progeny from spawning below the counting fence (most chinook spawn below the counting fence).

Annual abundance of coho from downstream trapping has averaged around 39,000 fry (range 9,500–393,800), and about 60,000 smolts (range 27,000–156,000) (Table 12). Again, these counts do not include progeny from spawning below the enumeration fence, however, they are likely a reasonable approximation of total coho production since most coho spawn above the counting fence.

Annual abundance of steelhead parr and smolts from downstream trapping has averaged around 12,000 parr (range 3,500–19,400), and about 10,000 smolts (range 6,500–16,400) (Table 12). As indicated above, these values do not include progeny from spawning below the counting fence.

Table 12. Annual production of fry and smolts from the Quinsam River above the hatchery counting fence. (Note: does not include production from the 3.7 km of stream below the fence).

Year	Chinook	Coho			Pink	Chum	Sockeye	Trout				
	Fry/Smolts	Wild Fry	Wild Smolts	Planted Smolts	Fry	Fry	Fry/Smolts	Trout Fry/Parr	Wild ST Smolts	Planted ST Smolts	Anadr. CT Smolts	Other spp.
1975	Present	393,800	39,960	–	2,736,000	56,310	4,639	Present	Present		Present	
1980		25,550	61,304	58,067				19,441	8,347			
1981		38,843	59,242	35,700				10,910	6,810			
1982		n/a	27,304	40,542				12,118	6,503			
1983		n/a	50,417	59,520				9,926	7,608			
1984		62,249	62,249	33,960				16,147	9,060			
1985		55,746	55,746	21,932					7,700			
1986		44,634	44,634	29,021					9,500			
1987		49,764	49,764	32,429					8,273			
1988		76,839	76,839	55,796	3,140,748			17,251	16,416			
1989	63,864	69,191	29,304	–	5,288,458	66,270	3,106	11,515	11,029		196	
1990	73,037	325,846	86,431	60,834	847,655	7,346	1,588	12,708	11,240		195+13M	
1991	26,297	9,464	35,900	40,421	598,699	6,961	440	5,891	8,351		50	DV
1992	13,854	14,024	57,998	39,775	681,643	17,128	2,268	19,060	11,873		318	DV,CC,L
1993–1995: no trapping due to budget constraints												
1996	58,516*	36,590	71,589	69,410	587,653	?	?	10,252	10,952		330	
1997	2,161	17,064	156,116	61,296	2,297,963	?	?	5,042	13,072		691	
1998	42,684	11,529	59,626	45,502	1,020,298	18,108	36,834	3,458	10,353	346	481	CC
Min	2,161	9,464	27,304	21,932	587,653	6,961	440	3,458	6,503	346	50	
Max	73,037	393,800	156,116	69,410	5,288,458	66,270	36,834	19,441	16,416	346	691	
Mean	40,059	39,345	60,260	45,614	1,911,013	28,687	8,146	11,825	9,818	346	323	

Source: Quinsam Hatchery files (from Dave Ewart, Quinsam hatchery); wild steelhead fry/parr and smolts for 1980 to 1987 from Lirette et al (1985) and Wightman (1996).
Abbreviations: ST steelhead trout, CT cutthroat trout, DV Dolly Varden char, CC sculpins, L: lamprey, – not present as none released in previous year.
Note: The mean for wild coho fry (39,345) excludes 1975 and 1990 values since these bias the mean.

7. ENHANCEMENT AND STOCKING INITIATIVES

There are two main enhancement programs on the Quinsam River: 1) the release of hatchery cultured fish that are ready for salt water, and 2) outplanting of coho and steelhead fingerlings for additional rearing in the upper watershed. There has also been some minor habitat improvement activities. These include the building of a dyke along the left downstream bank below the hatchery to prevent channel braiding and impingement on Cold Creek, stabilization of large woody debris below the dyke (by cabling and anchoring with rocks), and planting of willows to stabilize a sloughing bank about 1 km above the hatchery. In the 1930's consideration was given to the installation of 2 fishways at the cascades immediately below Lower Quinsam Lake to facilitate the passage of adult salmonids to upstream reaches (McHugh 1933, 1938). This potential enhancement was abandoned due to the anticipated costs ($6,000) relative to the amount of additional habitat that would be provided (erroneously estimated at 3-4 miles of stream), and because the "14 miles" of stream below the cascades were felt "quite sufficient for the quantities of salmon which frequent it" (McHugh 1933, 1938).

Enhancement facilities

The Quinsam Hatchery is located on the Quinsam River 3.3 km upstream from the Quinsam/Campbell confluence (Figure 8). The hatchery began operation in 1974 and was built for the purpose of enhancing salmon and anadromous trout stocks returning to the Quinsam and neighbouring rivers (Blackmun et al. 1985). Features of the hatchery include egg incubation facilities capable of handling 20 million eggs, and various rearing structures including aluminum troughs, circular tubs, concrete rectangular ponds, and earthen channels (Munro et al. 1985; Van Tine 1986). Brood stock for the hatchery program are obtained from fish that migrate directly into the hatchery via the attraction channel. Brood stock are also captured at the brood fence located 300 m above the hatchery, and at a temporary floating fence installed by the Quinsam Campground. The brood fence is a total barrier when in operation, however, panels are opened to allow enumeration and passage of fish to stream reaches above the fence. The floating fence is grated so that anything smaller than a 20 lb chinook can pass through. This fence is operated for about 2 weeks in October and provides 50–80% of the hatchery's chinook brood stock (Dave Ewart, Quinsam Hatchery, pers. comm.).

Quinsam Hatchery egg targets for 1999, and numbers of adults required to achieve these targets, are shown in Table 13. These targets include the provision of brood for enhancement projects outside of the Quinsam River. Targets are somewhat lower than in previous years due to better fry survival rates associated with improvements in culture facilities, techniques, and feed. In the case of pink salmon, the 1999 target was reduced due to funding cuts. For steelhead and cutthroat trout culture, hatchery objectives are based on achieving a certain number of brood as opposed to an egg target. It should be noted that actual numbers of eggs taken and brood processed may differ from annual targets due to factors such as size and timing of the returning run, fecundity of brood females, and the availability of labour to perform the tasks.

Table 13. Egg and brood targets for Quinsam Hatchery.

Species	1999 Production Targets [1]		Comments
	Egg Targets	Adults Required	
Salmon:			
Chinook	4.1 million	695 &’s	Similar to previous years
Coho	1.7 million	949 &’s	Reduced from 2.3 M eggs in 1998
Pink - For Quinsam Hatchery - For others projects	3.9 million 1.0 million	3,020 &’s [2] 775 &’s [2]	1999 targets were reduced due to funding cuts. The original target was 7.7 M eggs for Quinsam hatchery and 1-4.8 M for other projects. The 2000 target is under review.
Anadromous Trout (based on broodstock target as opposed to egg targets):			
Steelhead	12&’s+15%’s ÷ 50,000 eggs ÷ 20,000 smolts [3]		
Cutthroat	10&’s+10%’s ÷ 8,000 eggs ÷ 6,000 smolts		

Source: Dave Ewart, Acting Project Manager, Quinsam Hatchery.
Notes:
1. Actual numbers of brood captured and eggs taken may be greater or less than indicated dependent on run size and timing, fecundity of returning females, and availability of labour. Also, egg targets have decreased in recent years due to fewer fry loses that have accompanied improvements in culture facilities, techniques, and feed.
2. Adults required to achieve pink salmon egg targets differs between odd and even years due to differences in fecundity between even and odd year races.
3. In recent years the Ministry of Environment has opted to release some of these steelhead as fingerlings in the upper Quinsam River as part of the steelhead colonization program.

Smolt and Fry Release Program

The smolt and fry release program of the Quinsam Hatchery refers to the culture and release of juvenile fish that are ready for the downstream migration to salt water. Culture species include chinook, coho, and pink salmon, as well as steelhead and searun cutthroat trout. Chinook fry are reared for 3.5 to 4 months and released in mid May. Coho, steelhead, and cutthroat are reared for one year at the hatchery and released the following spring as smolts. Coho are released during the last 2 weeks of May, while steelhead and cutthroat are released during the last week of April to the first week of May. Release of these species into the Quinsam involves pulling screens at the bottom of the rearing channels and ponds, which allows the fish to enter the river of their own volition. The exception are a portion of the cutthroat smolts, which are trucked and released into the lower end of the Quinsam River in order to minimize angling mortalities (cutthroat smolts are very susceptible to angling). Pink salmon are released as fry immediately after emergence. They leave the hatchery of their own volition via an underground pipe that empties into the Quinsam River adjacent to the hatchery. In order to identify hatchery fish in the returning run, various marking techniques have been applied to released smolts. These include :

Chinook:	8%	adipose clip and CWT;
	all smolts since 1997	otolith[8] marks
Coho:	~ 60% of smolts	adipose clips and/or CWT
Steelhead:	all smolts	adipose clips only
Cutthroat:	all smolts	adipose clips only

Annual numbers released into the Quinsam River in recent years (1994-99 average) include about 1.87 million chinook smolts, 1.29 million coho smolts, 6.07 million pink fry, 20,000 steelhead smolts, and 3,600 cutthroat smolts (Table 14).

Table 14. Quinsam Hatchery migrant releases to the Quinsam River, 1994-99.

Release Year	Species	Release Site	Brood Year	Total Released
1994	Chinook	Quinsam R	1993	1,753,678
1995	Chinook	Quinsam R	1994	1,832,303
1996	Chinook	Quinsam R	1995	1,459,890
1997	Chinook	Quinsam R	1996	1,960,330
1998	Chinook	Quinsam R	1997	1,522,233
1999	Chinook	Quinsam R	1998	2,246,469
Mean				**1,795,817**
1994	Coho	Quinsam R	1992	1,128,936
1995	Coho	Quinsam R	1993	1,193,987
1996	Coho	Quinsam R	1994	1,215,267
1997	Coho	Quinsam R	1995	1,249,119
1998	Coho	Quinsam R	1996	1,411,259
1999	Coho	Quinsam R	1997	1,545,322
Mean				**1,290,648**
1994	Pink	Quinsam R	1993	4,524,741
1995	Pink	Quinsam R	1994	5,945,272

8 Otolith marks are achieved by imposing a temperature stress on the alevins (2EC or greater drop in temperature for 24 hrs), which causes the laying down of a growth check in the otolith banding pattern. This check mark can be discerned by examining otoliths of recovered adults.

Release Year	Species	Release Site	Brood Year	Total Released
1996	Pink	Quinsam R	1995	6,782,529
1997	Pink	Quinsam R	1996	5,606,811
1998	Pink	Quinsam R	1997	6,873,953
1999	Pink	Quinsam R.	1998	6,670,215
Mean				**6,067,254**
1994	Steelhead	Quinsam R	1993	23,206
1995	Steelhead	Quinsam R	1994	22,539
1996	Steelhead	Quinsam R	1995	15,264
1997	Steelhead	Quinsam R	1996	23,359
1998	Steelhead	Quinsam R	1997	24,222
1999	Steelhead	Quinsam R	1998	9,915
Mean				**19,751**
1994	Cutthroat	Quinsam R	1993	5,977
1996	Cutthroat	Quinsam R Low[1]	1995	2,093
1997	Cutthroat	Quinsam R	1996	2,288
1998	Cutthroat	Quinsam R Low[1]	1997	2,290
1999	Cutthroat	Quinsam R Low[1]	1998	5,280
Mean				**3,586**

Source: Digital file from Roberta Cook (DFO, Habitat and Enhancement Branch, Vancouver, B.C., 666-2879), except 1999 releases which are from Dave Ewart, Quinsam Hatchery, pers. comm.

Notes: [1] Cutthroat smolts have been released in the lower Quinsam River (near the mouth) in recent years in an effort to reduce angling mortalities.

Colonization Program

In 1978, Quinsam Hatchery began a yearly program of outplanting coho and steelhead parr into upper regions of the Quinsam Watershed, including areas above the anadromous barrier (15 m falls at km 41.5). The rational for this program was that production of coho and steelhead from the Quinsam River could be increased by outplanting juveniles into areas that are underutilised, or are inaccessible by the adults (Blackmun et al. 1985). Beginning in 1996, chinook fry (and in 1999 chinook eggs) were added to the outplanting program. The goals of the chinook outplanting initiative were to encourage returning adults to home and spawn in regions above the hatchery, to expand the amount of natural habitat used for rearing, and to add diversity to chinook production methods.

Transplant areas are shown in Figure 8. In most years, coho have been released in all 8 areas, while steelhead plants have been restricted to areas 5, 6 and 8. The outplanting for coho and steelhead has typically occurred in September when fish are about 5–10 g (Van Tine 1986). In recent years, steelhead have also been outplanted in October. During the initial years of the program (1978 to 1986), coho transplants were coded wire tagged (CWT) or fin clipped in order to distinguish them from wild coho. Outplanted steelhead were (and continue to be) distinguished using fin and maxillary clips. The practice of coded wire tagging and clipping coho was discontinued in 1987 due to funding cuts. There was also concerns of potential adverse effects of clipping and CWT's on freshwater survival. Currently, outplanted coho are distinguished from wild fish on the basis of length. Length frequency data from years when outplanted coho were marked indicated that wild coho smolts were typically # 103 mm, whereas outplanted coho smolts were usually $ 121 mm. In the region of overlapping length (103–121 mm), the mixture was estimated to be 54% wild and 45% colonized coho (Quinsam Hatchery files received from Dave Ewart, Quinsam Hatchery).

Transplant areas for chinook fry have included Lower Quinsam Lake as well as the section below this lake (Area 8 in Figure 8). Timing of these plants has been May, at which time fry weigh about 2.1 g. Chinook fry releases were undertaken in 1996, 1999, and 2000. No releases occurred in 1997 and 1998 (1996,97 brood years) due to insufficient fry numbers. During December 1999, chinook eggs were planted in various gravel beds of the Quinsam River between the Iron River confluence and Lower Quinsam Lake, and in the outlet of Middle Quinsam Lake (Dave Ewart, Acting Project Manager, Quinsam Hatchery, pers. comm.).

Annual numbers of coho, steelhead, and chinook outplanted into the Quinsam Watershed during the last 6 years are shown in Table 15. Releases of coho parr have averaged 234,000 fish during this period, while steelhead releases have averaged 17,000 parr. Releases of chinook fry have ranged from about 31,000 to 70,000.

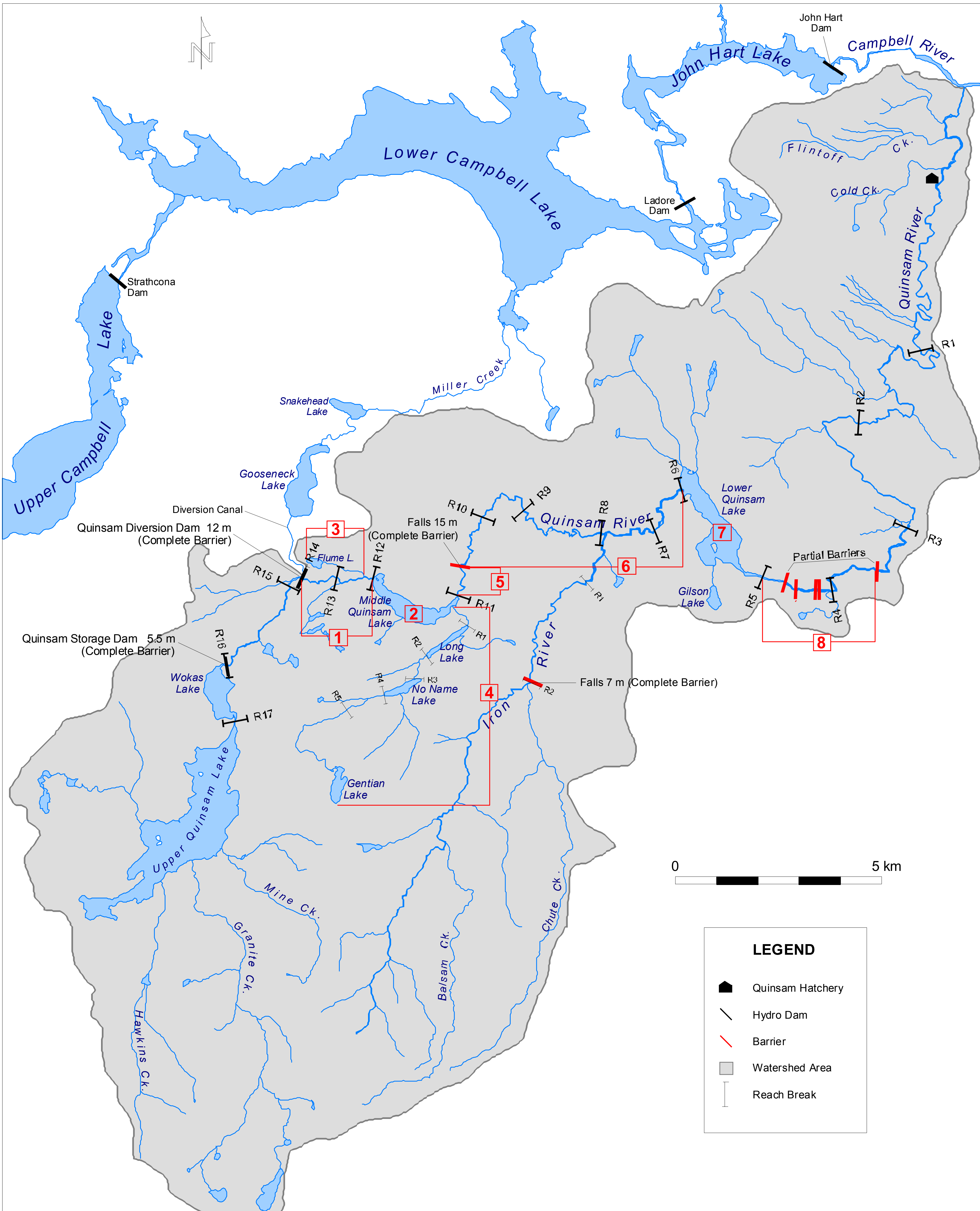

Figure 8. Map of the Quinsam River Watershed showing the 8 areas that have received coho and steelhead colonization.

[Spacer page for back side of Figure 8 (map 3)]

Table 15. Quinsam Hatchery colonization program, outplant summary for 1994–98.

Release Year	Release Site	Brood Year	Stage At Release	No. Released
COHO				
1994	Quinsam R (above hatchery)	1993	unfed fry	58,186
1994	Quinsam R (upper)	1993	parr	205,110
1995	Quinsam R	1994	eyed egg	153,701
1995	Quinsam R	1994	unfed fry	124,124
1995	Flintoff Creek	1994	fed fry	2,500
1995	Cold Cr	1994	fed fry	44,398
1995	Quinsam R (upper)	1994	parr	262,760
1996	Quinsam R	1995	parr	247,278
1997	Quinsam R (upper)	1996	parr	230,986
1998	Quinsam R (upper)	1997	parr	217,804
1999	Quinsam R (upper)	1998	parr	242,502
Mean			**parr**	**234,407**
STEELHEAD				
1994	Quinsam R	1994	parr	13,376
1995	Quinsam R (upper)	1995	parr	26,829
1996	Quinsam R (lower)	1996	parr	15,143
1997	Quinsam R (upper)	1997	parr	18,444
1998	Quinsam R (upper)	1998	parr	13,204
1999	Quinsam R (upper)	1999	parr	15,185
Mean			**parr**	**17,030**
CHINOOK				
1996	Quinsam R (Reach 5)	1995	fed fry	54,614
1999	Quinsam R (LQL)	1998	fed fry	30,847
Dec 1999	Quinsam R (above LQL)	1999	eyed egg	120,011
Dec 1999	Quinsam R (MQL outlet)	1999	eyed egg	4,500
2000	Quinsam R (LQL)	1999	fed fry	~70,000

Source: Quinsam Hatchery files (from Dave Ewart, Quinsam Hatchery, Campbell River, B.C., 250-287-9564)

Monitoring the success of the outplanting program has been possible due to the downstream trapping program conducted at the counting fence 300 m above the Quinsam Hatchery. Smolt production and release-to-smolt survival rates for outplanted coho and steelhead are given in Table 16 (from Dave Ewart, Quinsam Hatchery and Lirette et al. 1985). For coho plants, survival from September release till smolt migration the following spring has averaged 22.7%, and this has amounted to an annual production of about 47,000 smolts. The survival for steelhead is substantially less, an average of 5.8% for the 5 years shown in Table 16 (excluding 1978). Annual production of steelhead smolts from the outplanting program is about 800 fish. The lower survival rate for steelhead is expected given the extra time spent rearing in fresh water prior to smolt migration (1 winter for coho versus 1–3 winters for steelhead). However, the average shown for steelhead plants (5.8% survival) may be negatively biased by early data when the program was in its experimental stages. It is noteworthy that the 1997 steelhead release had a survival rate of 6.7% and the 1998 releases are likely to be well above 7% when year 2000 downstream trapping results are in.

