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VOLUME IIB -SIMILKAMEEN RIVER HABITAT INVENTORY

FINAL REPORT, 1983

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PREFACE

This project, No. 83-477,was funded by the Bonneville Power Administration in the FY 1983 Fish and Wildlife Program under contract No. DE-AC79-83BP119O2.

The report is presented in two volumes. The main body of the report (Volume I) contains a description and analysis of the habitat inventory data collected within the Similkameen River Basin upstream of Enloe Dam between August and October, 1983. Because of their volume, the appendices to the main report have been produced under a separate cover (Volume II) The appendices include the detailed habitat inventory summaries and the data calculations which formed the basis for the conclusions presented in Volume I.

Copies of Volume I or Volume II may be obtained from:

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ABSTRACT

During the summer low flow period, a habitat assessment of the Similkameen, Tulameen, Ashnola and Pasayten rivers in British Columbia and Washington State was conducted between August 10 and October 10, 1983.The biophysical survey assessed 400 km (250 mi.) of stream at 77 stations. Fish sampling was conducted at each station to assess the resident fish populations and standing crop. Rainbow trout populations and standing crops were found to be very low. Large populations of mountain whitefish and bridgelip suckers were present in the mainstem Similkameen River below Similkameen Falls. High densities of sculpins and longnose dace were found throughout the system except for sculpins above the falls, where none were captured.

Approximately 961,000 m^2 (1,150,000 yd^2) of spawnable area for steelhead trout were estimated for the entire system which could accommodate 98,000 spawners. Nearly 367,000 m^2 (439,000 yd^2) of chinook salmon spawnable area was also estimated, capable of accommodating 55,000 chinook. Rearing area for steelhead trout smolts was estimated for the whole system at 1.8 million m2 (2.2 million yd2). Chinook salmon smolt rearing area was estimated at 700,000 m^2(837,000 yd^2). Rearing area was found to be a limiting factor to anadromous production in the Simifkameen River system.

Smolt production from the system was estimated at about 610,000 steelhead trout and between 1.6 million and 4.8 million chinook salmon. No water quality, temperature or flow problems for anadromous saImonids were evident from the available data and the habitat inventory.

In addition to an irnpassable falls on the Tulameen River at river mile 32.5, only two other areas of difficult passage exist in the system, Similkameen Falls (a series of chutes) and the steep, narrow lower section of the Ashnola River.

EXECUTIVE SUMMARY

Between 1916 and 1923, the 54 foot high Enloe Dam and hydroelectric facility was constructed at river mile 8.3 of the Similkameen River. Power was generated from the facility until 1959, when operation of the dam became economically unfeasible. Enloe Dam was not provided with fish passage facilities.

The Northwest Power Planning Council's 1982 Columbia River Basin Fish and Wildlife Program identified Measure 704 (e) (i), Table 5(A) to provide fish passage at Enloe Dam. Completion of Enloe Dam passage and establishment of an anadromous fish run throughout the Similkameen River Basin would be considered as off-site mitigation for juvenile fish losses occurring on the mainstem Columbia River.

IEC Beak Consultants Ltd. was engaged by BPA (Contract No. DE-AC79-83BPl1902) to conduct Phase I of a multi-phase program to address the feasibility of the council's goal of fish passage and anadromous salmonid production above Enloe Dam. Phase I consisted of a basin wide inventory of fish habitat and resident fish populations. From the habitat inventory, estimates were made of the spawning and rearing capacity of the system for steelhead trout and chinook salmon as well as the probable production that could be expected for each species.

The 1383 inventory results are presented in two volumes, the main report (Volume I) and appendices (Volume II). The appendices contain the detailed data base collected in the inventory. Volume I summarizes and interprets that data base, outlines the methods used, discusses the results and lists the conclusions reached.

The Similkameen River drains about 9300 square kilometres (3620 square miles) of the Pacific Northwest with approximately 82 percent of the total drainage area in British Columbia. From its origin near the international boundary in Manning Provincial Park, the river flows north to Princeton, B.C. where it is joined by its largest tributary, the Tulameen River. These two streams, both with their headwaters in the Cascade Mountains, generate most of the basin's runoff. The Pasayten River converges with the Similkmeen River just upstream of Similkameen Falls. Flowing southeast from Princeton, the Similkameen River is joined by the Ashnola River near Yeremeos, From here, the river valley widens and the Similkameen River meanders in a southerly trend, crossing the international boundary near Nighthawk, Washington. South of the border, the river flows east towards its confluence with the Okanogan River near Oroville, Washington. A further 120 Kilometres (74 miles) downstream, the Okanogan River empties into the Columbia River at Brewster, Washington. The Columbia River then flows about 825 kilometres (516 miles) over 9 dams to the Pacific Ocean.

A detailed habitat and resident fish inventory was conducted on the Similkameen River watershed in the late summer and early fall of 1983. The Enloe Dam represented the downstream boundary of the study area.

Two field crews assessed approximately 400 km (250 mi.) of the Similkameen River mainstem and its major tributaries by making detailed biophysical inventories at 77 representative sites covering a total of 43 km (27 mi.) of stream (over 11% of the total study area). In addition, a minimum of 160 km (98 mi.) of accessible stream in the headwaters of major tributaries and the smaller tributaries, not yet assessed in-field, was estimated to be present.

The British Columbia Fish and Wildlife Branch's "Stream Habitat and Fish Population Inventory System" constituted the main inventory methodology since it most adequately fulfilled the study's assessment criteria. This methodology was modified slightly in order to provide additional information required to utilize the Wyoming Game and Fish Department's Habitat Quality Index (HQI) as we41 as the Slaney Steelhead Trout Model of production potential.

Fish population inventory methods consisted primarily of electrofishing and snorkel counts with beach seining, dip netting and angling providing additional information on the resident fish populations. From the inventory data collected, potential spawning area, rearing area and production estimates were calculated for steelhead trout and chinook salmon using Bovee's probability-of-use curves, the Slaney Steelhead Trout Model and fish densities from other similar streams. In addition, length/weight relationships, population estimates, densities and standing crops were calculated for the resident fish populations from the fish data collected. The rainbow trout data collected was further examined for age and growth. Potential rainbow trout standing crop estimates were predicted from the habitat inventory data using the Habitat Quali t v Index (HQI).

Discharges of streams in the study area were measured during the field program. Hydrometric data were analyzed by computerized statistical methods and a description of the basin's hydrological conditions was provided.

Water samples were collected at representative sites throughout the Similkameen River system for laboratory analysis of totai dissolved solids (TDS) and nitrate-nitrogen.

The Similkameen River, in general, progresses from a low gradient, meandering river near the British Columbia-Washington State boundary to a steep, bouldery creek at its origin in Manning Provincial Park. Although some large pools exist in the canyons between Princeton, B.C. and Similkameen Falls, the greatest percentages of pool cover (highest pool: riffle ratios) occur downstream of Princeton, as do the highest concentrations of favourable spawning substrates.

The lower Tulameen River is characterized by a low gradient with excellent spawning substrates and pool cover. The river profile steadily steepens above the town of Tulameen were canyons and rapids become numerous.

The Pasayten River is typically a cobble and boulder stream. Near the international boundary, the gradient is relatively low, providing the highest percentages of pool cover.

The Ashnola River is dramatically steeper than the Similkameen River or the two other main tributaries. The stream is narrow and water velocities are high throughout most of its length. Only one relatively low gradient section, between river miles 15 and 28, provides reasonabie quantities of spawning substrates and pool cover.

A fish barrier in the form of an approximately 100 ft high falls, exists on the Tulameen River at about river mile 32.5. Other areas of difficult passage include the

Similkameen Falls (a series of chutes) and the steep, bouldery lower reaches of the Ashnola River.

The Similkameen River system was estimated to contain approximately 5,316,800 m^2 (6,358,800 yd^2) of steelhead trout spauning substrate of which 961,000 m^2 (1,150,000 yd^2) was determined to be spawnable area (incorporating suitable water depth and velocity requirements). This area has a capacity for about 98,000 steelhead spawners,

The Similkameen River mainstem contains an estimated 55% or 529,600 m^2 (633,400 yd^2) of the available spawnable area in the entire system. The majority of this area, 365,000 m^2 (436,500 yd^2) occurs in the stream section between Keremeos and Princeton, B.C. The Similkameen River mainstem has an estimated spawner capacity of 54,000 steelhead trout.

The Tulameen River contains 30% or 288,800 m^2 (345,400 yd^2) of the entire system's spawnable area with the capacity for approximately 30,000 spawners. Resulting spawnable area and spawner capacity for the Ashnola River are 132,400 m^2 (158,300 yd^2) and 13,500 spawners, respectively and in the Pasayten River, 10,000 m^2 (12,000 yd^2) and 1,000 spanwers, respectively.