Table 16. Smolt production and survival rates for outplanted coho and steelhead fry.

Brood Year	Release Statistics				Recapture At Downstream Fence		Survival Rate [2] (%)
	Number Released	Date Released	Size (g)	Marks[1]	Number Recaptured	Year Recaptured	
Coho:							
1978	242,665	Sep-1979	4.9	CWT	58,067	1980	23.9%
1979	199,999	Sep-1980	8.5	CWT	35,700	1981	17.9%
1980	296,063	Sep-1981	10.3	CWT	40,542	1982	13.7%
1981	263,000	Sep-1982	11.0		59,520	1983	22.6%
1982	243,192	Sep-1983	10.5		33,960	1984	14.0%
1983	101,302	Sep-1984	6.4	CWT	21,932	1985	21.7%
1984	99,872	Sep-1985	6.8	CWT	29,021	1986	29.1%
1985	100,075	Sep-1986	7.0	fin clip	32,429	1987	32.4%
1986	263,875	Sep-1987	7.0	none	55,796	1988	21.1%
1987	0				–		
1988	195,000	Sep-1989	5.8	none	60,834	1990	31.2%
1989	218,932	Sep-1990	8.9	none	40,421	1991	18.5%
1990	239,219	Sep-1991	5.3	none	39,775	1992	16.6%
1991-1993: no downstream trapping 1993–95 (funding cuts)					n/a		n/a
1994	262,760	Sep-1995	5.6	none	69,410	1996	26.4%
1995	247,278	Sep-1996	5.0	none	61,296	1997	24.8%
1996	230,986	Sep-1997		none	45,502	1998	19.7%
1997	217,804	Sep-1998		none	62,722	1999	28.8%
Mean					**46,683**		**22.7%**
Steelhead:							
1978	26,671	Aug-1978	1.8	VC	322	1979,80,81,82	1.2%
1979	16,496	Oct-1979	8.3	AC	433	1980,81	2.6%
1980	10,246	Oct-1980	6.0	AC	330	1982,83	3.2%
1981	28,300	Sep-1981	9.0	LM	737	1982,83	2.6%
1982 – 1996 data not worked up							
1997	18,444	Sep-1997	4.0	RM	1,230	1998,99	6.7%
1998	6,204	Sep-1998	6.0	LM	408	1999,__ [3]	6.6%
1998	7,000	Oct-1998	~14.0	AC	913	1999,__ [3]	13.0%
Mean (excluding 1978)					**810**		**5.8%**

Source: Coho data from Quinsam Hatchery records; steelhead statistics from Lirette et al. 1985, except 1997/98 data which are from Quinsam Hatchery records.

Notes:

1 Marks - VC = Ventral Clip AC = Adipose Clip
RM = Right Maxillary clip LM = Left Maxillary clip

2 *Survival Rate = Number Recaptured ÷ Number Released × 100*

3 Additional steelhead smolts from September/October 1998 outplants are anticipated for the year 2000 downstream trapping, which will increase the survival rates for these releases.

8. COMMERCIAL AND SPORT FISHERIES

Quinsam River salmonids are an important resource for commercial and sport fisheries in salt water, and support several popular sport fisheries in fresh water. The following summarizes available information on saltwater (tidal) and freshwater fisheries.

Tidal Sport and Commercial Fisheries

Quinsam River salmonids contribute to a number of fisheries in the marine environment. These include domestic sport and commercial fisheries on the west coast of Vancouver Island, the inside passage between Vancouver Island and the mainland, and the central and north coast of British Columbia. In addition, Quinsam stocks are captured by American fishers in waters off Alaska, Washington, and Oregon. Within the commercial sector, harvest methods include gillnet, seine, and troll gear types. The main Quinsam stocks captured by commercial fishers are chinook, coho, and pink salmon. In the sport fishery, the main species have historically been chinook and coho, however, since 1995 substantial numbers of pink salmon have also been taken (Dave Ewart, Quinsam Hatchery, pers. comm.).

Harvest rates of Quinsam River chinook and coho are monitored using DFO's coded wire tagging (CWT) program. Under this program, a portion of Quinsam hatchery chinook and coho smolts are inserted with a CWT and adipose clipped upon release. Subsequent capture of these fish in sport and commercial fisheries provides information on where and which fisheries are harvesting Quinsam stocks, and rates of harvest by these fisheries. Pink salmon migrate to the ocean soon after emergence and are too small for coded wire tagging. As an alternative, for 1979–1992 brood years, a portion of hatchery pink releases were fin clipped and their harvest monitored in the different fisheries.

Table 17 shows exploitation rates for hatchery chinook, coho, and pink salmon, as well as the catch distribution among domestic sport, commercial, and US fisheries. Chinook and coho values are provided on an annual basis, while pink values are the average of odd and even year runs for the period 1979–92. Values are based on recovery of hatchery fish, however, it is generally assumed that wild stocks are captured at the same rates. For Quinsam River chinook salmon, the average exploitation rate for the 1974–93 brood years was about 70% of the returning run. Of this 70%, an average of 55% was taken by commercial fishermen, 26% by US fishermen (mostly from Alaska), and 19% by sport fishermen. During this period, the ratio of fish caught to fish that escaped to the river averaged 2.7:1. Following the 1993 brood year, exploitation rates on Quinsam chinook have been reduced in an effort to compensate for the poor ocean survivals experienced in the 1990's.

For Quinsam River coho, the average exploitation rate for 1974–91 brood years was about 65%, and of this, commercial fishers took 56%, sport 42%, and US 1.5% (Table 17). During this period the average catch:escapement ratio was 1.9:1. Following the 1991 brood year, exploitation rates were reduced, with a dramatic reduction for 1995 and later brood years. The large reduction in harvest for the 1995 and later broods was due to regulatory changes implemented since 1998. These have included fishing closures in sensitive zones, and non-retention or limited retention in less sensitive zones (Simpson et al. 2000).

For Quinsam River pink salmon, historic capture rates were about 68% for odd year pink returns, and 56% for even year pink returns, with commercial fishermen taking 100% of the catch (Table 17). This harvest distribution has changed in recent years, and sports fishermen are now taking a substantial number of pink salmon. As an example, in DFO's statistical area 13 (the region off Campbell River), the sport catch of pinks during July–September averaged 11,564 fish during the 1995–98 period. In 1999, the sport catch of pinks during these same months was 22,515 fish (Dave Ewart, Quinsam hatchery, pers. comm.). Since fin clipping has not been conducted on hatchery pinks since the 1993 releases, their current harvest rate and proportion taken by sport and commercial sectors is unknown.

Table 17. Marine exploitation rate, catch:escapement ratio, and survival rate of Quinsam River chinook and coho in the marine environment (statistics based on recovery of coded wire tagged fish).

Brood Year	Marine Exploitation	Distribution of Marine Catch			Catch to Escape. Ratio	Brood Survival Rate
		Sport	Commercial	US		
Chinook						
1974	74.2%	10.5%	71.4%	18.1%	2.9	3.3%
1975	63.4%	11.1%	83.7%	5.2%	1.7	0.7%
1976	80.3%	15.8%	65.0%	19.2%	4.1	2.9%
1977	86.6%	14.0%	55.9%	30.1%	6.4	1.0%
1978	82.0%	11.5%	66.2%	22.4%	4.6	1.5%
1979	81.2%	5.9%	54.9%	39.2%	4.3	0.8%
1980	71.2%	15.2%	55.3%	29.5%	2.5	1.0%
1981	71.7%	9.0%	47.9%	43.0%	2.5	2.0%
1982	66.5%	13.9%	50.1%	36.0%	2.0	1.1%
1983	67.3%	15.5%	62.6%	21.9%	2.1	1.1%
1984	58.6%	15.4%	55.5%	29.0%	1.4	1.4%
1985	64.0%	23.6%	43.0%	33.3%	1.8	0.4%
1986	59.0%	18.6%	53.0%	28.4%	1.4	0.7%
1987	78.0%	23.3%	51.0%	25.7%	3.5	0.5%

Brood Year	Marine Exploitation	Distribution of Marine Catch			Catch to Escape. Ratio	Brood Survival Rate
		Sport	Commercial	US		
1988	71.6%	19.5%	58.2%	22.3%	2.5	0.4%
1989	71.3%	26.8%	45.5%	27.6%	2.5	0.1%
1990	64.6%	29.6%	54.0%	16.4%	1.8	0.2%
1991	69.1%	13.4%	69.4%	17.2%	2.2	0.1%
1992	60.3%	46.1%	18.3%	35.6%	1.5	0.1%
1993	56.6%	39.8%	34.0%	26.3%	1.3	0.3%
1994	40.1%	37.3%	17.2%	45.5%	0.7	0.2%
1995	36.6%	40.1%	5.3%	54.6%	0.6	0.3%
1996	35.9%	40.8%	5.0%	54.2%	0.6	0.5%
1997	31.0%	47.6%	2.2%	50.1%	0.4	0.4%
Mean (1974-93)	69.9%	18.9%	54.7%	26.3%	2.7	1.0%
Coho						
1974	73.3%	34.2%	64.6%	1.3%	2.7	10.0%
1975	69.0%	42.4%	57.0%	0.6%	2.2	11.6%
1976	54.5%	51.9%	47.2%	0.9%	1.2	8.0%
1977	72.3%	37.3%	60.3%	2.3%	2.6	11.6%
1978	65.9%	24.2%	73.5%	2.2%	1.9	6.6%
1979	58.6%	27.3%	70.6%	2.1%	1.4	6.1%
1980	69.0%	23.2%	76.0%	0.8%	2.2	7.3%
1981	61.4%	36.9%	62.3%	0.8%	1.6	6.0%
1982	68.6%	54.6%	43.9%	1.5%	2.2	9.9%
1983	72.5%	40.5%	57.9%	1.7%	2.6	8.2%
1984	68.4%	55.1%	43.5%	1.4%	2.2	7.6%
1985	57.9%	52.1%	47.8%	0.1%	1.4	6.8%
1986	69.5%	45.1%	53.2%	1.7%	2.3	9.2%
1987	64.5%	53.1%	46.3%	0.5%	1.8	10.1%
1988	56.7%	15.9%	77.0%	7.1%	1.3	4.9%
1989	71.6%	55.7%	43.7%	0.6%	2.5	6.5%
1990	62.3%	68.0%	32.0%	0.0%	1.7	4.2%
1991	54.7%	44.4%	54.9%	0.7%	1.2	3.0%
1992	35.4%	20.1%	72.9%	7.0%	0.5	4.2%
1993	39.6%	48.2%	46.4%	5.5%	0.7	1.4%
1994	30.3%	64.0%	22.3%	13.7%	0.4	1.4%
1995	2.1%	0.0%	8.7%	91.3%	0.0	1.8%
1996	27.6%	74.4%	0.6%	25.0%	0.4	1.2%
1997	12.5%	40.5%	0.5%	59.0%	0.1	1.6
1998	1.2%	28.6%	0.0%	71.4%	0.0	2.0
Mean (1974-91)	65.0%	42.3%	56.2%	1.5%	1.9	7.6%
Pink						
Odd-yr (1979-91)*	67.7%	0.0%	100.0%	0.0%	2.2	3.6%
Even-yr (1980-92)	56.1%	0.0%	100.0%	0.0%	1.1	5.5%

Source: PCAD database. From Sue Lehmann, Program Coordination and Assessment Division, SEP, Vancouver, B.C.
* Statistics exclude 1987 catch and harvest as the harvest rate in this year was abnormally high (96.4%) relative to other years

Freshwater Sport Fisheries

Freshwater angling on the Quinsam River has traditionally included resident trout, steelhead, and coho fisheries. Regulations and monitoring of resident trout and steelhead fisheries are undertaken by the Provincial Ministry of Environment, Lands and Water Protection (MWLAP), while coho are under the jurisdiction of the Federal Department of Fisheries and Oceans (DFO).

The Quinsam River resident trout sport fishery occurs mainly on the lakes within the system, and the principal capture species are cutthroat and rainbow trout. Angling regulations for lakes allow for retention of up to 4 resident trout or char per day with only 1 being over 50 cm (Table 18). Estimates of fishing effort and catch rates are somewhat dated. The most recent is from a 1989 angler survey of Lower Quinsam, Middle Quinsam, Long, Gooseneck, and Snakehead Lakes when 11,069 trout were captured during 4,096 angler days (Law, in prep.). The survey did not include lakes above the Quinsam River Diversion Dam (e.g., Wokas and Upper Quinsam Lakes).

The Quinsam River supports a winter run steelhead population that has historically provided a popular angling fishery from about mid-November to mid-April. Since 1980, regulations have required that anglers release all wild fish, but harvest has been permitted on hatchery fish (distinguished by a clipped adipose fin), with a quota of up to 2 fish per day (Lough et al. 1993). This mandatory release of wild steelhead was instigated to maintain wild stocks. During these years, the only area closure was from the boundary sign at the Cold Creek confluence (300 m below the hatchery counting fence) to the boundary sign at the power line crossing (30 m above the hatchery counting fence), which was implemented to prevent harassment of fish congregating in the vicinity of the hatchery counting fence. However, with the serious decline of eastern Vancouver Island steelhead stocks in the 1990's (including Quinsam River stocks), the Province has implemented increasingly more restrictive angling regulations in an attempt to stop this trend. For example, the 1997/98 and 1998/99 freshwater fishing regulations included an angling closure upstream of the Cold Creek confluence, a natural bait ban downstream of the Cold Creek confluence, and mandatory release of both hatchery and wild steelhead below the Cold Creek confluence (Wightman et al. 1998). For the last 3 fishing seasons (1999/2000 to 2002/03), restrictions have been expanded to include a total angling closure in the Quinsam River between November 15 and June 31 (MWLAP News Bulletins, www.news.gov.bc.ca).

Table 18. Summary of sport fishing regulations for the Quinsam River and for tidal waters off the mouth of the Campbell River.

Regulation	Purpose
Tidal Regulations	
• Single barbless hooks for all salmon fishing	
• Aggregate daily limit of 4 salmon from tidal and non-tidal waters	
• Chinook (DFO Areas 12 to 19, 28 and 29)[1]: - Minimum size limit of 62 cm - Daily limit of 2 - Aggregate coast wide limit of 30, of which only 15 may be from the above areas	Chinook conservation
• Coho (all BC tidal and non-tidal waters): - Release of all coho in tidal and non-tidal waters - Selected waters in Area 13 were open to hatchery coho effective September 1, with a daily limit of 2 and minimum size of 41 cm.	Conserve depleted coho stocks
• Pink (DFO Areas 1 to 29): - Minimum size limit 30 cm - Daily limit 4, no annual limit	
• Chum (DFO Areas 1 to 29): - Minimum size limit 30 cm - Daily limit 4, no annual limit	
• Sockeye (DFO Areas 1 to 21, 23 to 29): - Minimum size limit 30 cm - Daily limit 4, no annual limit	
Regional Freshwater Regulations (Region 1, Vancouver Island)	
• Combined daily quota for trout and char is 4, but only: - 1 over 50 cm from lakes - 2 from streams (including hatchery steelhead)	
• With release of all: - wild steelhead - cutthroat trout from streams during Oct. 1 to May 31 - under 30 cm from streams (no minimum size limit for trout/char from lakes)	 - Protect wild stocks - Protect spawners - Protect juveniles
• Annual catch quota for hatchery steelhead is 10	
• Single barbless hook all year	Reduce hooking mortalities
• Natural bait ban all year	Primarily for steelhead protection
Quinsam River Regulations	
• Angling closure from the Cold Creek confluence upstream to the boundary sign 250 m above the Quinsam Hatchery counting fence	Prevent harassment of fish concentrating at counting fence

Regulation	Purpose
• Steelhead Conservation Measures: - Area closure upstream of the Cold Ck. confluence from December 15 to May 31 - Release of all hatchery and wild steelhead below the Cold Ck. confluence from December 15 to May 31 - November 15, 1999: total closure to all angling	Instigated since the 1997/98 season to conserve depleted winter steelhead stocks
• Release of all cutthroat below Lower Quinsam Lake	Protection of anadromous cutthroat stocks
• Coho: retention permitted from October 1 to December 31 on coho # 35 cm in length (Jacks) with a limit of 8 per day	

[1] A map showing DFO Management Areas can be found at www-comm.pac.dfo-mpo.gc.ca. The Management Area off the mouth of the Campbell River is Area 13.

The Quinsam River steelhead fishery is monitored on an annual basis using the Steelhead Harvest Questionnaire (SHQ), which is a mail-out survey sent randomly to about 60% of anglers who purchased a licence to angle steelhead in the previous fiscal year. Over the years, questionnaire response has resulted in a polling average of about 19% of steelhead sport anglers (Smith 1999). The program is currently administered and analysed by the British Columbia Ministry of Fisheries. The results for the Quinsam River are shown in Figure 9 with actual values provided in Appendix B. The graph shows an obvious decline in catch and effort after 1990, a trend which is likely linked to the decline in steelhead returns that has occurred since 1990. During the period 1982 to 1997, an average of 4,568 days were spent fishing for steelhead, for an average total catch of 2,777 fish, of which slightly less than half (45%) were of hatchery origin. During 1998 and 1999 (mandatory release of both hatchery and wild steelhead), catch and effort were among the lowest for the period of record: average of 1,448 days with a total catch of 318 fish (55% of hatchery origin).

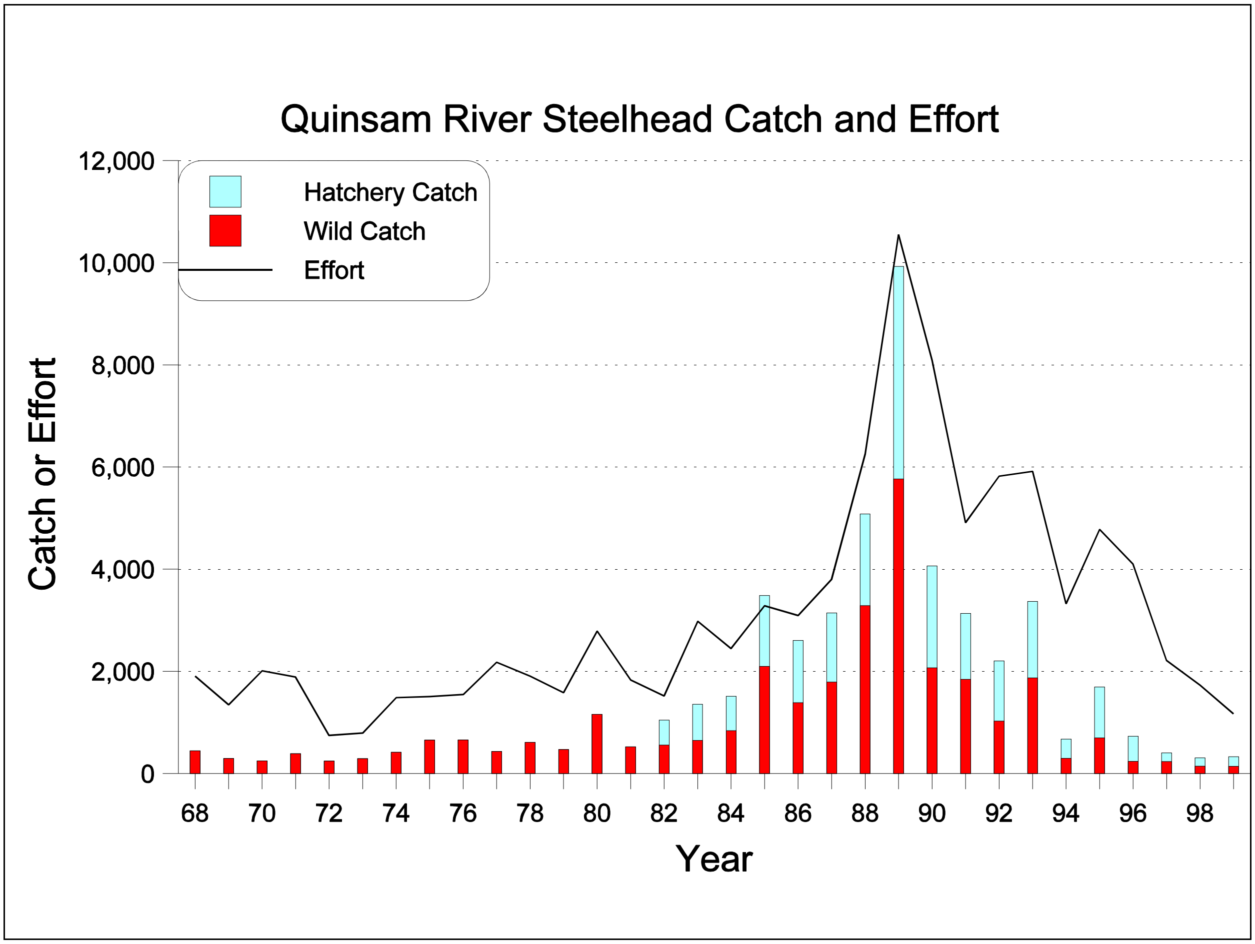

Figure 9. Estimated annual steelhead catch and effort (angler-days) for the Quinsam River, 1968–99 (from Rick Axford, MELP, Nanaimo based on the Steelhead Harvest Questionnaire).

The Quinsam River has traditionally supported a freshwater coho fishery from October 1 to November 31. Beginning in 1995, release of all adult coho was imposed on this fishery, with retention permitted only for "Jack" coho (coho that return to their native stream 1 year early). This restriction was implemented due to concerns over declining coho returns during the 1990's. "Jack" coho were distinguished in the angling regulations as fish # 35 cm in fork length (Table18). The 1999/2000 sport fishing regulations also included a "Jack" coho fishery, however, its duration was shortened to November 15 when a total angling closure imposed on the Quinsam River to protect dwindling steelhead returns (Dave Ewart, Acting Manager, Quinsam Hatchery, pers. comm.).

Prior to the 1995 regulation changes, about 400 adult coho were taken annually during the October to December fishery (Table 19). Annual catch of "Jack" coho during this fishery has averaged about 1,950 fish (1977–98 average, Table 19).

Table 19. Estimated annual catch of coho salmon in the Quinsam River sport fishery, 1977-99.

Year	Adults	Jacks
1977		4,000
1978	46	500
1979	100	3,000
1980	500	no estimate
1981	350	4,000
1982	500	3,000
1983	500	2,000
1984	108	715
1985	252	969
1986	400	1,000
1987	103	no estimate
1988	600	1,996
1989	300	800
1990	400	818
1991	908	1,487
1992	702	1,413
1993	363	1,259
1994	500	2,000
1995	adults closed	2,000
1996	adults closed	2,020
1997	adults closed	2,000
1998	adults closed	4,000
1999	adults closed	not complete
1977-94	390	1,810
1977-99	–	1,949

Source: PCAD annual escapement summaries from Sue Lehmann, Program Coordination and Assessment Division, SEP, Vancouver, B.C.

9. SUMMARY OF DATA GAPS AND RECOMMENDATIONS

The development of a Water Use Plan for the Quinsam River that incorporates fisheries requirements ultimately depends on the extent of our knowledge on the fish and fish habitat within this river system. This report has attempted to assist the WUP process by pulling a variety of fisheries information together under one cover, and by identifying data gaps in existing knowledge. The following is a summary of the most significant data gaps in our knowledge of the Quinsam River system. In order to serve the WUP process, data gaps most relevant to the WUP process are described first. *(Note: data gaps were drawn up prior to the initiation of WUP studies, and many have since been addressed by the WUP biophysical assessment conducted on the watershed in late 1999 and 2000).*

WUP Related Data Gaps

1) Natural Hydrograph is Unknown: The pre-regulation flow regime of the Quinsam River is unknown due to the absence of pre-project flow gauging. Naturalised flows for recent years may be assessed by adding diversion flows to those from existing Quinsam River stations, however, this may not provide long terms averages due to limited years of data for the diversion station (1997–present), and because this approach does not take into account potential influences of storage/release schedules at the Wokas Storage Dam.

Recommendation: A qualified hydrologist should review existing flow data and verify the accuracy of the naturalized hydrograph determined by the addition approach. For long term averages, accepted hydrologic modelling procedures should be undertaken to derive a naturalized hydrograph for the 3 DCP stations on the Quinsam River (08HD0021, 08HD027, and 08HD005).

(This data gap has since been addressed by the WUP process. Long-term averages have been estimated by BC Hydro hydrologists by reconstructing historic flows on the diversion and adding these to data from Quinsam River gauging stations. These data were used in the hydrology section of this report. However, as more years of data accumulate for existing gauging stations it may be pertinent at some point in the future to revisit these averages using measured data).

2) The influence of Flow Regulation on Fish and Fish Habitat is unknown: Flow patterns on the Quinsam River have been altered since 1957 by 3 structures: a storage dam at the outlet of Wokas Lake, a diversion dam 3.4 km further downstream, and a diversion canal that periodically routes Quinsam River water from the diversion dam to the Gooseneck/Snakehead Lake system from which it empties into Lower Campbell Lake. The effect of this flow regulation and abstraction on the habitat and life history stages of Quinsam River salmonids has never been examined. For example, the mean 30-day minimum flow (critical period streamflow) at the gauging station below Lower Quinsam Lake (08HD0027) was estimated at 10.2% of NMAD (0.86 m^3/s), which is equivalent to the Tennant short-term survival flow of 10% MAD. Also, the licensed minimum flow of 0.28 m^3/s below the diversion is equivalent to 9% NMAD, which may be inadequate as a long-term minimum. There is clearly a need to determine the appropriateness of current flow regimes on the various salmonid life history stages, and assess whether these flow regimes are placing any serious constraints on critical life stages (i.e., life stages that limit freshwater production).

Recommendations: This information gap could be addressed with surveys that collect depth/velocity transect data at 3 – 4 different flows. The depth and velocity data could be paired with habitat suitability index curves (HSI curves) to determine the suitability of various flow scenarios for different salmonid life stages (e.g., rearing, adult migration, and spawning). In addition, these data could also be input into the 2 dimensional model that BC Hydro is currently developing to quantify areal changes in habitat at different flow scenarios.

3) No Rigorous Examination of Fish Passage Flows: To date, their has been no rigorous examination of fish passage flow requirements at the various falls below Lower Quinsam Lake (Figure 6, Reaches 1, 2, 4, and 5). These falls appear to cause passage difficulties at low flows and those immediately below Lower Quinsam Lake also pose passage difficulties at high flows. There is concern that these falls may delay spawning migrations, and in the case of those immediately below Lower Quinsam Lake, may prevent a portion of annual coho and steelhead runs from gaining access to spawning habitats above Lower Quinsam Lake (thus, restricting potential salmonid production from the Quinsam system). Currently, fish passage flows below Lower Quinsam Lake are set at 1.7 m^3/s for the periods February 1 to May 31, and September 1 to November 15. This minimum flow requirement is based on observations in 1957 that coho were able to ascend the falls at km 24.2 when discharge reached 1.6–1.7 m^3/s (as noted by the presence of coho above this falls). These observations did not address ease of ascent at various flows above and below 1.7 m^3/s, multiple species considerations (steelhead, and anadromous Dolly Varden), and most significantly, they did not examine passage success at the most difficult section, the series of falls and cascades from km 26.3–27.4.

Recommendation: It is recommended that the most significant falls below Lower Quinsam Lake be surveyed with a total station to obtain plan, profile, and x-section drawings. This would best be accomplished at low flow (August). During September and later months, depth/velocity sampling and fish observations (visual and snorkelling) should be undertaken at various flows up to and beyond 1.7 m^3/s. The goal would be to determine which points across the falls offer the best ascent in terms of depth, velocity, and height, and to document fish jumping locations and success (presence of fish above the falls). A horizontal sonar may also be a consideration to document successful ascent of fish. This would best be placed above the uppermost falls (km 27.4) where the river switches to a straight deep run.

4) Outdated Biophysical Assessments: Previous biophysical assessments of the Quinsam River are dated (e.g. Lawseth 1978) or reconnaissance in nature (Quinsam Coal 1980; Norecol 1983; Resource Analysis Branch 1983; Hawthorn 1984). A common element missing in these early surveys is that they did not examine the extent and source of degraded habitats. Furthermore, in the years since these inventories the river may have changed (e.g., logging effects), and new habitat survey techniques have been developed. For example, current survey methods often focus on identifying the source and extent of degraded habitats (WRP surveys), or on the collection of specific data sets for insertion into Provincial databases (RIC surveys).

Recommendation: Undertake a biophysical assessment that incorporates WRP and RIC protocols.

5) Abundance and Distribution of Rearing Salmonids is Poorly Understood: Previous salmonid rearing studies have mostly provided presence/absence data as opposed to quantification of fish abundance (e.g., fish density; see Section 6.2.3). As a result of this deficiency it is not possible to compare rearing densities from one site with another (spacial abundance), from one year to the next (temporal abundance), or to relate rearing densities with expected densities at habitat capacity (stock status). In terms of the WUP, abundance and distribution data is useful for determining which species and life stages would be affected by various flow scenarios within a given reach. The data can also assistance in the selection of which habitat suitability index curves (species or life stage) are appropriate for a given by reach when examining flow/habitat relationships.

Recommendation: Conduct fish population sampling using total removal techniques (see Seber and Le Cren 1967; de Leeuw 1981). Sampling should be done at the end of the growing season (e.g., late September) when fish are largest with greatest territory and food demands. A minimum of 20 sites are recommended. This equates to slightly less than 1 site per 2 km of stream.

6) The Effect of High Water Temperatures is Unknown: The Quinsam River below Middle and Lower Quinsam Lakes experience extended periods each summer when water temperatures exceed provincial guidelines for the protection of freshwater aquatic life (mean weekly maximum temperature of 18°C, maximum daily temperature of 19°C, see Section 4). Available literature suggests that these periods of high temperature may diminish salmonid production from the Quinsam River. Temperature issues may also occur in other reaches of the upper Quinsam watershed, however, there has been no long-term temperature monitoring above Middle Quinsam Lake. Areas that may experience elevated summer temperatures include reaches from the Wokas Lake Dam downstream to the Iron River confluence (the

Iron River has a cooling influence). Lastly, the influence of water storage and diversion schedules on downstream temperatures has not been investigated.

Recommendations: A logical first step to address this data gap (and prior to biological studies on potential temperature effects on fish) would be to install continuous temperature recording devices at key points along the mainstem. Potential locations include 1) below Wokas Lake Dam, 2) at the Argonaut Bridge DCP station (08HD021), 3) the outlet of Middle Quinsam Lake, 4) immediately above the Iron River confluence, 5) below the Iron River confluence, and 6) the outlet of Lower Quinsam Lake. The data from these recorders could be used to assess both longitudinal profiles of temperature at various points in time as well as annual temperature regimes. In addition, in 2001 the Province released new temperature guidelines that incorporated temperature range criteria specific to individual species and life history stages (see MWLAP 2001). Existing temperature data (e.g. Quinsam River at Quinsam Hatchery) and data from new temperature loggers should be examined in light of these new guidelines.

Other Data Gaps

7) Absence of Quantitative Habitat Information: Previous habitat surveys have not been of the type that permitted quantification of spawning and rearing habitat. This often involves studies that quantify habitat based on area and hydraulic suitability (depth and velocity HSI preferences). Once the quantity of habitat is known (weighted usable area), it would be possible to estimate rearing and spawning capacity (by species) for the Quinsam River system. This in turn can assist fisheries managers in setting target escapements based on actual habitat potentials.

While this kind of information is of value to fisheries managers, in order to be of use to the WUP process, the area and depth/velocity data need to be collected at several different flow regimes. This would yield data on how weighted usable area for a given species and life stage changes with flow.

With respect to quantifying available spawning habitat, another approach, and one frequently adopted by Fisheries and Oceans, involves measuring the dimensions of known or potential spawning beds and summing all areas pertinent to a particular species. Spawning capacity is then determined based on biostandards of the number of square metres required per spawning pair. There is no link to flow and thus this method is of more utility to fisheries management than to WUP investigations.

Recommendation: If the full streamwidth depth/velocity data are collected for Data Gap 2, habitat area information could be collected at each of the flow regimes sampled by Data Gap 2. Due to the size of the Quinsam River the area data would probably have to be restricted to representative sections of a given reach. The area data could then be combined with weighted usable width data from the depth/velocity transects in order to quantify weighted usable area by species and life stage for each flow regime. Similarly, the amount of usable habitat can be paired with estimates of maximum potential fish density (e.g., rearing fry or parr per 100 m^2; number of m^2 per spawning pair) to estimate rearing or spawning capacity for the Quinsam River (See Burt and Burns 1995 for an example application).

8) Distribution of Spawning above the Hatchery is Uncertain: The distribution of spawning below Quinsam Hatchery is well known due to annual dead-pitch surveys and other activities by hatchery staff in this section of the Quinsam River. Very little has been done above the hatchery, however, and as a result the distribution of spawners in these reaches is poorly understood. There have been some studies that have identified "potential" spawning areas based on substrate composition (Lawseth 1979, Quinsam Coal 1980), but the only documentation the author could find on "observed" spawning distribution was in a 1957 fishery officer report (DFO 1957). This document presented spawning distribution and abundance of pink and coho salmon and provided maps showing the distribution of these species from the mouth up to Lower Quinsam Lake. Areas above this point were not covered, as was the distribution of steelhead spawning. At the time of these surveys, chinook distribution was not a factor as very few chinook spawned in the Quinsam prior to hatchery operations.

Recommendations: Conduct spawning distribution surveys from the hatchery counting fence upstream to the 15 m anadromous barrier at km 41.5. Some effort should also be expended on the Iron River due to the importance of this tributary for steelhead and Dolly Varden. Potential methods include foot, snorkel, and helicopter counts. It would be useful if this recommendation incorporated a spawning habitat inventory (Data Gap 7), even if simply areal measurements of existing spawning beds. This could be used to better establish escapements targets, particularly for the region from the hatchery upstream to Lower Quinsam Lake.

9) Fish Habitat and Fish Use in Tributaries is Poorly Understood. Very little effort has been devoted to determining the nature of habitat and relative abundance of fish in Quinsam Watershed tributaries (previous investigations have focussed on species presence/absence). Tributary habitats within anadromous reaches are particularly important for the production of coho salmon and anadromous cutthroat trout (see Figure 6).

Recommendations: Addressing this data gap is more relevant to fisheries management than to WUP completion. This data gap would best be served by baseline habitat inventories (e.g., RIC and/or WRP inventories) in conjunction with fish population surveys (total removal techniques).

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APPENDICES

Appendix A. Annual escapement of salmon to the Quinsam River, 1957–2002. Escapements are separated as fish that spawned in the river and those that were processed at the hatchery (numbers exclude jacks).

Year	Sockeye	Coho		Pink		Chum		Chinook	
	River	River	Hatchery	River	Hatchery	River	Hatchery	River	Hatchery
1957	un [a]	7,500 [a]	0	3,500 [a]	0	1,500 [a]	0	25 [a]	0
1958	1,958 [a]	1,500 [a]	0	7,500 [a]	0	3,500 [a]	0	75 [a]	0
1959	un [a]	7,500 [a]	0	3,500 [a]	0	200 [a]	0	25 [a]	0
1960	1,960 [a]	1,500 [a]	0	750 [a]	0	200 [a]	0	25 [a]	0
1961	un [a]	7,500 [a]	0	3,500 [a]	0	750 [a]	0	un [a]	0
1962	un [a]	7,500 [a]	0	750 [a]	0	750 [a]	0	un [a]	0
1963	un [a]	3,500 [a]	0	3,500 [a]	0	750 [a]	0	un [a]	0
1964	un [a]	3,500 [a]	0	1,500 [a]	0	200 [a]	0	un [a]	0
1965	un [a]	12,000 [a]	0	3,000 [a]	0	400 [a]	0	un [a]	0
1966	un [a]	3,500 [a]	0	1,500 [a]	0	400 [a]	0	un [a]	0
1967	un [a]	1,500 [a]	0	1,500 [a]	0	750 [a]	0	un [a]	0
1968	75 [a]	3,500 [a]	0	1,500 [a]	0	200 [a]	0	un [a]	0
1969	0 [a]	750 [a]	0	750 [a]	0	400 [a]	0	un [a]	0
1970	0 [a]	3,500 [a]	0	1,500 [a]	0	750 [a]	0	0 [a]	0
1971	25 [a]	1,500 [a]	0	400 [a]	0	400 [a]	0	25 [a]	0
1972	200 [a]	1,500 [a]	0	3,500 [a]	0	1,500 [a]	0	75 [a]	0
1973	50 [b]	3,000 [b]	0	4,000 [b]	0	1,000 [b]	0	5 [b]	0
1974	25 [a]	3,500 [b]	2,332	7,500 [b]	0	400 [b]	0	64 [b]	175
1975	104 [b]	2,706 [b]	1,113	30,000 [b]	0	400 [b]	0	53 [b]	237
1976	32 [b]	964 [b]	1,126	23,926 [b]	0	400 [b]	0	38 [b]	226
1977	20 [b]	7,986 [b]	13,703	4,235 [b]	0	27 [b]	0	17 [b]	405
1978	7 [b]	5,317 [b]	6,404	14,760 [b]	338	5 [b]	0	83 [b]	342
1979	28 [b]	6,409 [b]	6,639	7,075 [b]	2,472	355 [b]	0	444 [b]	466
1980	11 [b]	17,355 [b]	21,683	17,387 [b]	3,804	2 [b]	0	521 [b]	587
1981	150 [b]	8,715 [b]	17,137	15,832 [b]	2,709	150 [b]	50	512 [b]	424
1982	42 [b]	8,750 [b]	13,171	2,059 [b]	4,781	204 [b]	47	1,492 [b]	534
1983	58 [b]	10,234 [b]	12,161	20,939 [b]	7,953	0 [b]	0	1,246 [b]	550
1984	27 [b]	11,766 [b]	15,439	3,628 [b]	9,265	500 [b]	0	1,002 [b]	1,677
1985	29 [b]	12,263 [b]	19,140	13,858 [b]	16,743	514 [b]	0	1,744 [b]	2,046
1986	25 [b]	10,488 [b]	26,163	213,380 [b]	18,594	2 [b]	0	960 [b]	1,885
1987	0 [b]	14,151 [b]	12,136	106,960 [b]	16,583	1 [b]	0	1,434 [b]	2,226
1988	8 [b]	12,450 [b]	22,740	147,375 [b]	23,225	104 [b]	0	5,467 [b]	4,458
1989	30 [a]	12,700 [b]	17,483	17,894 [b]	17,466	un [b]	0	7,809 [b]	4,700
1990	8 [b]	17,100 [b]	7,523	316,650 [b]	120,643	4 [b]	0	10,330 [b]	2,558
1991	34 [a]	11,993 [b]	12,933	90,891 [b]	14,726	100 [a]	0	4,104 [b]	2,760
1992	24 [b]	11,200 [b]	7,732	210,296 [b]	20,466	5 [b]	0	1,326 [b]	3,003
1993	56 [b]	6,198 [b]	3,314	19,226 [b]	11,164	6 [b]	0	852 [b]	1,319
1994	20 [b]	7,475 [b]	3,121	70,305 [b]	21,797	300 [b]	0	476 [b]	1,902

Year	Sockeye	Coho		Pink		Chum		Chinook	
	River	River	Hatchery	River	Hatchery	River	Hatchery	River	Hatchery
1995	50 [b]	30,611 [b]	4,348	17,895 [b]	19,130	300 [b]	0	1,053 [b]	1,100
1996	17 [b]	7,755 [b]	2,761	100,562 [b]	21,272	135 [b]	0	744 [b]	1,864
1997	691 [b]	16,174 [b]	4,178	62,094 [b]	21,008	25 [b]	0	905 [b]	1,656
1998	68 [b]	21,411 [b]	2,927	46,163 [b]	29,779	95 [b]	50	2,422 [b]	1,999
1999	21 [b]	9,500 [b]	3,408	121,686 [b]	16,944	414 [b]	40	3090 [b]	3,661
2000	48 [b]	16,526 [b]	3,763	120,883 [b]	26,159	50 [b]	18	4233 [b]	2,355
2001	8 [b]	17,294 [b]	6,284	219,767 [b]	28,011	31 [b]	0	9723 [b]	2,804
2002	9 [b]	18,849 [b]	3,982	77,947 [b]	31,200	1,535 [b]	0	8565 [b]	1,959
Average 1983-92	24	12,435	15,345	114,187	26,566	137	0	3,542	2,586
Average 1993-02	99	15,179	3,809	85,653	22,646	289	11	3,206	2,062

Source:

[a] Salmon Escapement Data System (SEDS) from Lyse Godbout, Pacific Biological Station, Nanaimo, B.C.