The area of Chinook salmon spawning substrate in the Similkameen River system is estimated to be 4,978,900 m^2 (5,954,700 yd^2) of which only 366,900 m^2 (438,800 yd^2) of spawnable area exists, capable of supporting 54,700 spawners.

The majority of the system's chinook spawnable area, 55% or 203,100 m^2 (242,900 yd^2), is located in the Tulameen River and has a spawner capacity of 30,300. The mainstem Similkameen River contains the second largest concentration of spawnable area, 118,500 m^2 (141,700 yd^2) with the capacity for 18,000 spawners. The Ashnola River contributes 41,500 m^2 (49,600 yd^2) of spawnable area capable of accommodating 5,200 spawners. Only 3,800 m^2 (4,500 yd^2) of chinook spawnable area with the capacity for about 540 spawners Is present in the Pasayten River.

Potential rearing area for steelhead trout was estimated at 1,802,600 m^2 (2,152,800 yd^2) for the Similkameen River system. The majority, 76% (1,372,000 m^2 or 1,640,900

yd^2), is located in the mainstem Similkameen River of which 33% (594,700 m^2 or 7 11,300 yd2) is between Keremeos and Princeton, B.C. Of the remaining rearing area, 18% (319,400 m^2 or 382,000 yd^2) occurs in the Tulameen River, 3% (63,600 m^2 or 76,100 yd2) in the Ashnola River and 3% (47,300 m^2 or 56,600 yd^2) in the Pasayten River.

Estimated Similkameen River system juveniie chinook salmon rearing area was determined to be 698,600 m2 (835,500 yd2). The majority, 71% (496,800 m2 or 594,200 yd2), is situated in the marnstem Similkameen River with 35% (243,400 m2 or 291,l00 yd^2) between Keremeos and Princeton. Percent contributions to the total chinook rearing area were: 24% (167,900 m2 or 200,800 yd2) in the Tulameen River, 4% (26,600 m^2 or 31,800 yd^2) in the Pasayten River and 1% (7,300 m^2 or 8,400 yd^2) in the Ashnola River.

Within the basin's major streams, rearing area was found to be a limiting factor to production for both species.

The Similkameen River system was calculated to be capable of producing about 680,000 steelhead trout smolts using the Slaney Steelhead Trout Model. The majority, 80% (492,500), would eminate from the mainstem Similkameen River with 33% (205,000) from the stream section between Xeremeos and Princeton. The remainder of the production would constitute 9% (55,400) from the Tulameen River, 4% (26,200) from the Ashnola River and 2% (1 1,500) from the Pasayten River. The total of nearby 610,000 smolts would yield adult escapements of 9,200 and 24,400 at 1.5% and 4% smolt-to-adult survivals, respectively.

Additional steelhead smolt production estimates were calculated using stream area and juvenile spacial requirements, resulting in a range of 398,000 to 718,000 smolts. The estimate of 610,000 made from the steelhead model, falls within this range.

Chinook salmon smolt production estimates for the Similkameen River system ranged from 1,559,300 based on stream length to 4,775,500 based on stream area. Production ranges were 923,400 to 3,586,000 for the Similkameen River mainstem, 214,700 to 559,700 for the Tulameen River, 259,200 to 374,000 for the Ashnola River and 162,000 to 255,500 for the Pasayten River. Adult escapements would range from 4,900 to 14,400 at 0.3% smolt-to-adult survival.

The main species of fish caught or observed in the Similkameen River system included rainbow trout, mountain whitefish, bridgelip suckers, longnose dace, and sculpins. incidental species included northern squawfish, black crappie, and kokanee. Above Similkameen Fails only rainbow trout and longnose dace were found.

Rainbow trout, the main sport fish in the system, was found to be comparatively slow growing, requiring up to four years to reach 200 mm (8 in.). The total population of rainbow trout, in the Similkameen River system was estimated to be 142,300 fish, with a total standing crop of 3,600 kg (7,940 lb). Densities ranged from 0 to 0.20 fish/m2 (0 to 5.78 g/m2), Rainbow trout densities were far lower than those found in other British Columbia streams. Angling pressure appears to be the main factor affecting rainbow densities. The majority (30%) of rainbow trout in the Similkameen River system were found between Keremeos and Princeton. Next to the mainstem Similkameen River, the Ashnola River contained the second largest population of rainbow trout.

on average, the measured standing crop estimates of rainbow trout in the Similkameen River system was lower than that predicted by the Habitat Quality Index (HQI) in areas of the system with good stream access and therefore, likely higher fishing pressure.