[b] Quinsam Hatchery files from Dave Ewart, Acting Project Manager, Quinsam Hatchery, Campbell River, B.C.

Appendix B. Annual catch and effort for steelhead angled from the Quinsam River based on the Steelhead Harvest Questionnaire.

Harvest Year	Wild			Hatchery			Combined Catch	Effort
	Kept	Released	Total	Kept	Released	Total		
1968	443	0	443	0	0	0	443	1,906
1969	296	0	296	0	0	0	296	1,346
1970	247	0	247	0	0	0	247	2,010
1971	237	150	387	0	0	0	387	1,888
1972	163	83	246	0	0	0	246	746
1973	196	95	291	0	0	0	291	792
1974	251	163	414	0	0	0	414	1,485
1975	347	307	654	0	0	0	654	1,506
1976	240	416	656	0	0	0	656	1,545
1977	158	272	430	0	0	0	430	2,178
1978	163	446	609	0	0	0	609	1,907
1979	76	391	467	0	0	0	467	1,584
1980	204	954	1,158	0	0	0	1,158	2,789
1981	72	450	522	0	0	0	522	1,829
1982	3	554	557	87	401	488	1,045	1,519
1983	55	594	649	194	513	707	1,356	2,980
1984	4	835	839	103	571	674	1,513	2,443
1985	41	2,057	2,098	196	1,189	1,385	3,483	3,284
1986	7	1,381	1,388	227	989	1,216	2,604	3,094
1987	0	1,791	1,791	215	1,137	1,352	3,143	3,804
1988	9	3,277	3,286	402	1,394	1,796	5,082	6,258
1989	51	5,716	5,767	876	3,285	4,161	9,928	10,554
1990	0	2,069	2,069	407	1,587	1,994	4,063	8,088
1991	42	1,802	1,844	276	1,013	1,289	3,133	4,909
1992	0	1,027	1,027	321	858	1,179	2,206	5,819
1993	7	1,865	1,872	386	1,113	1,499	3,371	5,911
1994	2	296	298	101	275	376	674	3,323
1995	0	698	698	118	877	995	1,693	4,782
1996	0	236	236	106	386	492	728	4,102
1997	16	217	233	43	127	170	403	2,210
1998	0	143	143	0	163	163	306	1,728
1999	0	141	141	25	164	189	330	1,167
Mean 1968-81	221	266	487	0	0	0	487	1,679
Mean 1982-97	15	1,526	1,541	254	982	1,236	2,777	4,568
Mean 1998-99	0	142	142	13	164	176	318	1,448

Source: Rick Axford, MWLAP, Nanaimo based on Steelhead Harvest Questionnaire results.

ANNOTATED BIBLIOGRAPHY
QUINSAM RIVER SYSTEM

Literature Related to the Aquatic Resources of the Quinsam River System, Vancouver Island

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CITATION:
Albreiht, J. 1980. Memorandum: Review of technical reports on the Quinsam Coal Limited Project. Fish and Wildlife Branch, Ministry of Environment, Province of British Columbia, File 0760/01. 16 p.

ABSTRACT SOURCE:
Abstract by author

ABSTRACT:
The review of 12 reports submitted and/or requested by Coal Guidelines Steering Committee are accomplished with input from both the Fisheries and Wildlife sections within the Region, in addition to the Habitat Protection section. Comments covering technical adequacy of data, data gaps, problems with methods employed and/or inappropriate interpretation of the data follows on a report specific basis.

CITATION:
Alderdice, D.F., and W.E. McLean. 1982. A review of the potential influence of heavy metals on salmonid fishes in the Campbell River, Vancouver Island, B.C. Can. Tech. Rep. Fish. Aquat. Sci. 1104: vii + 60 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Potential joint toxic effects of dissolved and extractable zinc, copper and cadmium levels in water samples taken from the Campbell River, Vancouver Island, B.C. over the past 12 years (1971–1982) are assessed for three salmonids native to the river – the chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon and the steelhead trout (*Salmo gairdneri*). As little direct evidence is available regarding toxicity of Campbell River water, the assessment is based on relevant data from the current toxicological literature. There has been a consistent increase in zinc levels in river water, rising from about 0.007 mg/L early in 1971 to about 0.048 mg/L at the end of 1980. No consistent rise in copper concentrations could be demonstrated in the same period. However at a mean hardness of 21.5 (as mg/L CaCO3) (1971-1982) mean metal levels in the river in recent years have been 0.0464 mg/L of zinc (1981-1982), 0.0021 mg/L of copper (1980-1982) while cadmium has been below detection limits since 1971 (<0.0005 mg/L). In the last few years (1980–1981) "spikes" of high concentration have reached maxima of 0.066 mg/L zinc and 0.0035 mg/L copper. Since mid-1981 there is a suggestion that metal levels may have declined somewhat, a possibility requiring further monitoring of the water to substantiate.

Estimates of 96-h LC50 concentrations and data relating to maximum acceptable toxicant concentrations (MATC) are marshalled from the literature for the species examined in tests at water hardness levels near that of Campbell River water. From these data MATC values are estimated and compared with existing metal levels from the water samples. Assuming additivity of toxic effects (Zn+Cu), the number of toxic units (TU) equivalent to (Zn+Cu) concentrations in the samples are derived for the three species considered. Based on average heavy metal loads, Campbell River water is calculated to have been toxic to naive juvenile *S. gairdneri*, (those moving into the main river from feeder streams or from the Quinsam hatchery) for most of the period between February 1980 and September 1981. Pre-exposed (non-naive), juvenile salmonids incubated as eggs and hatched in the river are judged to be more resistant to heavy metals, presumably through induction of metallothionein proteins that tend to bind and detoxify heavy metal ions. For pre-exposed fish, Campbell River water appears still to be non-toxic although the extent of risk can not be quantified at this time. The Zn+Cu loads in the Campbell River appear to have become critical to naive juveniles within the last two years (1980-1981). In that period, levels of heavy metals in water samples are predicted to have been toxic as follows: 3 of 38 samples (chinook), 30 of 40 samples (S. gairdneri), and 0 of 38 samples (coho). In general, susceptibility of the three species to heavy metal toxicity is estimated as S. gairneri>chinnok>coho. Although there are differences in susceptibility of naive (feeder stream and hatchery) and pre-exposed (main Campbell River) fish, small differences in water characteristics resulting from changes in upstream conditions (e.g. decreases in hardness or pH) could increase the toxic potential of current heavy metal loads in the river water. It is concluded that water quality in the Campbell River has reached a critical state with regard to the well-being of salmonids native to the river. In view of the apparent severity of the current situation, the following recommendations are made: (1) immediate remedial action should be taken to protect indigenous salmonids in the Campbell River by reducing zinc and copper concentrations now occurring in the river, and (2) an investigation should be instituted to determine maximum acceptable heavy metal

levels (Zn+Cu+Cd) for naive and pre-exposed native salmonids as well as representative organisms (algae, invertebrates) in the supporting food web in the Campbell River system.

CITATION:
Andrew, J.H., M. Lightly and T.M. Webb. 1988. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Campbell and Quinsam Rivers, 1985. Can. MS Rep. Fish. Aquat. Sci. 2007: 46 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Intensive spawning ground surveys were conducted on the Campbell and Quinsam rivers in 1985 as part of the chinook key stream program. The Petersen carcass tagging estimate of chinook escapement to the Campbell River was 1,427 ± 201 fish (95% CL) and to the Quinsam River was 1,590 ± 175 fish (95% CL). In both rivers, males predominated at age 4_1 and females at age 5_1. Estimated escapements by age are presented.

There were 78 adipose marked Chinooks in the Campbell dead recovery and 237 in the Quinsam. Escapements of adipose clipped Chinooks, based on these recoveries, were 160 to the Campbell and 393 to the Quinsam. These are presented by age, sex and individual tag code. The total hatchery contribution to the escapements were estimated using coded wire tagged/adipose mark rates at release. In the Campbell, the hatchery contributed 38.9% of the male chinook escapement and 50.3% of the female escapement. In the Quinsam, the hatchery contributed 72.2% of the male and 80.3% of the female escapement.

CITATION:
Anon. 1982. DOE/DFO Quinsam Coal Task Force report. Environment Canada and Fisheries and Oceans. 87 p.

ABSTRACT SOURCE:
Abstract by author

ABSTRACT:
This report has been prepared in response to the proposal by Quinsam Coal Limited (QCL) to construct and operate a surface coal mine adjacent to Middle Quinsam Lake 27 km west of Campbell River, B.C. A joint DOE/DFO Quinsam Coal Task Force was established in January 1978 to review the project. Concerns regarding the resulting effects of acid generation, heavy metals, nutrients, sediment control, groundwater, port development, and assurance of mitigation on water quality in the Quinsam system are addressed in this report.

CITATION:
Atkins, R.G. and K.K. Anderson 1994. Campbell River watershed diversion performance review. 60 p.

ABSTRACT SOURCE:
Abstract by author

ABSTRACT:
The purpose of the review was to assess the operational performance of the diversion projects in the Campbell River watershed. Each diversion project is reviewed independently in terms of energy potential, water license conditions and fisheries requirements. The diversion projects did not maximize energy and financial revenue benefits and may effect adherence to the water license requirements and the satisfaction of environmental concerns.

CITATION:
BC Hydro. 1994. Report on the electric system operations review. The Ministry of Employment and Investment and The Ministry of Energy, Mines and Petroleum Resources. 3 p.

ABSTRACT SOURCE:
Abstract by author

ABSTRACT:
Low flows, on the Quinsam River, during late summer are associated with high water temperatures. These temperatures can stress rearing juvenile salmonids and exceed resident fish tolerance levels. Increasing Quinsam River flows from 1.7 m^3/s to 4.24 m^3/s from 1 February to 31 May, and from 1 September to 15 November may not address the water temperatures concerns but, would decrease the low flow impacts on salmon spawning and rearing habitat. The increase in flows may also increase overall fish production. Two possible options to provide an increase in flows are decreasing the rate of diversion to Lower Campbell Lake and increasing the headwater storage for use during low flows.

CITATION:
BC Hydro. 1998. Campbell River field facility guide. Power Facilities. 51 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
The Bridge River/Coastal Generation Field Facilities Guide is a response to the need to provide Facility Staff with quick reference material concerning the Bridge River/Coastal Facility Managers meeting held in February 1996. The binder provides a general background regarding the operating history, maintenance requirements and environmental information with respect to the generation facilities.

The following subjects pertaining to the power project are covered in this document: facility descriptions; operating history; licenses, permits and approvals; fish; water quality; reservoir debris; forestry, agriculture and vegetation; wildlife; pollution prevention; heritage sites; First Nations issues; and recreation. The primary audience for this document is intended to be BC Hydro personnel including Field Managers, PSO staff, Project Managers and Plant staff. The public and agency staff may also be interested in the information presented in this document.

The information provided in this summary is a compilation of existing data collected mainly from BC Hydro documents and databases, consultant reports, discussions with BC Hydro staff and information provided by Federal and Provincial government agencies. Due to the lack of updated information on some of the material, some inaccuracies may occur. Users are encouraged to contact the Area Environmental Coordinator for Bridge River/Coastal Generation at BC Hydro with any updated or additional information, or with corrections to inaccurate material. This field guide is a revisable document, subject to refinement and changes as new information becomes available.

This document is designed to provide a broad overview of information related to the Campbell River system. The document is to be used as an initial reference source only and should not be used as a substitute for other legislative and technical reports. It is the users responsibility to ensure that the information is current and accurate.

CITATION:
Bilton, H.T., A.S. Coburn, and R.B. Morley. 1983. Time and size at release experiment: four releases of the three size groups of juvenile chinook salmon from the Quinsam Hatchery in the Spring of 1982. Can. Data Rep. Fish. Aquat. Sci. 397: iv + 18 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
This report provides, in readily accessible form, background information required to assess the results of an experiment in progress at the Quinsam River production hatchery, Campbell River, B.C. The experiment is designed to measure the effects of time and size at release of juvenile chinook salmon (*Oncorhynchus tshawytscha*) on their subsequent survival, growth, distribution, and age at maturity. In the spring of 1982 four releases (May 5, May 26, June 16, and July 7) of juvenile chinook salmon, each comprised of three size groups, were released from the Quinsam River hatchery, representing a combined total of 315,986 marked and tagged fish. Prior to each release, samples of smolts were obtained for examination for disease, proximate analysis, and sea water challenge tests. Specific information on lengths, weights, sex composition, health, and ability of released fish to adapt to sea water is given.

CITATION:
Bilton, H.T., R.B. Morley, A.S. Coburn, and D. Brouwer. 1984. Time and size at release experiment: four releases of three size categories of juvenile chinook salmon from the Quinsam Hatchery in the Spring of 1983. Can. Data Rep. Fish. Aquat. Sci. 463: 23 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
This report provides, in readily accessible form, background information required to assess the results of an experiment in progress at the Quinsam River production hatchery, Campbell River, B.C. The experiment is designed to measure the effects of time and size at release of juvenile chinook salmon (*Oncorhynchus tshawytscha*) on their subsequent survival, growth, distribution, and age at maturity. In the spring of 1983, four releases (May 5, May 26, June 16, and July 7) of juvenile chinook salmon, each comprised of three size groups, were released from the Quinsam River hatchery, representing a combined total of 359,514 marked and tagged fish. Information from samples collected just prior to release on lengths, weights, sex composition, health, body composition, and ability of released fish to adapt to sea water is given.

CITATION:
Bilton, H.T., R.B. Morley, A.S. Coburn, and J. Van Tyne. 1984. The influence of time and size at release of juvenile coho salmon (*Oncorhynchus kisutch*) on returns at maturity; results of releases from Quinsam River Hatchery, B.C., in 1980. Can. Tech. Rep. Fish. Aquat. Sci. 1306: 98 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Releases of juvenile coho salmon (*Oncorhynchus kisutch*) were made from Quinsam River production hatchery, Vancouver Island, British Columbia, on April 20, May 10, May 30, and June 19, 1980. These fish had been graded into small, medium, and large size groups, nose-tagged, and marked by removal of the adipose fin. Each time-size combination was replicated three times giving a total of 36 groups. Returns of jacks (precocious males, age 1.0) and adults (age 1.1) to the hatchery and various fisheries were analysed using both returns (catch plus escapement) of 11.2% are predicted for release of 15.7 g juveniles on June 4 (Julian day 156). Since this weight is below the actual weight range tested for this date, a release weight of approximately 20 g is recommended until the lower weight can be tested. Returns of approximately 10.2% are predicted for fish of this size. The effects of size at release were minor compared to those of time of release, with very little change in the optimum release weight over the season. As in an earlier study, production of jacks was favoured by early release of large juveniles; within the tested ranges jack returns were predicted to be the highest (2.5%) for release of 30 g juveniles on about May 8. For both jacks and adults, fish from earlier releases were larger on return. There was also a pronounced tendency for larger juveniles to produce larger jacks; a similar but less pronounced correlation was observed for adults. Taking these weight differences amongst mature fish into account, response surface analysis indicates maximum biomass of returns from a release of 16.6 g juveniles on June 3 (day 155), a combination only slightly different from that predicted to maximize percent return of adults. Almost all fish taken by the fishery were caught as adults. Most (41%) were taken in the net fishery, the remainder was divided approximately equally between commercial troll and sport, the sport proportion increasing with later release. Fish from earlier releases had a more extended northward range and there was strong evidence of selection by the fishery for larger fish and for males. Comparison of Quinsam returns with a previous study at an experimental hatchery on E. Vancouver Island and with other production hatcheries suggests the possibility of site specific factors limiting the production at Quinsam. Nevertheless, the results indicate that production could be approximately doubled by the release of juveniles about 2 weeks later and approximately 5 g smaller than is currently practised.

CITATION:
Blackmun, G.J., B.V. Lukyn, W.E. McLean, and D. Ewart. 1985. Quinsam watershed study: 1983. Can. Manuscr. Rep. Fish. Aquat. Sci. 1832: ix + 65 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Hatchery coho and steelhead fingerlings have been transplanted to the Quinsam watershed, yearly, since 1978. In the winter of 1983 the opportunity arose to monitor the fish distribution and smolt production from this area. The study was extended to include the monitoring of stream flows and basic water quality parameters. The effort was intensified in the Middle Quinsam Lake area because this is the site of a proposed surface coal mine.

Trapping success indicated that the heaviest coho utilization occurred in Flume and Long Lakes. Steelhead were more abundant in the streams. Downstream migration began in late April. By the end of May it was estimated that at least 32,500 coho smolts had moved out of Middle Quinsam Lake area.

The lowest stream flow occurred in late spring and summer. The outlet of Long Lake was below 0.01 cubic metres per second for an extended period.

Suspended solids levels for the streams flowing into Middle Quinsam Lake remained low throughout the year (<3 mg/l) while the lower Quinsam River and the Iron River became quite silty (>20 mg/l) during storm events. pH values were generally above 7.0 and the dissolved oxygen levels were typically above 85% of saturation. Flume Lake outlet was exceptional in that the pH values were consistently below 7.0 and the dissolved oxygen level had decreased to 64% of saturation by August.