High standing crops of suckers and mountain whitefish (152,800 and 171,100 kg, respectively) were found in the mainstem Similkameen River beIow Similkameen Falls. Sculpin and longnose dace standing crop values were also high in most regions of the system.

The Similkameen River Basin can he divided into two relatively distinct hydrological zones almost exclusively on the basis of elevation. The high elevation areas of the western portion of the basin produce most of the basin’s runoff, dominantly from snowmelt, and are designated the “wet zone”. The lower-lying remainder of the basin is quite dry and includes some desert-like areas. This region is the “dry zone”.

The dominant hydrological event throughout the Similkameen River Basin is the annual freshet which occurs in May and June. The majority of the annual runoff is discharged during this event. Slight increases in the mean monthly discharges of wet zone streams occur in November and December as a result of late fall rainstorms.

Water resources problems are most common in the Lower Similkameen Valley, downstream of Princeton. Water shortages occur during late summer as low river discharges overlap with the peak demand for irrigation waters. The same region is also the most susceptible to flooding in the spring, however, dyking in recent years has provided some protection from the peak flows.

Streams within the wet zone are characterized by lower water temperatures than those of the dry zone. Water temperatures in the main rivers (especially the Similkameen) reflect a mixing of warmer and cooler waters from their tributaries. In general, temperatures increase along the mainstem of the Similkameen River towards the Enloe Dam.

The waters of the Similkameen River Basin are generally low in concentrations of total dissolved solids and nitrate-nitrogen (parameters commonly used as a measure of stream nutrients or productivity). Streams draining the warm, dry areas of the basin contain higher concentrations of nutrients.

No major water quality, temperature or flow problems in the Similkameen River system for either steelhead trout or chinook salmon were evident from the data available or the field survey.

Based on the resulting Similkameen River basin habitat inventory and anadromous salmonid production estimates (Phase I), it is evident that provision of passage at Enloe Dam is justified on the basis that it would allow access to extensive anadromous salmonid rearing and spawning areas. Phase II (1984) of the Enloe Dam Passage Project proposes to address the fish introduction plan and passage alternatives. followed with the conceptual design of passage alternatives (Phase III) and fish planting (Phase IV).

1.0 INTRODUCTION

In the fall of 1905, the Similkameen Falls Power and Development Company acquired the water rights to the Similkameen River (Bureau of Reclamation, 1976). However, it wasn't until between 1916 and 1923 that the 54 foot high Enloe Dam and hydroelectric facility were constructed by the Okanogan Valley Power Company (Eugene Enloe, President) at river mile 8.8. The rights of this company were subsequently transferred to the Okanogan Public Utility District, the present owner of the dam. Power was generated from the facility until 1959, at which time its operation was deemed economically unfeasible. In 1978, Enloe Dam and its powerhouse were listed on the National Register of Historic Sites (Bureau of Reclamation, 1979).

Since Enloe Dam was not provided with fish passage facilities, discussions among the various Canadian and U.S. agencies on providing passage have occurred since the 1920% without success (Wahle, pers. comm. 1983). The Pacific Northwest Electric Power Planning and Conservation Act of 1980 (the Northwest Power Act) permitted the adoption of recommendations put forth by the U.S. federal and state fish and wildlife agencies, Indian tribes and other interested parties intended "to protect, mitigate, and enhance fish and wildlife, including related spawning grounds and habitat, on the Columbia River and its tributaries" (Northwest Power Planning Council, 1982). The Act also gave the Bonneville Power Administration (BPA) the authority and responsibility to use its legal and financial resources "to protect, mitigate, and enhance fish and wildlife to the extent affected by the development and operation of any hydroelectric project on the Columbia River and its tributaries in a manner consistent with . . . the program adopted by the Council . . . and the purposes of this Act."

As a result of the recommendations requested by the Northwest Power Planning Council, the Council's Columbia River Basin Fish and Wildlife Program (1982) commits Measure 704 (e) (i), Table 5(A) to removal or laddering of Enloe Dam, providing access for anadromous salmonids to many miles of spawning and rearing habitat in the upper Similkameen River watershed. Completion of Enloe Dam passage and establishment of an anadromous fish run throughout the Similkameen River Basin would be considered as off-site mitigation for juvenile fish losses occurring on the mainstem Columbia River.