CITATION:
Carswell, L.B., R.S. Hooton, and V.A. Lewynsky. 1986. Campbell/Quinsam River creel surveys, 1975-76 to 1979-80. Fish. Tech. Circ. No. 72. 23 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
The Campbell/Quinsam River system was surveyed from 1975-76 to 1979-80 to assess the effects of steelhead production from the Quinsam Hatchery on the winter steelhead fishery and to compare estimates obtained by the on-site creel survey with those calculated by the annual mail survey (Steelhead Harvest Analysis). Angler use, among the most intense in the province, was consistently higher on the Campbell River, but tended to decrease as use increased on the Quinsam River. An increase in angler use of the Quinsam River occurred after 1977-78 when the first adult hatchery steelhead entered the fishery. This numerical response by anglers implies general acceptance after 1977-78 but the estimated increase may not necessarily reflect real changes in either of the two parameters. Possible confounding effects are discussed.

Estimates of angler-days by the mail survey appeared to be less biased than those calculated by the on-site creel survey. Estimates of catch rates and catch by both survey methods were probably inflated.

There was little evidence to support concern among winter steelhead anglers that a spring "smolt fishery" was adversely affecting adult returns.

No detectable relationship was evident between the time or size of hatchery smolts released and subsequent adult catch.

CITATION:
Craig, J. April 15, 1999. Observations of fish and habitat impacts below the Salmon and Quinsam River Diversions, March 26 - April 1, 1999. Ministry of Environment, Lands and Parks, Nanaimo, B.C., Files 34560/(Salmon) and 34560/(Quinsam): 16 p. text + 26 p. photos.

ABSTRACT SOURCE:
Abstract by author

ABSTRACT:
Report is a compilation of file notes (dated April 15, 1999) describing results of snorkel and visual observations on the Salmon and Quinsam Rivers in the vicinity of their diversion dams. The purpose was to examine the effects of ramp-down operations on fish and fish habitat.

For the Quinsam River, flows were ramped from 6.3 m^3/s (220 cfs) down to 0.28 m^3/s (10 cfs). Inspection of the 300 m section below the diversion dam located 7 stranded fish (2 resident trout, 1 juvenile trout, 3 coho, 1 sculpin), and inspection of the 400 m of stream below the Argonaut Bridge found 4 stranded fish (3 juvenile trout, 1 coho). Recommendations for the Quinsam Diversion Dam included implementation of a slow and smooth ramp-down rate, reconnaissance of the right hand channel below the dam after each ramp-down and removal of any stranded fish, and continued monitoring of ramping events to further assess stranding and mortality issues.

CITATION:
DFO. 1957. Untitled report on the 1957 salmon run to the Quinsam River. Obtained from Jim Van Tine's files, Quinsam Hatchery: 4 p. + maps

ABSTRACT SOURCE:
Abstract by author

ABSTRACT:
This document provides information on the 1957 salmonid run (pink, coho, and steelhead) to the Quinsam River. Topics covered include magnitude and timing of the run, spawning density relative to the perceived spawning capacity, effects of reduced discharge, and distribution of spawners. The report is particularly important in that it documents impedance of salmon migration due reduced discharge associated with the hydroelectric development (Wokas Storage Dam and Quinsam River Diversion). From October 17–23 migrating coho were blocked at the falls below Lower Quinsam Lake. In addition, the low flows resulted in 70–80% of the pink run spawning in depths of 15–20 cm (6–8 in.). During this period flows below Lower Quinsam Lake ranged from 0.82–0.96 m^3/s (29–34 cfs). On October 18, the B.C. Power Commission was asked to provide 1.13 m^3/s (40 cfs) to the stream. The gate at the dam was opened on October 19, and by October 22 1.56–1.70 m^3/s (55–60 cfs) was flowing over these falls. Observations made during this period indicated that coho were unable to ascend the falls until discharge had built up to between 1.56–1.70 m^3/s. Pink salmon did not benefit from the increased flows since their spawning was complete by the time the increased water arrived.

CITATION:
Eastwood, G.E.P. 1984. Geology of the Quinsam Lake Area, Vancouver Island. Mineral Resources Division, Geological Branch, Ministry of Energy, Mines and Petroleum Resources, Province of British Columbia, Paper 1984-3. 36 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
The Quinsam coal measures and adjacent terrain described in this report underlie an area of about 130 square kilometres west and southwest of Campbell River on Vancouver Island. Figure 1 shows the location and the principal features of the surrounding area.

The area is more or less centred on the northwest end of the belt of coal-bearing Upper Cretaceous rocks. The original purpose of this study was an assessment of the coal potential; however, in outlining the extent of the coal measures, identification and correlation problems arose with the surrounding older rocks, and the mapping was necessarily extended. It was further extended northwest to Strathcona Dam to locate more accurately the north contact of the Quinsam stock and to show, in reconnaissance fashion, the occurrence of pyritic rocks containing minor amounts of copper and southwest to include known mineral showings west of Gentian Lake.

CITATION:
Fish Habitat Inventory and Information Program. 1990. Stream summary catalogue. Subdistrict 13N, Campbell River. Department of Fisheries and Oceans, Vancouver, B.C. or Ministry of Environment, Lands and Parks, Nanaimo, B.C. 6 p. + 9 p. references

ABSTRACT SOURCE:
Abstract by author

ABSTRACT:
This is a bound version of the Fish Information Summary System (FISS) database on the Quinsam and Iron Rivers (watershed codes 92-2600-010 and 92-2600-010-500, respectively). The database provides synoptic data on the habitat and fish resources of the Quinsam Watershed as well as a list of published and unpublished references. The database can also be accessed on the internet, and while this source is updated more frequently than the bound version, less detail is provided for some pieces of information (internet site: http://www.env.gov.bc.ca/fsh/IS).

CITATION:
Frith, H.R. 1993. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Campbell and Quinsam rivers, 1992. Can. Manuscr. Rep. Fish. Aquat. Sci. 2207: vii + 56 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Estimates of escapement were derived for the Campbell/Quinsam River system for 1992 using carcass tagging as part of the chinook key stream program. The Petersen estimate of chinook escapement was 4,782 in 1992. Both males and females were predominantly age 4 and 5 but the specific age structure varied between The Campbell River, and the Quinsam River and hatchery. Escapement estimates are presented by river, sex, and age.

Escapement of adipose-clipped chinook to the entire system was 318 in 1992. This estimate was further stratified by age, sex, and tag code. The total hatchery contribution (marked and unmarked) to the escapement was estimated by expanding the number of observed adipose clips by the adipose-clip mark rate at release. In 1992 the hatchery contribution was 86.0% and 77.0% for male and female chinook escapements, respectively. These hatchery contribution estimates were compared with those estimated using the Mark Recovery Program (Kuhn 1988) method of coded wire tag expansions. Using the MRP method, the total hatchery contribution was 83.6% for males and 74.0% for females in 1992.

CITATION:
Frith, H.R., and T.C. Nelson. 1994. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Campbell and Quinsam rivers, 1993. Can. Manuscr. Rep. Fish. Aquat. Sci. 2251: ix + 59 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Estimates of escapement were derived for the Campbell/Quinsam River system for 1993 using carcass tagging as part of the chinook key stream program. The Petersen estimate of chinook escapement was 2,486 in 1993 and includes hatchery removals (sales, broodstock, mortalities) and chinook passed over the hatchery fence. Males and females were mostly age 5, except in Quinsam Hatchery where males were mostly age 3. The female chinook age distribution was similar for the Campbell River, Quinsam River and the hatchery with age 5 fish contributing greater than 70%. Males were variable in age distribution and ranged from 72.2% age 5 in Campbell River to 26.2% age 5 in Quinsam Hatchery.

Estimated escapement of adipose-clipped chinook to the entire system was 133 in 1993. This estimate was further stratified by age, sex, and tag code. The total hatchery contribution (marked and unmarked) to the escapement was estimated by expanding the number of observed adipose clips by the adipose-clip mark rate at release. In 1993, the hatchery contribution was 63.9% and 70.8% for male and female chinook escapements, respectively. These hatchery contribution estimates were compared with those estimated using the Mark Recovery Program (Kuhn 1988) method of coded wire tag expansions. Using the MRP method, the total 1993 hatchery contribution was 61.6% for adult males and 65.8% for adult females.

CITATION:
Frith, H.R., and T.C. Nelson. 1995. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Campbell and Quinsam rivers, 1994. Can. Manuscr. Rep. Fish. Aquat. Sci. 2325: ix + 61 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Estimates of escapement were derived for the Campbell/Quinsam River system for 1994 using carcass tagging as part of the chinook key stream program. The Petersen estimate of chinook escapement was 2,982 in 1994 and includes hatchery removals (sales, broodstock, mortalities) and chinook passed over the hatchery fence. Males and females were mostly age 4, except in Campbell River where females were mostly age 5. Males and females were variable in age distribution. Females ranged from 37.8% age 4 in Campbell River to 68.6% age 4 in Quinsam Hatchery. Males ranged from 46.4% age 4 in Quinsam River to 71.4% age 4 in Campbell River.

Estimated escapement of adipose-clipped chinook to the entire system was 182 in 1994. This estimate was further stratified by age, sex, and tag code. The total hatchery contribution (marked and unmarked) to the escapement was estimated by expanding the number of observed adipose clips by the adipose-clip mark rate at release. In 1994, the hatchery contribution was 69.8% and 85.3% for male and female chinook escapements, respectively. These hatchery contribution estimates were compared with those estimated using the Mark Recovery Program (Kuhn 1988) method of coded wire tag expansions. Using the MRP method, the total 1994 hatchery contribution was 64.0% for males and 83.2% for females.

CITATION:
Grant, W., K. Brydges, and D. Tripp. 1995. The fish and fish habitat at selected sites in the Oyster River operations area. TimberWest Forest Limited, Campbell River, B.C. pp. 653-822.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
This catalogue and a series of accompanying maps document the classification of streams within the Oyster River Operations of TimberWest Forest Limited. The primary task was the verification of the upstream limits of fish bearing water in the streams draining the operational area. The study area roughly encompasses the area surrounding Strathcona Provincial Park on Vancouver Island, from Campbell River south to Courtenay and west to Gold River. Between April 21 and September 13, a total of 499 sites were sampled in 12 drainages.

The survey was undertaken because a lack of specific information on fish distribution was identified as a problem in audits and assessment action plans in many of the TimberWest operational areas. These included Beaver Cove, Middlepoint, Oyster River, Sandspit, and South Island. That lack of information was slowing the approval process for cutting permits. It also prevented both efficient block layout and the targeting of those previously logged streams requiring debris removal.

The recent operational regulations of the Forest Practices Code (FPC) require a Riparian Management Area (RMA) beside all streams, lakes, and wetlands. Although the exact width of each RMA is subject to interpretation by the district manager and local government environmental agencies, RMAs will definitely reduce the allowable harvest along fish bearing streams. Without adequate stream classification, managers cannot accurately gauge the impact of the new regulations on timber inventory. This creates uncertainty about the available timber supply and may influence the harvest rate that allows a sustained yield.

CITATION:
Griffith, R.P. 1991. Evaluation of hatchery steelhead smolt release programs in British Columbia. B.C. Fisheries Branch, Victoria, B.C. 65 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Many of the hatchery steelhead smolt programs that are currently ongoing in British Columbia were initiated in the late 1970's or early 1980's. In some cases, existing hatchery steelhead programs were expanded at this time. Roughly a decade later, in 1990 the B.C. Fisheries Branch initiated a study to evaluate these programs on the basis of a defined set of criteria.

All data used in the study were provided by the B.C. Fisheries Branch. Only ongoing programs (as of 1990) were addressed. The major component consisted of steelhead smolt release statistics, commencing with the 1979 brood year, and corresponding Steelhead Harvest Analysis results up to, and including, 1990. Limited data regarding production costs and various hatchery production procedures were also provided. Programs for a total of 23 different stream systems were addressed. For systems with smolt programs for both winter and summer run fish, release numbers and subsequent catch results for both programs were combined. In order to standardize as much as possible, the principal focus was on data commencing with the 1982 brood year. Where questions arose, a mean fish size of at least 25g was used as the standard for designating releases as smolts.

CITATION:
Hartman, G.F., and C.A. Gill. 1968. Distribution of juvenile steelhead and cutthroat trout (*Salmo gairdneri* and *S. clarki clarki*) within streams in southwestern British Columbia. J. Res. Bd. Can. 25(1): pp. 33-48.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Trout were collected and identified from 66 streams or stream systems of different size and gradient. Total dissolved solids (T.D.S.) and pH were determined on most streams. Size and profile of streams to a large degree determined the species of trout present. Large streams, with drainage area over 130 km^2, were predominantly occupied by steelhead. Small streams, drainage area under 13 km^2, were predominantly occupied by cutthroat. Streams less than 120 km^2 in drainage area with steep gradients, and emptying directly into the sea, usually supported steelhead, as did large rivers. Those which dropped steeply and then levelled and ran through several miles of sloughs usually supported cutthroat. Where both species occurred, cutthroat were most often predominant in the small tributaries and headwaters, and steelhead in the lower reaches of the main stream. Stream pH's were usually lower in winter than in summer, but had no obvious effect on trout distribution. Many cutthroat streams had high T.D.S. readings in the lower reaches in summer and low T.D.S. readings in these areas in winter. Otherwise there were no marked differences between steelhead and cutthroat streams in terms of T.D.S.

CITATION:
Hawthorn, R.S. 1984. Aquatic resource values of the Middle Quinsam area. Water Management Branch, Victoria, B.C. 21 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
This report discusses the results of a survey (conducted by staff of the Water Management Branch in September, 1984) of the aquatic resources in those areas of the Quinsam River System which would be potentially impacted by the proposed Quinsam Coal development. In addition, comments from other sources (Quinsam Coal Ltd., Norecol, Dept. of Fisheries and Oceans, etc.) were examined and summarized for each area surveyed by Water Management Branch (WMB).

The results of the 1984 survey indicate that fish spawning habitat is very limited in the area subject to impact from the proposed coal development. Much of this existing spawning area exists in one particular river section - that portion of the Quinsam River immediately upstream of Middle Quinsam Lake. It is considered imperative that maximum protection be afforded this one particular area and that fish are not deterred from reaching it.

Good rearing habitat exists in several stream and lake sections and does not appear to be limiting hence does not warrant the same protection as the one spawning area.

CITATION:
Hillier, F.A., L. Edgeworth, and A.J. Lynch. 1983. Quinsam Coal Inquiry report. Report to the Minister of Environment on the Quinsam Coal Project public inquiry held at Campbell River, Oct. 12 - Nov. 25, 1983. Ministry of Environment, Lands and Parks, Nanaimo, BC, Quinsam Lake Files. Abstract only

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
The Quinsam River and its watershed are a very sensitive area to potential environmental damage from the operations of the open-pit coal mine. Both the system and its watershed have the characteristics of a virtually undisturbed natural environment. The system also supports a vigorous and valuable fishery, not only in the river system itself, but also in the surrounding salt waters of the Campbell River area. A Federal Government salmonid hatchery is located near the confluence of the Quinsam and Campbell Rivers, about 3 to 4 kilometres from the sea.

The proposed coal mine will be an open-pit operation located 27 kilometres southwest of Campbell River. The expected capacity of the mine is to be some 900,000 M. tonnes of thermal coal per year, with production extending over a fifteen-year period. The coal will be mined from seven or eight open pits immediately east and south of Middle Quinsam Lake and Long Lake, which form part of the Quinsam River system. The coal will be transported over 30.9 kilometres of existing provincial highways and logging roads to Middle Bay, where it will be loaded on to 4,500 M. tonne barges for transshipment to a deepsea British Columbia port.

The serious potential pollutants from the mine-site which could have very harmful effects to the Quinsam River system and the fishery, if not properly controlled, are as follows:

- acid mine drainage and heavy metals which would be toxic to fish life.

-Excessive amounts of suspended solids in the mine effluent which could have deleterious effects on the fish and their spawning grounds.

-Discharge of nutrients (nitrogen and phosphorus) which could cause excessive algal growth in the waters of the Quinsam system, which in turn would be deleterious to water quality and fish production.

The commission has concluded, after studying all of the evidence presented at the hearing, and all of the information available pertinent to the project, that the mine, and its ancillary facilities, can be constructed and operated, with appropriate mitigative measures, so that the impact to the environment, including the fishery, will be small in nature, provided the recommendations of the Commission are followed. There is no doubt, however, that there will be some changes to the ecosystem in the area, but the Commission firmly believes that these changes would be minimal, provided that adequate surveillance of the operations of the mine takes place and immediate corrective action be instigated in the event that a problem develops, unforeseen or otherwise.

CITATION:
Hirst, S.M. 1991. Impacts of the operation of exiting hydroelectric developments on fishery resources in British Columbia. Volume I. Anadromous salmon. Can. Manuscr. Rep. Fish. Aquat. Sci. 2093: 144 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
B.C. Hydro operates 25 dams and diversions on 16 British Columbian rivers which support anadromous salmon. Impacts on salmon vary according to the degree of flow regulation, the operating mode of the plants and the extent of downstream habitats and populations. Most frequently recorded impacts include low flows restricting spawning migrations and mainstem spawning and rearing; high water temperatures in summer; flooding and sedimentation causing loss of eggs, rearing fry and habitats; fluctuating water levels leading to stranding and exposure of fry and eggs; migrating spawners being delayed at powerhouse tailraces or dam spillways; and smolt and fry mortalities occurring during passage through powerhouse turbines. The quantitative and /or economic extent of these impacts has seldom been documented.

Six of the 25 dams or diversions have requirements for flow releases written into the conditional water licences, while agreements on water releases have been negotiated for an additional four. Releases are usually set at or close to the minimum monthly flows and fall far short of that needed for sustained salmon production. There has been little follow-up or monitoring to check on the value of releases. Some regulated rivers have incurred impacts not directly related to hydroelectric regulation, e.g. urban encroachment and/or gravel removal.

Three installations (Seton Creek, Puntledge and Quinsam) have specific water release schedules and/or operational constraints based on studies, observation and trial and error; these have improved conditions for migrating and spawning salmon. Informal agreements on water releases are in effect for an additional seven plants (Coquitlam Alouette, Stave, Wahleach, Shuswap, John Hart and Cheakamus); the benefits of these arrangements to the salmon resources are not yet documented.

Existing knowledge of most regulated salmon-bearing rivers is inadequate to permit an estimation of the amount of improvement to be gained by improving flow conditions. Escapements, spawning success, egg-to-fry survival rates, adult return percentages and other production parameters are affected by multiple factors, many of them far removed from the river system being managed. Accuracy and reliability of escapement counts used to measure the strength of salmon stocks in regulated rivers are often questionable.

CITATION:
Hooton, R.S. 1978. Campbell/Quinsam creel survey report. Fish. Tech. Circ. No. 35. 9 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
To document characteristics of the Campbell/Quinsam winter steelhead fishery, prior to the return of hatchery fish, creel surveys were undertaken in 1975-76 and 1976-77. Results of the 1975-76 program indicated that Campbell River anglers fished an estimated 4,376 days to catch 532 steelhead of which 172 were released. Quinsam River anglers kept 54 steelhead and released 60 in 832 days fished.

Early season catch and effort estimates for both rivers were reduced by some small proportion by the late start in 1975. Late season figures were confused by anglers fishing mainly for trout and by the entry of kelts to the fishery. Inability of survey personnel to contact some Quinsam River anglers, during the early stages of the 1975-76 program, also reduced catch figures.