IEC BEAK Consultants Ltd. was engaged by BPA (contract No. DE-AC79-835Pl1902) in 1983 to conduct Phase I of a multi-phase program, intended to achieve the Council's goal of fish passage and anadromous salmonid production above Enloe Dam and fulfill Measure 704 (e) (i), Table 5(A) of the Fish and Wildlife Program.

The first phase, entitled "1983 Similkameen River Habitat Inventory for Enloe Dam Passage (Project 83-477)" is presented in two volumes, the main report (Volume I) and appendices (Volume II). Volume I provides an introduction to the study (Section 1.0), a description of the study area (Section 2.0), the methods employed (Section 3.0), the results obtained (Section 4.0) and a summary of the relevant findings (Section 5.0).

The main objectives of the 1983 field studies conducted above Enloe Dam between August and October were to:

I, Conduct a habitat assessment of the mainstem Similkameen River and its major tributaries upstream of Enloe Dam in Washington and throughout the basin in British Columbia.

2. Conduct an inventory of the system's resident fish populations.

3. Estimate the quantity of spawning and rearing area available for steelhead trout and chinook salmon.

4. Estimate the system's potential steelhead trout and chinook salmon smolt production.

5. Describe the hydrology and general water quality of the Similkameen River Basin as it relates to fish production.

The extensive appendices to this report, summarizing the habitat and fish inventory data as well as the calculations forming the basis of the conclusions, are contained separately in Volume II.

2.0 DESCRIPTION OF STUDY AREA

2.1 Similkameen River Basin

The Similkameen River drains about 9300 square kilometres (3620 square miles) of the Pacific Northwest with approximately 82 percent of the total drainage area in British Columbia. From its origin near the international boundary in Manning Provincial Park, the river flows north to Princeton, B.C. where it is joined by its largest tributary, the Tulameen River. These two streams, both with their headwaters in the Cascade Mountains, generate most of the basin's runoff. The Pasayten River converges with the Similkameen River just upstream of Similkameen Falls. Flowing southeast from Princeton, the Similkameen River is joined by the Ashnola River near Keremeos, B.C. From here, the river valley widens and the Similkameen River meanders in a southerly trend, crossing the international boundary near Nighthawk, Washington. South of the border, the river flows east towards its confluence with the Okanogan River near Oroville, Washington. A further 120 kilometres (74 miles) downstream, the Okanogan River empties into the Columbia River at Brewster, Washington. The Columbia River then flows about 825 kilometres (516 miles) over 9 dams to the Pacific Ocean. Figure 2-1 locates the Similkameen River system within the Columbia River Basin.

‘he Enloe Dam, which is located on the Similkameen River about 14 kilometres (8.8 miles) upstream from its mouth, represents the downstream boundary of the study area. Figure 2-2 shows the study area, including its major towns and highways.

2.2 Specific Study Streams

In terms of the project objectives, the study area includes the major streams within the Similkameen River Basin which might be utilized by anadromous trout and salmon if fish passage was to be gained at the Enloe Dam. Within this capacity, detailed in-field assessments were made of the main channels of the Simiikameen, Tulameen, Pasayten and Ashnola rivers during 1983. In addition to the main streams studied, tributary streams with potential habitat for spawning and/or rearing of anadromous species have also been noted.

The main trunk of the Similkameen River traverses nearly 200 kilometres (125 miles) from its headwaters to the Enloe Dam. In Manning Provincial Park, the river weaves through a narrow valley to the confluence with the Pasayten River. About one kilimetre downstream of the Similkameen/Pasayten confluence, the river cascades through a series of small falls and chutes at Similkameen Falls. The river then becomes confined to a narrower path downstream to Princeton, B.C., with many reaches flowing through canyons. Downstream of Princeton, the river is generally confined to a single channel entrenched in older river sediments. At Hedley, B.C., the valley widens to about one kilometre and the river is pushed from side to side by alluvia: fans formed along the valley walls. At Keremeos, the valley widens further to between two and three kiiometres. Historically, the river meandered freely on the wide floodplain. However, dyking in this lower stretch of the river in recent years has restricted most flows to a single path across the international boundary. From Palmer Creek to the Enloe Dam, the river becomes confined and eventually enters a canyon at Shanker's Bend, which marks the upstream end of the reservoir.

The Pasayten River originates in Washington State, with about two-thirds of its catchment area south of the border. It is predominantly a boulder and cobble stream over its entire length. Near the international boundary, the river meanders on a relatively flat reach. Otherwise, the river flows quite straight in a single channel often entrenched in its own alluvial sediments.

The Tulameen River, like the Similkameen River, originates in the mountainous terrain of the Cascade Mountains. A waterfall, about 30 metres (100 feet) in height immediately upstream of Vuich Creek, defines the upstream extent of fish migration and the study area. Through most of its Ienqth, the river is confined to a single channel, Canyons, rapids and chutes are common along the river above the town of Tulameen. Below Otter Creek, the river valley widens allowing the river channel to shift slightly. The river valley narrows again downstream of Coalmont, B.C., to the confluence with the Similkameen River at Princeton.

The Ashnola River, which forms most of the north and west boundaries of Cathedral Lakes Provincial Park, has its headwaters in Washington State. Although it is steep and very bouldery there, its gradient decreases and its valley widens north of the border. This relatively flat stretch of the Ashnola River is characterized by finer substrate sediments (cobbles and gravels) and av more meandering nature. About mid-way between the international boundary and its mouth, the river regains its steep gradient and narrow channel. The river has many rapids and chutes along the remainder of its course, with many bedrock controlled reaches.

Other streams of interest include Allison, Summers, Hayes, Keremoes and Sinlahekin creeks. These streams are all of relatively low gradient, draining the warm, dry agricultural areas of the basin.