In 1976-77, anglers fished 3,360 days on Campbell River to land 379 fish, 152 of which they released. Quinsam anglers tallied 725 days and kept 105 of an estimated 174 fish caught. An angler day was 2.0 hours in duration in 1975-76. In 1976-77, Campbell River anglers fished 2.7 hours/trip, while their Quinsam River counterparts averaged 3.4 hours/trip.

Catch and effort data, derived from the Fish and Wildlife Branch annual sampling of steelhead licensees (by mailed questionnaire), contrasted sharply with those of these surveys and others on the Campbell and Dean rivers. Estimates of catch and effort from the questionnaire method were much higher than those from on-stream creel surveys, suggesting the former should be fully evaluated.

CITATION:
Hooton, R.S. and L.B. Carswell. 1981. Steelhead tagging studies on the Campbell and Quinsam Rivers during the 1978-79, 1979-80 and 1980-81 fishing seasons. Fisheries Report No. VI 812. 10 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
The Fish and Wildlife Branch of British Columbia and the Campbell River Chapter of the Steelhead Society cooperated on a steelhead tagging program on the Campbell and Quinsam Rivers during 1978-79, 1979-80 and 1980-81 winter steelhead seasons. During the study, a total of 424 steelhead were marked with coloured and numbered anchor tags. During the 1978-79 season, 37% of the steelhead tagged in November/December and 17% of those tagged in March/April were recaptured by angling. Similarly, in 1979/80 39% of the fish tagged prior to and 19% of those tagged after January 15 were recaptured. This data suggested that steelhead entering the river early in the season reside in the fishing areas longer and may be more vulnerable to angling than late season fish. Due to the probability of tag losses and non-reporting the recapture rates are considered minimum values. Tagged steelhead captures occurred at variable times and distances from the original capture location. Roughly equal numbers of tagged fish were recaptured upstream and downstream from their tagging point. Only 2 of 51 steelhead tagged in the Campbell River above the Quinsam River confluence were recaptured in the Quinsam River. Snorkel survey assessment of the Quinsam River suggested that a relatively few skilled sport anglers could capture and tag a significant portion of the total steelhead returns. It also indicated that migration rates of early and late stocks differ but spawning destination may not.

Recommendations on improving future programs involving the public were discussed.

CITATION:
Hooton, R.S. 1985. A questionnaire survey of Vancouver Island steelhead angler's opinions and preferences on management issues. Fisheries Management Report No. 84. 30 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:

A questionnaire, which was mailed to a systematic sample of every second Vancouver Island steelhead trout angler, was used to evaluate their preferences for fishery management policies. The main objective was to assess angler attitudes toward augmenting steelhead production by stocking hatchery fish, and to develop recommendations for incorporation into a steelhead management plan for Vancouver Island.

A total of 1,693 completed forms out of 3068 (62%) were returned. Most Vancouver Island steelhead anglers had fished for five years or less, fished only during winter months, and failed to catch a steelhead. Years fished, days fished, and catch were highly variable and not correlated. A small proportion of anglers accounted for a large proportion of the steelhead catch. Lists of favourite streams, most fished streams, and streams most preferred for stocking were similar. Anglers belonging to a fishing club or society comprised 17% of the sample and some significant differences were apparent in the behaviour, experiences, and management preferences of club versus non-club anglers. Sixty-one percent of all respondents favoured production of steelhead from hatcheries for Vancouver Island in general and 85% favoured hatchery production for the Campbell/Quinsam river system. The results emphasized the need for the Fisheries Branch to acquaint anglers with all aspects of the hatchery steelhead issue and to publicize the intent of catch and release regulations. Postal contact was the recommended option for reaching anglers. In view of the diversity of respondent experiences and preferences, it was recommended that management units contain fishing options roughly in proportion to user group preferences.

The potential bias associated with estimates of steelhead harvest based on a single mail out survey was also described; the need for accurate estimates identified; and an alternate approach involving follow-up contact and regression procedures suggested. Considering the highly unequal distribution of steelhead catch amongst anglers, it was recommended that experimental regulations limiting the number of steelhead an angler could release be instituted on at least one stream.

CITATION:
Hooton, R.S., B.R. Ward, V.A. Lewynsky, M.G. Lirette, and A.R. Facchin. 1987. Age and growth of steelhead in Vancouver Island populations. Fish. Tech. Circ. No. 77. 39 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
This report summarizes life history characteristics of winter and summer runs of wild and hatchery steelhead (since 1952) based on scale analysis. Where possible, annual growth rates and age structures were summarized for each stream and hatchery. To back-calculate lengths from scale measurements, the natural logarithm of scale radii vs the natural logarithm of body length for fish >45 mm to adult size was used in the Fraser-Lee back-calculation procedure. Separate regression equations were calculated in systems with sufficient data, and for wild and hatchery fish.

Condition factors were highest for wild winter runs, followed by hatchery winter runs, then wild summer runs. Wild winter run fish were mainly 2.2, most wild summer runs were 2.3 and 3.3 at spawning. Winter runs had a higher incidence of repeat spawning. Repeat spawning was higher among females than males.

Mean back-calculated length at smolting for 6 individual river systems ranged from 173 to 185 mm. Mean back-calculated smolt lengths from systems where separate regressions were not available ranged 132 mm (Nimpkish River) to 177 mm (Little Qualicum River).

Back-calculated smolt length increased with freshwater age, and adult length increased with ocean age. Larger smolts tend to have and earlier age-at-return. Back-calculated smolt and ocean age sizes indicated variation in marine growth from 1952 to 1982, mainly evident in the growth from smolting to sea age 1 and from sea age 1 to sea age 2.

Recommendations for aging and back-calculation procedures are included with discussion of limitations to scale analyses.

CITATION:
Horncastle, G.S. and S.E. Hay. 1981. Evaluation of juvenile steelhead scale characteristics from six Vancouver Island streams, 1979-81. Fisheries Report No. VI 811. 32 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Circulus and annulus formation among wild and hatchery steelhead juveniles was studied from six Vancouver Island streams; Big Qualicum River, Quinsam River, Ash River, Robertson Creek, Cooper Creek, and Salmon River. The purpose of this study was to evaluate monthly changes in scale parameters and fork length as a function of temperature 1979-81. Annulus formation occurred between mid-February and mid-May depending on the stream and its geographic location. Juveniles from streams to the north completed annuli later than those from streams to the south. Wild parr and smolts from the study streams averaged 11.0, 11.2, and 8.7 circuli to the first, second, and third annulus, respectively. Scale diameters to each annulus averaged .266 mm, .517 mm and .676 mm, respectively. Circuli formation and scale diameter growth was closely related to increases in fork length and temperature. This was especially evident among hatchery juveniles. Hatchery juveniles from the Big Qualicum River, Quinsam River, and Robertson Creeks averaged 25.0 circuli and had scale diameters of .795 mm shortly before release.

CITATION:
Kangasniemi, B.J. 1989. Campbell River Area: Middle Quinsam Lake sub-basin: water quality assessment and objectives. Water Management Branch, Ministry of Environment, Province of British Columbia. 15 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
This report assesses the water quality of the Middle Quinsam Lake sub-basin within the Campbell River system on Vancouver Island. The sub-basin includes Middle Quinsam Lake, Long Lake and a portion of the Quinsam River. An open pit coal mine eventually producing 910 000 tonnes of thermal coal per year is being developed in this sub-basin. Provisional water quality objectives have been set to ensure protection of existing and future water uses.

The lakes, streams and river are valuable habitat for wild trout and hatchery-raised salmon. A public inquiry into the potential impact of the coal mine concluded that the project can proceed if certain environmental safeguards are met. Present water quality is characterized by very low levels of dissolved and particulate matter and a low pH-buffering capacity.

The coal mine represents the only major source of waste loading to the sub-basin. A system of settling ponds incorporating flocculation treatment will capture all surface water draining the mine site. Waste water from the coal preparation plant will be recycled. The potential for acid mine drainage exists; a program of material testing and handling is expected to prevent its occurrence. The close proximity of valuable fish habitat and salmon migration corridors to the proposed effluent discharge sites may require further study.

CITATION:
Korman, J., B. Bravender, and C.D. Levings. 1997. Utilization of the Campbell River estuary by juvenile chinook salmon (*Oncorhynchus tshawytscha*) in 1994. Can. Tech. Rep. Fish. Aquat. Sci. 2169: 45 p.

ABSTRACT SOURCE:
Abstract by author

ABSTRACT:
Juvenile salmon population growth and abundance data collected in the Campbell River estuary in 1994 were analysed to describe chinook habitat use, residency timing, growth, and potential competitive interactions between wild chinook fry, hatchery chinook, and other salmon species. Wild chinook fry densities were highest in estuarine zone sites while hatchery chinook densities were generally higher than wild densities in transition zone sites. Habitat type significantly affected density of wild chinook in the estuary where their densities were greatest at riparian and intertidal island sites. Hatchery and wild chinook juveniles showed different patterns in their seaward emigration timing. The timing of peak abundance of hatchery chinook in the estuary coincided with the peak abundance of wild fry; this was considered a likely period of strong competitive interaction between hatchery and wild chinook salmon. Wild and hatchery chinook juveniles were generally larger at transition zone sites compared to those from the estuarine zone. Growth rates of wild chinook tended to be slightly higher than growth rates from hatchery chinook. The inverse relationship between wild chinook fry size and total salmon biomass, assessed in mid-May, was similar to that established with earlier data, supporting the conclusion that growth of wild chinook in the Campbell River estuary may be density dependent. Close to half the estuarine habitat of the estuary has been degraded due to industrial development since the early 1900s. Recovery of degraded estuarine habitat would improve rearing conditions for wild chinook fry. These measures should be integrated with freshwater habitat improvement.

CITATION:
Kotyk, M.S., C.D. Levings, T.J. Brown, C.D. McAllister, J.S. Macdonald, J.R. McBride, and U.H.M. Fagerlund. 1985. An account of an experimental release of marked juvenile chinook to freshwater, estuarine, and marine habitats near Campbell River, B.C., 1984. Can. Tech. Rep. Fish. Aquat. Sci. 1397: 31 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Smolt to adult survivorship of juvenile chinook salmon was tested by releasing hatchery reared fish into four contrasting (river, estuarine, transition, and marine) habitats. Transport of 142,000 marked chinook smolts (3 g) by helicopter from the Quinsam River Hatchery to the four release sites near Campbell River was performed. The transport did not unduly aggravate the state of stress already induced during holding in painted troughs after marking. The furthest site, Deepwater Bay, was about 10 minutes flying time from the hatchery, but air time for the other three treatments was equalized to balance the experiment. At Deepwater Bay (marine release) fish were released directly into sea water. Short term high cortisol levels were noted in fish released at the marine and estuarine sites. Nevertheless, there was no evidence of immediate direct mortality due to stress or osmoregulatory shock. SCUBA observations showed that the fish schooled and aggregated near surfaces and suggested that behaviour was normal. However the marine release fish were exposed to more bird and fish predation. Feeding may have been re-initiated more slowly at the marine site and transition sites compared to estuarine locations. However the forage ratio at the marine site surpassed all other locations after a three week period. Mortality of cage-held chinook was very low at all sites (<1%). Seawater challenge tests indicated that the chinook were smolted and "ready for sea". Beach seine data obtained up to 10 weeks after the releases showed that the marine fish did not disperse into the Campbell River estuary or transition zones and were not found after one week following the release. Recaptures of chinook from the other releases also suggest rapid and wide dispersal.

CITATION:

Lashmar, M.A. 1979. Memorandum: Electrofishing and gillnet sampling data on the Quinsam River drainage by International Environmental Consultants Ltd. BC Fish and Wildlife Branch, Ministry of Environment, Lands and Parks, Nanaimo, BC, V9R 5C8, Quinsam River File. 20 p.

ABSTRACT SOURCE:

Abstract from reference

ABSTRACT:

The June field survey included electrofishing at four locations on the Quinsam River and gillnetting on the Middle Quinsam (two sets) and Long Lakes (three sets). The September survey included only gillnetting–two sets on Middle Quinsam Lake and one set on Long and "No Name" Lakes.

Electrofishing was carried out (using a Coffelt portable electroshocker) by walking upstream and collecting stunned specimens with dip nets.

All juveniles captured were retained in formaldehyde for later identification, weighing and measurement of fork length.

Each experimental gillnet was composed of several gang of varying mesh size. Nets were normally set late afternoon or evening with the bottom line weighted and a float line buoyed so to position the net along the lake bottom. They were retrieved the following day. All fish captured were identified to species, weighed and their fork length measured. Surviving individuals were tagged and released immediately. For the remaining specimens gonads were examined for sexing and scales collected for age determination. Selected gut samples were retained for gut analysis and several fish were preserved for reference purposes. The remainder were discarded.

CITATION:
Lawseth, D.W. ~1979 (draft). A bio-physical survey of the Quinsam River. Obtained from Jim Van Tine's files, Quinsam Hatchery: 39 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
The Quinsam River bio-physical survey was undertaken in 1977 to gather data pertinent to rearing potential, spawning area, bottom and bank composition, and stream characteristics for salmonid stock management of the system. Observations to migrant salmonids were assessed and are discussed on the basis of problems and future improvements. Enhancement techniques to realize full production potentials are recommended.

The study are covered 48.5 km (including 3.5 km of the Iron River) of the Quinsam River from the B.C. Hydro Diversion Dam to the Quinsam River/Campbell River confluence.

There are two migration obstructions to adult salmonids within the study area, in the form of cascades/falls. Rearing potential above these obstructions exists for about 35,000 coho smolts. To achieve this production the obstructions would be eliminated, or salmonids would be transported above them as either adults or juveniles.

An intensive water quality monitoring program is recommended to commence immediately to establish background characteristics before the anticipated coal min venture in the heart of the Quinsam River watershed begins (scheduled for mid-1981).

CITATION:
Lewis, B. 1996 BC Environment, Region 1, Vancouver Island, Watershed restoration priority list for Fisheries values, February, 1996. Ministry of Environment, Lands and Parks Files, Nanaimo, B.C. 22 p.

ABSTRACT SOURCE:
Abstract by author

ABSTRACT:
To ensure the restoration proposals received by the Ministry of Environment, Lands and Parks covered areas of high value a priority list became necessary. The priority list covers pertinent information such as: Fisheries management values, level of angling use, presence of unique species, decrease from previous population levels, risk of population extinctions, presence of enhancement activities, presence of a designated fishing corridor, and indication of past research in the watershed.

CITATION:
Lindsay, D.J. 1987. Water quality changes within the Quinsam watershed following forest fertilization. British Columbia Forest Products Ltd., Resource Planning Group, Crofton, B.C. 35 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
In recent years, intensive forest practices such as spacing and forest fertilization have become more common. Lake fertilization has also become an extremely successful area of the Salmonid Enhancement Project (Hyatt and Stockner, 1985), and research studies have indicated that stream fertilization is very promising (Perrin et al. 1987). However, government fisheries agencies are still apprehensive about aerial fertilization of urea over forests that have the potential to drain into or leach into fish habitat. Fertilizer-free zones of 10 m to 30 m are required adjacent to major watercourses to prevent direct overspray of urea into streams (McDougall 1986, pers. comm.).

Although data concerning nitrogen and phosphorus levels in the Quinsam River are known, the potential of added nitrogen from the surrounding forested land created concern from government fisheries agencies. To alleviate these concerns and for added water quality information, British Columbia Forest Products Limited initiated a water quality sampling program. It was designed to assess concentrations of nitrogen and phosphorus in the affected watercourses before, during, and after aerial fertilization of urea.

CITATION:
Lirette, M.G., R.S. Hooton, and W.R. Olmsted. 1985. A summary of wild steelhead smolt enumeration and habitat productivity studies at Quinsam River, 1976-1984. Fish. Tech. Circ. No. 67. 17 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Emigrant steelhead parr and smolts were enumerated at the Quinsam River counting fence by the Ministry of Environment and the Department of Fisheries and Oceans from 1976 to 1984. Total emigration during each of these years was calculated by mark/recapture. Age, length and weight data were collected from subsamples. Estimated mean number of steelhead parr and smolts emigrating from the Quinsam River were 14,446 and 6,975, respectively during the years of trapping. Smolt age 2. and 3. comprised the majority of the sample, and age 2. was numerically dominant. Estimated smolt numbers were compared with the yield predicted by the Ministry's production model developed for Keogh River. This model overestimated Quinsam River smolt production by approximately 75 percent. Smolt yield resulting from outplanting above impassable barriers was slightly over 2 percent and represented minimal steelhead production. Factors which affected estimated parr and smolt production, and management implications are discussed.

CITATION:
Lirette, M.G., R.S. Hooton, and V.A. Lewynsky. 1987. Preliminary steelhead production capability estimates for selected Vancouver Island streams. Fish. Tech. Circ. No. 74. 23 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Steelhead smolt production capabilities were estimated for 17 Vancouver Island watersheds using two preliminary yield models developed from research conducted on Keogh River (Slaney MS 1981). Habitat measurements for the refined model were obtained from low elevation aerial photographs. Cost and benefits of Aerial photographs relative to conventional ground surveys are discussed.

The two models predicted average smolt yields of 0.021 and 0.023 smolts per metre squared for Vancouver Island streams. Steelhead survival rates, derived from the Keogh River (Ward and Slaney MS 1984), were applied to the smolt yield prediction to estimate average run size and escapement requirements for each stream.

The accuracy of model predictions could not be determined in the absence of empirical measurements of smolt yield from a variety of streams. A general comparison was made, however, between predicted run size and angler catch (Steelhead Harvest Analysis 1971-1996). These comparisons suggested that some streams including Little Qualicum, Gold, Cowichan, Englishman, Big Qualicum and Campbell rivers were near carrying capacity, while other streams including Tsolum, White, Chemainus, Sooke, Koksilah and Nimpkish rivers appeared to have severely depressed steelhead populations.

Recommendations on model improvements and management are presented.

CITATION:
Lirette, M.G. and R.S. Hooton. 1988. Coded-wire tag recoveries from Vancouver Island sport caught steelhead, 1982-1986. Fisheries Management Report No. 92. 20 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Hatchery reared steelhead trout (*Salmo gairdneri*) released into various streams on Vancouver Island between 1979 and 1983 were adipose fin clipped and coded-wire tagged (C.W.T.). Sport anglers, who harvested the returning adult steelhead, were encouraged to submit the fish's head to depots located throughout the Island.

Between 1982/83 and 1985/86 steelhead anglers harvested a portion (23%) of the hatchery steelhead they caught and voluntarily returned heads from 13% of the fish they killed. A total of 1660 heads were recovered from 17 watersheds on Vancouver Island. The heads represented 0.11% of the total coded-wire tags released. Depending on the stream stocked, each adult C.W.T. recovered represented 40 to 200 dollars in tagging costs.

Significant numbers of marked steelhead were caught in streams other than where they were released as juveniles. For six study watersheds, the straying rate averaged 9.6% and ranged 4.3% for streams where incubation and rearing was on-site to 32.7% for smolts outplanted to a receiving stream. Depending on the recovery stream, stray steelhead (non-indigenous) made up varying proportions (0-44%) of the total hatchery returns. Coded-wire tagged steelhead were recovered from eight unstocked watersheds.

Fisheries management implications of hatchery steelhead production and assessment are discussed.