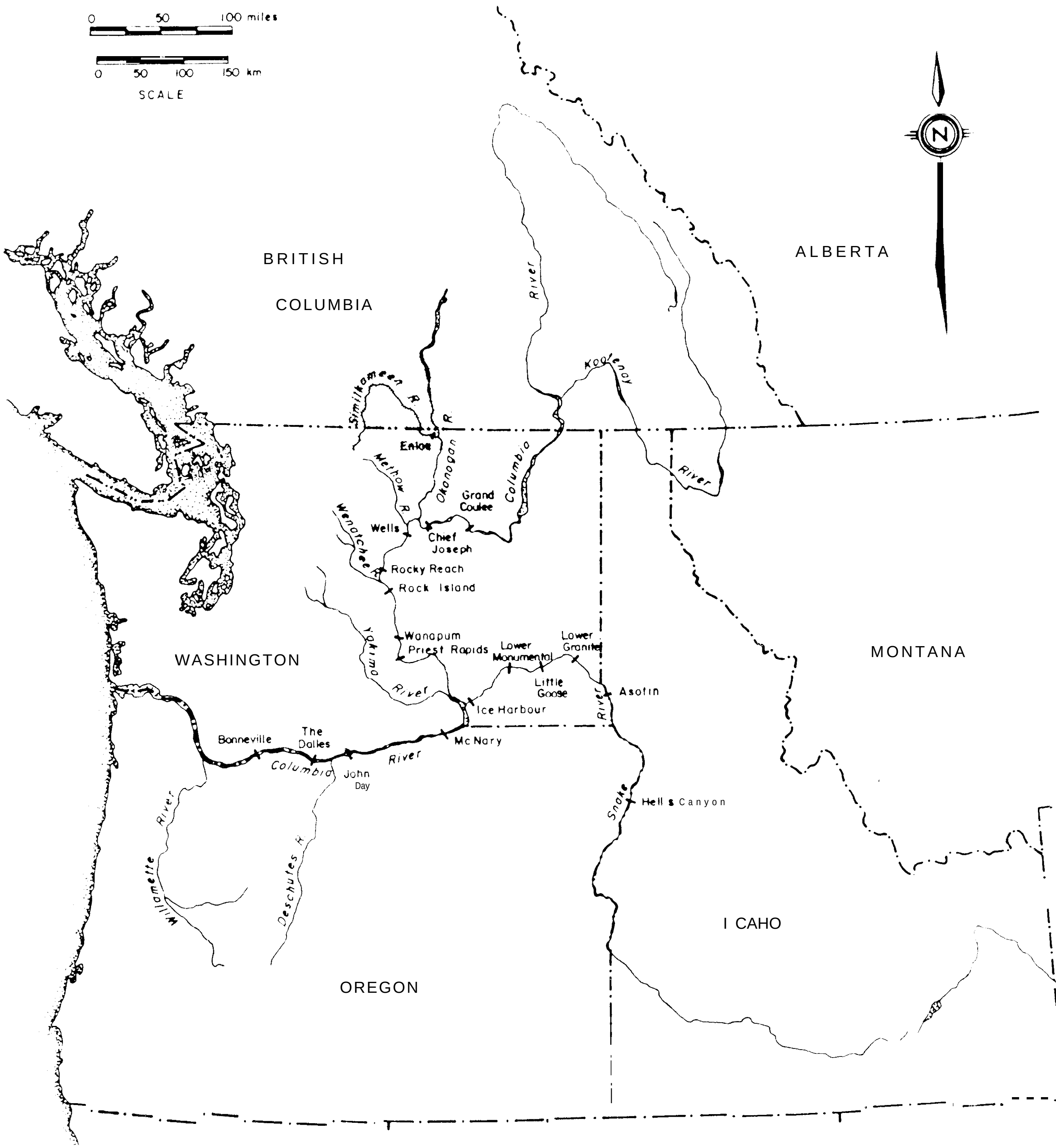

FIGURE 2-I : Location of the Similkameen River System Within the Columbia River Basin.

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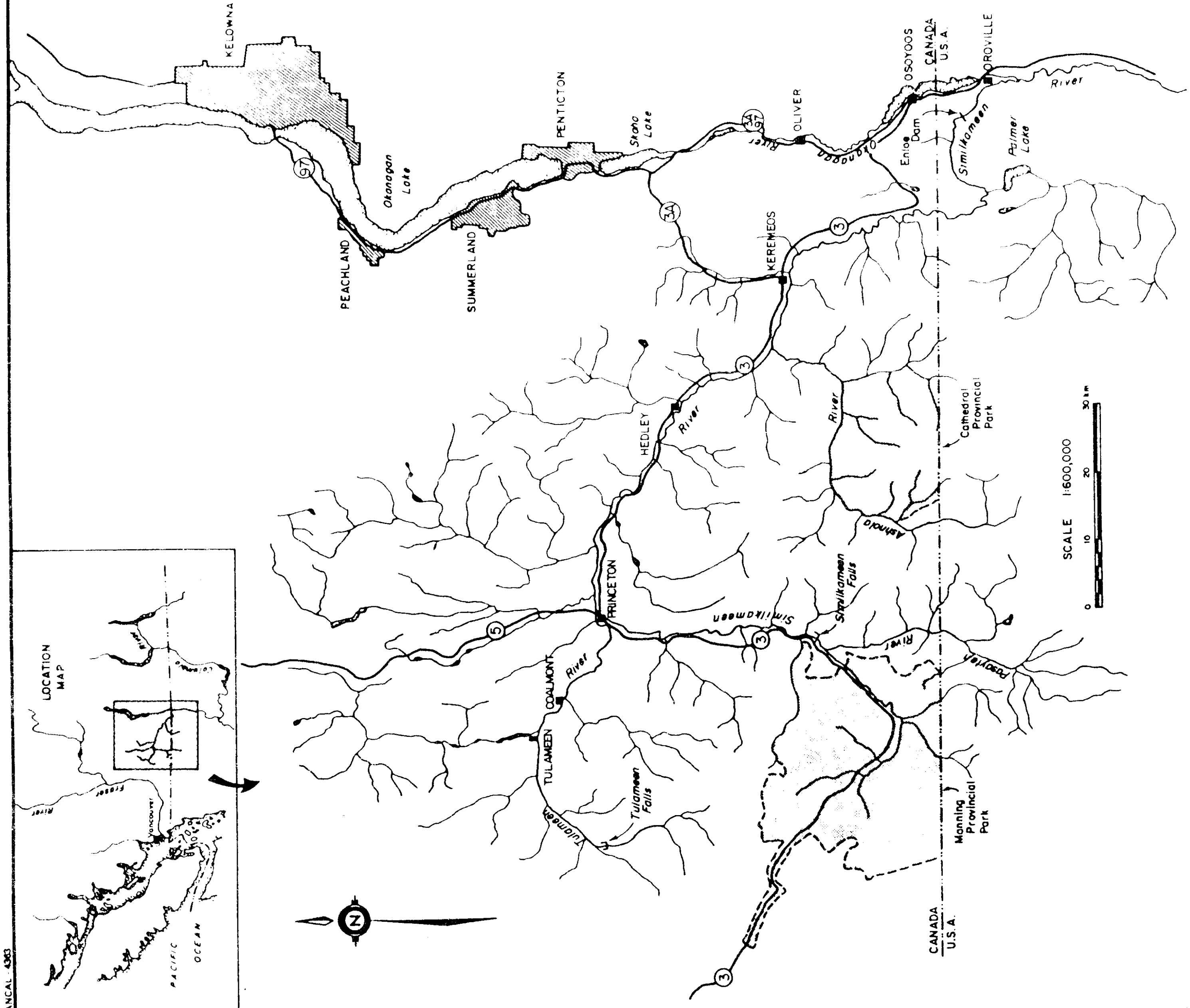