CITATION:
Lirette, M.G. 1989. Monitoring of tagged hatchery summer steelhead in Campbell River, 1988-89. Ministry of Environment, Lands and Parks, Nanaimo, B.C., Fisheries Report No. VI 892. 27 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
The Ministry of Environment, Lands and Parks and the Campbell River Chapter of the B.C. Steelhead Society cooperated in a steelhead (*Oncorhynchus mykiss*) tagging program on the Campbell River during 1988 and 1989. A total of 138 adult summer steelhead, stocked as smolts into the Campbell River, were anchor tagged between June 6 and November 6, 1988. Fourteen of these fish were tagged with radio transmitters. Thirty-five of the marked steelhead (25%) were reported recaptured by anglers. Recapture rates varied from 0 to 43% depending on the month of tagging. Recapture occurred from the same day to 280 days after tagging. Forty percent of the recaptures occurred in the Quinsam River, a tributary to the Campbell River. During August, 70% of the radio-tagged steelhead occupied the furthest accessible upstream pool (5.3 km). In September and October, a majority (70%) of the radio-tagged steelhead moved downstream where two disappeared, eight became stationary, two were killed by anglers, and two were followed through spawning and emigration. Three radio-tagged steelhead entered the lower Quinsam River in November and December, and this represented more than half of the tagged fish still active during this period.

Recommendations on future steelhead management for the Campbell River are discussed.

CITATION:
Lough, M.J., S.E. Hay, and R.B. Rollins. 1993. Campbell River aquatic study: diversion drainages and lower Campbell River. B.C. Hydro, 6911 Southpoint Drive, Floor 16, Burnaby, B.C. 97 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
The purpose of this study is to review existing fisheries information and to document issues regarding the fisheries resource for the Heber, Quinsam, Salmon and Lower Campbell rivers. A chronology of human impacts in these systems indicate similar patterns of early logging/mining activities followed by hydroelectric generation developments, then increased exploitation of the fishery by expanding commercial and sport fisheries.

Water licenses for the hydro projects were issued in the 1940's and 1950's, and in most cases no provisions for fishery concerns, due partly to the lack of baseline fisheries information. Formal minimum flow agreements were eventually appended to the water licenses during the 1960's for all diversion systems except the lower Campbell River (where an informal agreement now exists).

Stocks in the Campbell and Salmon River (especially chinook and chum) are still below historic levels. Reasons cited for this are overfishing, construction/operational impacts from B.C. Hydro facilities, and habitat degradation resulting from poor logging practices. Salmon and steelhead stocks in the Quinsam and Heber rivers are presently rebuilding from depressed levels in the 1960's and 1970's. Quinsam stock increases are being accomplished mainly through hatchery production.

In the Heber, Quinsam, and Salmon Rivers, production capability is limited by a combination of reduced rearing habitat for juveniles during low summer flows and the inherently low nutrient levels which are typical of Vancouver Island streams.

Significant operational impacts of B.C. Hydro upon the fisheries resource have included the loss of suitable rearing and spawning habitat caused by extreme flow variations (Campbell River), and the loss of up to 95% of steelhead and coho production from juvenile rearing areas upstream of diversion (Salmon River). In the Salmon River, and smolt screen, fishway, colonization program and stream fertilization are rectifying the situation now.

Prior to minimum flow requirements being appended to the water licenses, critical low summer flows were often diverted for power generation, which at times completely dewatered the stream below the diversion. A review of more recent flow information indicates that in most cases, there are no diversions during late summer, and the license requirements are being met.

A key issue common to all systems except the Campbell River, is whether the 30 year old minimum flow recommendations correctly reflect the requirements for fish production.

Future management options include low flow studies to ensure required flows are adequate, a stream fertilization program to address low nutrient levels, beneficial use of headwater storage, and continued operation of smolt screens to prevent losses into the reservoirs of the Campbell system.

CITATION:
Lukyn, B.C., D. Ewart, G.J. Blackmun, and W.E. McLean. 1985. Quinsam watershed study: first addendum (Jan. - Aug., 1984). Can. Data Rep. Fish. Aquat. Sci. 523: 34 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
This data record is the first addendum to the Quinsam Watershed Study: 1983 (Blackmun et al., 1985). It provides observations concerning winter ice cover as well as smolt enumeration, water flow rate and water quality data for the Quinsam Watershed over the period January - August, 1984.

An enumeration program at the hatchery counting fence allowed assessment of the downstream migration of colonized and wild coho smolts. Of the coho transplanted to areas upstream of the hatchery in September of 1983, an estimated 14.0% migrated downstream in the spring of 1984.

Low water flow rates were encountered during the summer. Measurements taken during this period resulted in improvements to the preliminary discharge curves established in the 1983 study.

Water quality parameters including suspended solids, dissolved oxygen, pH, turbidity and metals were also monitored over this time period.

CITATION:
Lukyn, B.C., W.E. McLean, G.J. Blackmun, and D. Ewart. 1985. Quinsam watershed study: second addendum (Sept. - Dec., 1984). Can. Data Rep. Fish. Aquat. Sci. 524: 47 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
This data record forms the second addendum to the Quinsam Watershed Study: 1983 (Blackmun et al., 1985) and covers the September - December, 1984 period. During this time, storm events produced high levels of turbidity and non-filterable residue in the lower watershed, while the upper watershed showed little change.

Additional water flow measurements resulted in further improvements to the discharge curves. These "final" relationships, which incorporate all staff gauge and flow records collected since the beginning of the study, were used to recalculate water flow rates at each gauge site. Previously reported flow information is now superseded by these new values.

The coho colonization program, which involves the transplant of fingerlings from the hatchery to upstream areas, continued. In September of 1984, 101,302 marked coho fingerlings (CWT and adipose clip) were transported by helicopter to the upper watershed.

CITATION:
MacIsaac, E.A., and J.G. Stockner. 1985. Current trophic state and potential impacts of coal mine development on productivity of Middle Quinsam and Long lakes. Can. Tech. Rep. Fish. Aquat. Sci. 1381: 63 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Middle Quinsam and Long lakes are typical examples of the small oligotrophic lakes common to the coast of British Columbia. They share the common features of high rates of winter flushing, high water transparencies, very low concentrations of nitrogen and phosphorus, and low levels of pelagic productivity. Long Lake supports a 20 to 40% higher level of pelagic productivity than Middle Quinsam Lake, but a shallower morphometry and deeper light penetration suggest a higher level of benthic productivity in Middle Quinsam Lake. Long Lake experiences significant hypolimnetic oxygen depletion (0.8 mg O_2*L^{-1}*mo^{-1}) during its growing season, but the current light climate of Middle Quinsam Lake permits hypolimnetic photosynthesis to maintain high oxygen levels in the hypolimnion. Inorganic nitrogen is depleted to detection limits for most of the growing season in both lakes. Based on nutrient bioassays and a comparison of summer chlorophyll:phosphorus yields, Middle Quinsam and Long lakes are slightly and moderately nitrogen-limited, respectively, during their growing seasons.

Middle Quinsam Lake is expected to respond to high-nitrogen loadings from future coal mine development with a 20 to 50% increase in algal production. This small increase in productivity may be beneficial to its salmonid production if current levels of phosphorus and water clarity are maintained. A doubling of algal productivity in Long Lake is predicted in response to nitrogen-rich discharges from mine operation. This level of productivity is sufficient to put Long Lake at significant risk of serious hypolimnetic oxygen depletion with attendant impacts on salmonids and their supporting food webs.

CITATION:
McAllister, C.D., and T.J. Brown. 1991. Effects of hatchery production on wild chinook fry (*Oncorhynchus tshawytscha*) in the Campbell River estuary, British Columbia. Department of Fisheries and Oceans, Biological Sciences Branch, Pacific Biological Station, Nanaimo, B.C. 33 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
The estuary of the Campbell River, on the east coast of Vancouver Island, British Columbia, is an important rearing area for fry of wild chinook salmon, and also receives smolts of chinook and coho salmon produced by the Quinsam Hatchery. Wild chinook fry are numerically dominant in the estuary, but biomass is dominated by hatchery and coho smolts originating from the hatchery. Size and growth residuals of the wild chinook fry in the estuary varied significantly during the years 1982-86. Mean yearly growth residuals were negatively correlated with total biomass of young salmon in the estuary, suggesting limited rearing capacity. Some evidence suggests that the density dependent effects on size may be reflected in subsequent survival. The coupling between biomass and growth was very tight, and also occurred within seasons. Dispersal of wild chinook fry within the estuary increased, and residence time decreased with increases in biomass. Limited evidence suggests that the density dependent effects on growth and size of wild chinook fry may have decreased after 1986, due to effects of habitat reclamation.

CITATION:
McHugh, J. 1933. Memo for Chief Supervisor Re. Falls, Quinsam River (November 18, 1933). DFO file 31-3-Q (obtained from Jim Van Tine's files, Quinsam Hatchery): 3 p.

ABSTRACT SOURCE:
Abstract by author

ABSTRACT:
This memo details the results of several inspections of the falls and cascades that occur in the one mile of river below Lower Quinsam Lake by the local DFO engineer. Within this section of stream, 2 locations stood out pre-eminently as places of difficult fish passage. The first was near the foot of the one mile cascades section, where a 12 ft falls was noted. Cost of building a fishway to bypass this falls was estimated at $1,430. The second location of difficult passage, is the series of falls immediately below the lake outlet, where there is a drop of approximately 28 feet in 400 feet of stream. Four falls were identified within this stretch, each about 5 feet in height. Construction of a fishway to surmount this 400 feet of river was estimated at $4,537. The author requested further opportunity to survey the falls in order to determine whether or not salmon successfully ascended the falls.

CITATION:
McHugh, J. 1938. Precis of Quinsam River File 31-3-Q (January 14, 1938). DFO file 31-3-Q (obtained from Jim Van Tine's files, Quinsam Hatchery): 3 p.

ABSTRACT SOURCE:
Abstract by author

ABSTRACT:
This document provides a chronological summary of activities and communications from April 5, 1933 to November 13, 1934 pertaining to the series of falls below Lower Quinsam Lake. The DFO supervisor of the time ("Supervisor Tait") decided not to go ahead with construction of fishways at the 2 main areas of difficult passage. The explanation given by the supervisor was as follows:

> The spawning areas available above the falls are not of sufficient extent to warrant any large expenditure for the purpose of making these areas available to salmon frequenting the Quinsam River. The first Quinsam lake which is immediately above the fall contains very little beach area suitable for spawning. however, I would advise that from 3 to 4 miles of gravel stream beds could be made available in the upper Quinsam River draining into the lake and in Iron River which is a tributary of the upper Quinsam. A short distance above the confluence both of these streams are obstructed by the continuation of falls and the upper reaches, including the middle and upper Quinsam lakes can not possibly be developed as spawning areas on account of the rapid rise of the land. .... Following the sinuosities of the stream the length of spawning area now available in Quinsam River below the falls is at least 14 miles and I consider this quite sufficient for the quantities of salmon which frequent it.

CITATION:
Morley, R.B., H.T. Bilton, A.S. Coburn, D. Brouwer, J. Van Tyne, and W.C. Clarke. 1988. The influence of time and size at release of juvenile coho salmon (*Oncorhynchus kisutch*) on returns at maturity: Results of studies on three brood years at Quinsam Hatchery, B.C. Can. Tech. Rep. Fish. Aquat. Sci. 1620: 120 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Juvenile one year old coho salmon (*Oncorhynchus kisutch*) were released from Quinsam hatchery on April 20, May 10, May 30, and June 19 in both 1980 and 1981 and on May 30, 1983; fish of each release were graded to three size categories and coded wire tagged. The resulting returns to the catch and escapement were examined for influences of time of release and size of juveniles at release. While there were differences in total survival among studies (i.e. brood years) the relative differences associated with time and size at release were quite consistent within studies. Time of release strongly influenced survival. Response surface analysis indicated maximum adult returns from juveniles released on June 5; returns increased gradually until this date and then decreased sharply. The effect of juvenile size on adult returns was minor, with slightly higher returns from smaller juveniles indicated, especially for early releases. The incidence of jacks increased with earlier release and was strongly affected by juvenile size, the incidence being higher for larger juveniles; the size-associated differences observed in the adult returns appear to have been largely attributable to these differences in the incidence of jacks and their effect on production of adults. Maximum biomass was indicated for releases made 3-5 days in advance of the date for maximum adult returns, reflecting the larger size of adults from earlier releases. Geographic and gear type distribution in the adult fishery was quite consistent between years; the most notable feature was the increasing proportion of the catch taken in the southern area sport fishery associated with later releases. Seawater challenge tests indicated that differences in return rate among the four release dates did not result from changes in seawater adaptability of the smolts, which was at its optimum about seven weeks in advance of the optimum release date; rearing at lower temperatures to delay smolting is suggested as a possible means of further increasing survival.

CITATION:
Morley, R.B., A.Y. Fedorenko, H.T. Bilton, and S.J. Lehmann. 1996. The effects of time and size at release on returns at maturity of chinook salmon from Quinsam River Hatchery, B.C., 1982 and 1983 releases. Can. Tech. Rep. Fish. Aquat. Sci. 2105: 88 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Juvenile chinook were released from the Quinsam River Hatchery on Vancouver Island on four different dates (May 5, May 26, June 16 and July 7) in both 1982 and 1983. Fish from each release group were graded into small, medium and large size categories, and each group differentially coded-wire tagged. Returns to catch and escapement were examined for the effects of time and size at release on survival, growth, age at maturity and catch distribution.

The study showed the highest survivals resulted from earlier (May) releases of larger (6-10 g) juveniles. Compared to later releases, May releases also showed the strongest release size effects, with larger juveniles returning at higher rates. (These survival trends may well be specific to the 1982 and 1983 releases of Quinsam hatchery chinook, reflecting the genetic make-up of these broods, as well as the freshwater, estuarial and marine conditions). Effects of release time and size were generally minor on the adult age and size composition in the escapement. These effects were also minor on the marine catch distribution. Of the total catch of Quinsam chinook, over 80% were taken in Alaska and North-Central B.C. waters.

CITATION:
Munro, K.A., S.C. Samis, and M.D. Nassichuk. 1985. The effects of hatchery effluents on water chemistry, periphyton and benthic invertebrates of selected British Columbia streams. Can. Manuscr. Rep. Fish. Aquat. Sci. 1830: xvii + 203 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
The effects of effluents from selected British Columbia salmon hatcheries on receiving water quality, periphyton, and benthic invertebrates were studied from 1978 to 1981. Elevated concentrations of total phosphate and ammonia were recorded in streams downstream of effluent discharges. Higher periphyton chlorophyll a and organic weight accumulations on artificial and natural substrates and greater abundance of benthic invertebrates were found in streams immediately downstream of effluent discharges and reflected nutrient enrichment rather than degradation of habitats in most streams.

Species composition of the periphyton differed in areas upstream and downstream of hatchery discharges. The green algae *Ulothrix zonata* and *U. tenuissima* were abundant in most streams, particularly immediately downstream of the discharges. The diatom *Achanthes minutissima* was predominant in most streams. However, diatoms more typical of nutrient-rich conditions, such as *Nitzschia palea*, *Ni.* cf. *fonticola*, and *Navicula pelliculosa*, were abundant in downstream areas. Chironomidae (Diptera) were the most abundant benthic invertebrates in most streams, and, along with Naididae (Oligochaeta) in some streams, were more abundant downstream of effluent discharges than upstream.

The response of benthic communities to hatchery discharges was affected by the size of the hatchery and the quantity of phosphate and ammonia in the effluent. The levels of nutrients, periphyton, and benthic invertebrates present upstream of the hatchery discharges also influence the response of the benthos to effluent discharges. The streams with the highest natural productivity responded most strongly to effluent addition.

CITATION:
Nagtegaal, D.A., B. Riddell, S. Lehman, D. Ewart, and B. Adkins. 2000. Assessment of Campbell/Quinsam chinook salmon (Oncorhynchus tshawytscha). Canadian Stock assessment Secretariat, Research Document 2000/151. 64 p.

ABSTRACT SOURCE:
Abstract from reference.

ABSTRACT:
The development and assessment of effective management strategies for the rebuilding of chinook salmon stocks to historical levels requires accurate estimates of escapement as well as estimates of the relative contribution of hatchery and natural production to that escapement. In 1984, various "key streams" were chosen including the Campbell/Quinsam River system. The key stream program was designed as a means of monitoring escapements parameters in specific spawning areas and initiated in response to objectives set out in the Canada-U.S. Pacific Salmon Treaty. The goal for these selected streams was to use the escapement and exploitation information from these stocks as an indicator of harvest and exploitation rates for neighbouring stocks. The Quinsam/Campbell was chosen to represent Upper Georgia Strait/Johnstone Strait chinook.

Interim escapement goals for British Columbia chinook stocks were established by the Chinook Technical Committee (Pacific Salmon Commission 1986). Goals for natural and enhanced stocks were double the 1979-82 base period or, for key streams, double the 1984 escapement. The interim escapement goal for the Quinsam/Campbell was set at 5,970. Since 1989, chinook returns to the Campbell/Quinsam system initially continued to decline but in recent years have rebounded., However, the escapement goal has only been reached once (1999), even with substantial enhancement efforts.

The Campbell River was historically one of the most important producers of chinook in the Strait of Georgia. Three over-riding key aspects were identified to have contributed to the decline of the Campbell River chinook stock. Hydroelectric development and associated construction of dams and water diversion are suggested to have significantly contributed to the decline of salmon stocks. Major changes in river discharge and flow regimes are known to have considerable detrimental effects to both the adult and juvenile life stages. Secondly, the estuary has been used extensively by industry and for urban development which has also been documented to have had a considerable impact on the rearing capacity for juveniles. And finally, high exploitation of this stock in previous years at non-sustainable levels has obviously been detrimental to the natural chinook stock in the Campbell River.

Reduction in exploitation by approximately 50% since the late 70's and up to 500% improvement in marine survival in recent years should contribute substantially to the rebuilding process. In 1999 there were double the number of natural spawners in the Campbell River compared to the previous 5 years.

CITATION:
Narver, D.W. and F.C. Withler. 1971. Age and size of steelhead trout (Salmo gairdneri) in anglers' catches from Vancouver Island, British Columbia, streams. Fisheries Research Board of Canada, Biological Station, Nanaimo, B.C., Circular No. 91. 26 p.

ABSTRACT SOURCE:
Abstract from reference.

ABSTRACT:
In recent years Vancouver Island steelhead fishermen have become more and more uneasy about the future of their sport. They have noted a steadily increasing fishing pressure each year arising from greater numbers of local people taking up steelheading and from an increase of fishermen from elsewhere. At the same time, Vancouver Island's rapidly increasing population requires that more and more water be diverted to industrial and domestic use while it provides more opportunities for pollution of the watersheds either intentionally or accidentally. Thus steelhead fishermen find themselves in a box which shrinks from both ends – as their own numbers increase, the amount of good quality fresh water necessary to produce steelhead contracts.

Under these conditions, it is inevitable that artificial means of sustaining or increasing the steelhead populations will have to be provided. What these aids will be is uncertain. There are advocates for a variety: hatcheries, controlled flow, spawning channels, transplants, feeding areas for the young, and so on. Until we know more about the fish itself and its habits the best choice of artificial aid or combination of them will be uncertain.

With the belief that a better understanding of the steelhead and its needs is required, in the winter of 1969-70 the Fish Committee of the Nanaimo Fish and Game Club initiated a study of steelhead taken by anglers on Vancouver Island streams. Anglers were asked to submit information about the fish they caught along with scale samples for age interpretation. The information was tabulated and analysed by members of the Nanaimo Fish and Game Club. The purposes of this report are to provide the fishermen who participated in the program a summary of the information they submitted about their catches and to put on record further information about Vancouver Island steelhead.

CITATION:
Norecol Environmental Consultants. September 1993. Quinsam Coal project, fisheries studies - progress data report. Quinsam Coal Limited, Vancouver, B.C.: Cover letter (5 p) + Appendices 1 through 8 (70 p) + 2 maps.

ABSTRACT SOURCE:
Abstract by author

ABSTRACT:
This report provides a description of field/analysis methods (cover letter) and results (appendices) for fisheries work conducted on the Quinsam River during 1983 for the Quinsam Coal Project. The following are the titles of the 8 data Appendices included in this document:

1. Aquatic biophysical data collected in the Quinsam River drainage by Norecol Environmental Consultants Ltd.
2. Aquatic biophysical reach descriptions of study area drainages
3. Fish data, collected in the Quinsam River drainage and Gooseneck Lake June 29 - July 9, 1983
4. Length frequency distribution and length-weight relationships of fish collected in the Quinsam River drainage June 28 - July 9, 1983
5. Physical stream inventory data collected in the Quinsam River drainage, July 6-7, 1983
6. Fish population data collected at inventory sites in the Quinsam River drainage July 2 - 5, 1983
7. Cutthroat trout tagged by Norecol Environmental Consultants Ltd. in the Quinsam River drainage and Gooseneck Lake June 29 - July 8, 1983
8. Summary of fish data collected by Norecol Environmental Consultants Ltd. in the Quinsam River drainage and Gooseneck Lake June 28 - July 9, 1983

Maps provided with this report included:

1. Aquatic biophysical data for the Quinsam River study area
2. Norecol fish sampling sites

CITATION:
Oliver, G. 1975. No title. Contains stream inventory results for Quinsam River from Lower Quinsam Lake to the fish hatchery. Obtained from Jim Van Tine's files, Quinsam Hatchery, Campbell River, B.C.: 14 p + 2 maps

ABSTRACT SOURCE:
Abstract by author

ABSTRACT:
This document presents results of a stream inventory conducted on the Quinsam River on August 12 and 13, 1975. The survey was conducted from Lower Quinsam Lake to the Quinsam River Hatchery. This portion of the river was subdivided into 3 reaches and results were summarized by reach. The upper 2 reaches were surveyed by walking while the lower reach was surveyed by snorkelling. Features reported include general description, overall productivity, gradient, substrate, stream channel type, flow pattern, pool/run/riffle ratio, obstructions, stream cover, fish/aquatic plant/invertebrate observations, general vegetation types, land use, and recreation potential.

CITATION:
Parkinson, E.A. 1984. Genetic variation in populations of steelhead trout (*Salmo gairdneri*) in British Columbia. Can. J. Fish. Aquat. Sci. 41: 1412-1420.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
The geographic distributions of biochemical genetic variants at four loci in indigenous British Columbia steelhead (*Salmo gairdneri*) populations indicated that there was a large-scale subdivision of the species into three major groups. At intermediate geographic scales, gene frequencies were uniform over unexpectedly large areas, but at the smallest geographic scale, significant differentiation was observed between populations in adjacent streams. This pattern of variation supports the view that this species is subdivided into a large number of semi-isolated populations each having the potential to evolve adaptations to local environmental conditions.

CITATION:
Pommen, L.W., and R.N. Nordin. 1984. Memorandum: Quinsam Coal Project - nutrients/algal growth. Water Management Branch, Ministry of Environment, Province of British Columbia, File WQU 64.04030301. 11 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Appendix I contains the predicted phosphorus increases in the Quinsam system due to sewage disposal, fertilizer from reclamation, and groundwater/surface water from the pits and waste dumps. In summary, we predict that winter P concentrations in the Quinsam system will increase by 3 to 8 or 9 Fg/L, and that summer P concentrations will increase by 2 or 3 to 8 or 10 Fg/L in Middle Quinsam Lake and the Quinsam River, and by 10 to 23 Fg/L in Long Lake and its outlet stream.

Appendix II contains the predicted increases in algal growth that could result from the predicted phosphorus (and nitrogen) increases. In summary, we predict that at the lower end of the range of P increases mentioned above, algal biomass would increase three to four fold in Middle Quinsam Lake, and approach the 5 Fg/L chlorophyll a concentration representative of eutrophy. Long Lake is a more serious problem, and the lake would become clearly eutrophic, and the water quality would be substantially degraded. The outlet stream from Long Lake would be in considerable danger of being subject to very heavy algal growth, beyond the level that would be acceptable (i.e., the 10 Fg/L criterion proposed by Chris Perrin). However, there do exist mitigation measures which could prevent this unacceptable level of algal growth, particularly the proposed forest spray irrigation technique.

CITATION:
Quinsam Coal Ltd. 1980. Quinsam Coal Project. Volume III - biophysical inventory. Stage II Submission. 322 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Quinsam Coal Ltd. proposes to develop a thermal coal mine in the Middle Quinsam Lake area, 27 km (17 mi.) inland from Campbell River on Vancouver Island (see Figure 1). The coal will be transported to the Middle Bay area, where it will be loaded onto barges and shipped to a major coal terminal in Vancouver. Mining will be based on surface coal mining techniques. Construction is planned to commence in 1982 and last approximately 2 years. Total capital cost of the project is estimated at $58 million, while annual operating costs will exceed $14 million (1979 dollars).

The development of this mining operation will also include a water management system so that the water quality of the Quinsam River watershed can be maintained. The system will consist of: a portable water pump house and supply line from the Quinsam River; the use of Middle Quinsam Lake as a reservoir for process and fire water supply; a sewage plant; and a series of ditches, impoundments and treatment stations to maintain the quality of run-off waters from the mine site. Surface run-off will be either diverted away from the proposed open pits, or collected with mine drainage pumped from the pits for conveyance to the project treatment stations.

CITATION:
Redenbach, A. 1989. Quinsam Coal Development: A monitoring report on the effluent and receiving environment: 1988/1989. Environment Canada, Conservation and Protection, Environmental Protection, Pacific and Yukon Region, Victoria, B.C. Abstract only

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Concerns expressed by the Commission of Inquiry (acid mine drainage, metals, sediment, nutrients and eutrophication) are addressed by monitoring receiving waters in the vicinity of the Quinsam Coal Mine and mine effluent. Receiving water quality is similar to the baseline data. All parameters are less than the Canadian Water Quality (CCME) Guidelines established to protect aquatic life. Periphyton is phosphorus limited throughout but becomes more pronounced with distance downstream of Middle Quinsam Lake. Periphytic biomass is generally low with the exception of Station 5A which exceeds the B.C. Water Quality Criterion for the protection of aesthetics and recreation. Current monitoring data is usually lower than QCC's baseline data.

Effluent monitoring of the Settling Pond 4 discharge indicates that dissolved zinc and total dissolved phosphorus occasionally exceed permitted levels, while iron exceeds the permit levels consistently. Settling Pond 4 discharges have significantly higher levels of dissolved aluminum and iron than the surface flows in the pond. At Middle Quinsam Lake Road, however several parameters (conductivity, sulphate, hardness, nitrate and dissolved zinc) occasionally exceeded the CCME guidelines or were elevated relative to baseline data and/or applicable CCME guidelines. Discharges from Settling Pond 4 which collects all surface drainage from the 2N open pit are less than 5% expected from precipitation data collected concurrently.

CITATION:
Redenbach, A. 1990. Quinsam Coal Development: A monitoring report on the effluent and receiving environment: 1989/1990. Environment Canada, Conservation and Protection, Environmental Protection, Pacific and Yukon Region, Victoria, B.C. Abstract only

ABSTRACT SOURCE:
Abstract from reference

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Concerns expressed by the Commission of Inquiry (acid mine drainage, metals, sediment, nutrients and eutrophication) are addressed by monitoring receiving waters in the vicinity of the Quinsam Coal Mine and mine effluent. Receiving water quality is similar to the baseline data. All results are less than the Canadian Water Quality (CCME) Guidelines established to protect aquatic life. Periphyton growth is phosphorus limited throughout but becomes more pronounced with distance downstream of Middle Quinsam Lake. Periphytic biomass is generally low with the exception of Station 5A which exceeds the B.C. Water Quality Criterion for the protection of aesthetics and recreation. Current monitoring data is usually lower than Quinsam Coal Corporation's (QCC) baseline data.

Effluent monitoring of the Settling Pond 4 discharge indicates that total dissolved phosphorus occasionally exceeds the permitted level, while iron exceeds the permit levels consistently. Settling Pond 4 discharges have significantly higher levels of dissolved iron than the surface flow into the pond. At Middle Quinsam Lake Road, however several acid mine drainage indicator parameters (conductivity, sulphate, hardness) were elevated relative to baseline data. Discharges from Settling Pond 4, which collects surface drainage from the 2N open pit, are 6-7% of that expected from precipitation data collected concurrently.

CITATION:
Regnier, R., B. Wipperman, and G.S. Holms. 1996. State of water quality of the Quinsam River, 1986-1995. Water Quality Branch, Environmental Protection Department, Ministry of Environment, Lands, and Parks, Victoria, B.C. 54 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
The Quinsam River is located on eastern Vancouver Island, west of the town of Campbell River, B.C. (Figure 1) The total drainage area of the Quinsam River is 280 km^2. The main economic activities pertaining to the Quinsam River are fishing, coal mining, and hydroelectric power. This report assesses water quality and flow data collected by Environment Canada at stations near the mouth of the Quinsam River between 1986 and 1995. We conclude that:

- Increasing trends were observed for calcium, hardness, specific conductivity, magnesium, sodium, sulphate, and strontium. These increases were probably due weathering of exposed rock at the coal mining operation within the drainage basin.

- Selenium values appeared to decrease to be consistently at or below the minimum detectable limit. We have no explanation for this apparent decline.

- Turbidity, apparent colour and total metal values followed an annual cycle similar to that of river flow (peaking in the winter and subsiding in the summer). Turbidity removal and disinfection are needed prior to use for drinking water.

- Aluminum, cadmium, iron, lead, manganese and zinc exceeded water quality criteria or objectives for aquatic life or drinking water at times, but this was due to elevated turbidity. The metals were probably not bio-available, and would have been removed by the treatment needed to remove turbidity prior to drinking.

- Chromium and copper exceeded aquatic life criteria or objectives at times. At least half of these instances were due to elevated turbidity, but some of them occurred when turbidity was low, indicating that the metal may have been bio-available. Elevated chromium may have been natural or due to artificial contamination.

- The water was soft with a low to moderate sensitivity to acid inputs.

- The water was usually cool enough to be aesthetically pleasing for drinking, but was rarely warm enough for swimming.

The Quinsam River sustains an important fishery and is a potential drinking water supply. We recommend that monitoring be continued at the site on the Quinsam River near the mouth due to increasing trends in a number of water quality indicators. These increases, while not a direct threat to aquatic life at present, will also be addressed through additional monitoring near the mine.

CITATION:
Reinhardt, R., and C.N. MacKinnon. 1978. Quinsam River: 1975 downstream enumeration and wild coho smolt marking. Fish. Mar. Serv. Tech. Rep. 840: 27 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
The spring program on the Quinsam River began with the installation of the counting fence for downstream operation on March 1, 1975.

An estimated total of 2,736,000 pink salmon fry (*Oncorhynchus gorbuscha*), 56,310 chum salmon fry (*O. keta*), 393,800 coho salmon fry (*O. kisutch*), 39,960 coho salmon smolts, and 4,639 sockeye salmon fry emigrated out of the Quinsam River from above the diversion fence. In addition 8,464 trapped wild coho smolts were released with an adipose clip and coded wire tag (code 2/2/4).

Data from this program is essential to the operation of Quinsam hatchery, permitting assessment of Quinsam River contribution relative to that of the hatchery.

CITATION:
Resource Analysis Branch. 1983. Reach cards from March 1983 survey of the Quinsam River. Obtained as digital files from Stu Hawthorn, Ministry of Fisheries, Victoria, B.C.: 24 cards.

ABSTRACT SOURCE:
Abstract by author

ABSTRACT:
Reach cards were completed for 18 reaches of the Quinsam River mainstem (including lakes). The survey was undertaken via helicopter on March 3, 1983. Biophysical parameters collected followed RAB methodologies. Data was later transcribed onto 1:20,000 maps which are also available from the same source.

CITATION:
Shardlow, T.F., T.M. Webb, and D.T. Lightly. 1986. Chinook salmon escapement estimation on the Campbell and Quinsam Rivers in 1984: accuracy and precision of mark/recapture techniques using tagged salmon carcasses. Can. Tech. Rep. Fish. Aquat. Sci. 1507: 52 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
The chinook escapement to the Campbell and Quinsam Rivers in 1984 was estimated by using a simple carcass tagging method. Marked carcasses from the Quinsam hatchery were released on two occasions in each river and the proportion of these carcasses recovered in the dead pitch was used as an index of the effectiveness of the dead pitch. In this report, the theory behind the use of carcass tagging is examined and the expected levels of precision and the potentials for bias are assessed. Two different estimation methods are examined, one based on a Petersen approach and the other on the Schaefer method. The need for corrections for differences in the sex ratio between live sampling and dead sampling is discussed.

The escapements of the Campbell and Quinsam Rivers are estimated to be 1600 and 1385 respectively with a sex ratio of 59.7% male and 40.3% female, based on the Quinsam hatchery live sampling. It is estimated that the Quinsam hatchery contributes 50% of the escapement in the Campbell River and 58% in the Quinsam River.

CITATION:
Smith, B.D. 1998. Assessment of wild steelhead (*Oncorhynchus mykiss*) abundance trends in British Columbia using MELP's Steelhead Harvest Questionnaire. Prov. of B.C. Fisheries Management Report No. 000. 88 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Intra-regional similarities and inter-regional differences in wild steelhead (Oncorhynchus mykiss) abundance patterns over time throughout British Columbia were identified using Catch-per-Angler-Day (CpAD) as an index of abundance of wild in-river adult steelhead abundance. This index was calculated from data collected by MELP's Steelhead Harvest Questionnaire (SHQ) from 1967/68 until 1995/96. Time-series methods rejected hypotheses that changes in fee schedules, regulations affecting an angler's entitlement to retain wild steelhead, the actual percent retention of wild steelhead (i.e., percent catch-and-release), sport anglers' methods/skills, angler residency, etc., are generally important factors affecting real or apparent trends in wild steelhead CpAD. However, there is evidence that hatchery supplementation and angler dynamics can bias CpAD as an index of abundance for individual years or certain rivers. Interpretation of trends for some regions and watersheds is complicated by low sample sizes, the mixture of rivers with winter-run and/or summer-run steelhead populations, and hatchery supplementation. However, wild CpAD for recent years shows a latitudinal trend consistent with a general pattern of increasing salmon abundance in northern waters related to favourable marine conditions. For the years 1992/93 and later, changes to steelhead sport angling regulations and mitigation of steelhead interception and retention by marine commercial salmon fisheries may have influenced wild CpAD for the Skeena and Nass watersheds. Trends in adult steelhead CpAD for the east and west coasts of Vancouver Island correspond with data on smolt-to-adult survival for the Keogh River corroborating studies there that marine survivorship is an important factor determining adult steelhead abundance for those regions. Future work will pose explanations for the observed patterns in wild CpAD province-wide based primarily on changes in marine and freshwater climate over the past two or three decades.

CITATION:
Sullivan, M.A., S.C. Samis, J.A. Servizi, and R.W. Gordon. 1985. Survey of selected British Columbia and Yukon salmon streams for sensitivity to acidification from precipitation. Can. Tech. Rep. Fish. Aquat. Sci. 1388: ix + 105 p.

ABSTRACT SOURCE:
Abstract from reference

ABSTRACT:
Surface water samples from 174 Pacific salmon streams on the British Columbia North Coast, Queen Charlotte Islands, Vancouver Island, Sunshine Coast and Lower Mainland of British Columbia and near Whitehorse in the Yukon were collected between 1982 and 1983 and analysed for pH, alkalinity and metals. Snow samples were collected in 1983 from 26 of the watersheds drained by these streams and analysed for pH, alkalinity and metals. Twenty-five streams on the North Coast and Queen Charlotte Islands, 43 streams on Vancouver Island and the Sunshine Coast and 22 streams on the Lower Mainland were found to have alkalinities below 200 $ueq*L^{-1}$ for at least part of the year. Buffer capacities ($ueq*L^{-1}*pH^{-1}$) were calculated for 57 of these low alkalinity streams.

CITATION:
Van Tine, J. 1986. Coho colonization of inaccessible headwater habitats in the Quinsam River watershed. In: Proceedings of the Workshop on Habitat Improvements, Whistler, British Columbia. 8-10 May, 1984. (Patterson, J.H., ed.) Can. Tech. Rep. Fish. Aquat. Sci. 1483: pp. 38-42.

ABSTRACT SOURCE:
Abstract by author

ABSTRACT:
Each year since 1978, the Quinsam hatchery has outplanted about 250,000 coho fingerlings. Fry release has occurred from the cascades at 25 km to the hydro diversion. Smolt enumeration transpires, in May, as the smolts migrate past the counting fence above the hatchery. Average survival rates from fry to smolt has been 18.6 percent. Annual adult escapements to the Quinsam River have been around 1,100 fish. Decisions still have to be made about the genetic stocks used for colonization and where to outplant.

CITATION:
Wightman, J.C. March 1996 draft. Campbell River Hydro/Fisheries Advisory Committee, Biological Sub-Committee Report: Campbell/Quinsam steelhead resource. Ministry of Environment, Lands and Parks, Nanaimo, B.C.: 22 p.

ABSTRACT SOURCE:
Abstract by author

ABSTRACT:
This purpose of this report was to clearly identify target production levels for steelhead trout in the Campbell/Quinsam system. This information will complement the stock status review being prepared by DFO, which together will identify production targets for major anadromous species occurring in this watershed. This information is required to direct the scale and types of future fisheries restoration projects in the watershed.

Steelhead smolt yield from the Campbell River was previously estimated by Lirette, Hooton and Lewynsky (1987) and by Burt and Burns (1995). Different models were used in the two studies. The first study predicted a smolt yield of 3,400-4,250 with 180 spawners required to fully seed available rearing habitat. The second study estimated a smolt yield of 3,800-4,400 with 66 spawners required to seed available rearing habitat (based on a flow of 34 m^3/s). Based on these 2 spawner estimates, the author suggested that the target steelhead escapement for the Campbell River be a minimum of 100 spawners.

Steelhead smolt yield from the Quinsam River was previously estimated by Lirette, Hooton and Lewynsky (1987). This paper estimated that the Quinsam was capable of producing 9,700-14,200 steelhead smolts annually, and that at least 600 spawners were required to seed available rearing habitat.

Major constraints to steelhead production in the Campbell River were identified as excessive flows during summer rearing periods, and the loss of the canyon reach between John Hart Generating Station and Elk Falls as productive fish habitat. Within the Quinsam River, major constraints were identified as the decrease in mean annual discharge due to water diversion, low summer flows (reduced rearing habitat and elevated water temperatures), and low flows during adult migrations. Other concerns in the Quinsam included impacts from logging and the release of waste water from the Quinsam Coal operation.

CITATION:
Wightman, J.C., B.R. Ward, R.A. Ptolemy, and F.N. Axford. October 1998. Draft: A recovery plan for east coast Vancouver Island steelhead trout (*Oncorhynchus mykiss*). Ministry of Environment, Lands and Parks. Fisheries Project No. __: 131 p. + 85 p. of appendices.

ABSTRACT SOURCE:
Abstract by author

ABSTRACT:
This document provides a comprehensive overview of land use impacts, the Provincial steelhead management program, and the status of steelhead stocks on east coast Vancouver Island. A blueprint for the recovery of Vancouver Island steelhead stocks is proposed. Watershed-specific recovery recommendations are given for key east coast Vancouver Island steelhead producing streams.

With respect to the Quinsam River, recommendations included the need for a comprehensive biophysical and habitat capability assessment, the continuation of recent sport fishing conservation regulations, and the continuation of reduced hatchery smolt releases (10,000 fish) to reduce genetic risks to wild stocks through wild-hatchery interbreeding. Habitat concerns expressed, related logging on Private Managed Forest Land, the effects of water abstraction at the Quinsam Diversion Dam, and the potential for water quality impacts from past and present mining operations in the watershed.