FIGURE 2-2:
Study Area.

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3.0 METHODS AND MATERIALS

3.1 Habitat Assessment

3.1.1 Project Methodology

Several approaches to aquatic habitat assessment are presently being employed in western North America. Methodologies designed by the U.S. Forest Service (Herrington and Dunham, 1967), the Bureau of Land Management (Duff and Cooper, 1978) the Wyoming Game and Fish Department (Binns, 1982), the British Columbia Aquatic Studies Branch (Chamberlin, 1980), and the British Columbia Fish and Wildlife Branch (de Leeuw, 1981) were reviewed for their suitability in describing the existing fish habitat and associated resident populations within the Similkameen River basin.

It was evident that in order to successfully assess a watershed as to its suitability for anadromous salmonid introduction, a detailed and comprehensive habitat survey was required. In addition, it was felt that the status of the resident fish population be determined to assist in the assessment of potential anadromous fish impacts, especially on the rainbow trout.

The British Columbia Fish and Wildlife Branch Methodology, "Stream Habitat and Fish Population Inventory System" (de Leeuw, 1981) most adequately fulfilled the assessment criteria, therefore, formed the basis of the study's habitat inventory. Their approach provided parameters to describe and quantify continuous units of varying fish habitat (pools, riffles, etc.) among other aquatic and terrestrial stream features important to the fish.

In following this methodology, the habitat evaluations were conducted during the summer low flow period. The streams were divided into homogeneous sections or reaches based on stream slope (% gradient). A representative sampling site location(s) was then selected within each reach, with the number of stations dependent upon reach length and homogeneity. Generally, each sampling site or station consisted of twelve consecutive hydraulic units (i.e. pools, riffles, runs etc.) for which twenty-one habitat parameters were measured within each unit (described in -Section 3.1.3).

Owing to the fact that the upper portions of a large watershed, such as the Similkameen River, differ greatly from the lower regions, the twelve hydraulic unit sampling stations did not always adequately characterize a particular reach. In the upper watershed, twelve units occurred in a very short distance due to the diversity of habitat. Conversely, in the lower reaches of the river, the twelve units would have covered a great distance resulting in the over sampling of the few units present. Consequently, an evaluation goal of approximately 10 percent of the reach length was set which could have included up to twelve hydraulic units per station and a number of sampling stations per reach.

Within a representative section of a station, the fish population was sampled for species composition and abundance, length, weight and for the rainbow trout, age determination. Section 3.2 provides a detailed account of the fish population sampling methodology.

Although the above habitat inventory method formed the basic framework of the project methodology, additional parameters and more detailed measurements of certain parameters were included to obtain estimates of available rainbow trout habitat potential, rainbow trout standing steelhead trout smolt production.

In the case of rainbow trout habitat potentia! and standing crop, the Wyoming Game and Fish Department methodology (Binns, 1982) provided such estimates and thereby assisted in the assessment of the resident trout population.

The Wyoming Game and Fish Department's Habitat Quality Index (HQI) was developed as a habitat evaluation tool and has served to predict trout standing crop and assess the effects of habitat alterations (Binns, 1982). This methodology has been described in greater detail in Section 3.2.4. Additional stream habitat attributes derived from this method included cover for trout, amount of bank erosion and nitrate-nitrogen content of the water. These were added to the list of habitat parameters designed bv the B.C. Fish and Wildlife Branch. Again, in accordance with the basic methodology used, the Wyoming Game and Fish Department method required that the attributes be measured in a representative section of the reach during late summer iow flow (CPF -

critical period flow). Another modification of the basic inventory procedure was necessary in order to utilize a steelhead trout smolt yield model developed by P. Sfanev of the B.C. Fish and Wildlife Branch (Slaney, 198 1 - see Section 3.5.1 including Table 3-2). The definition for one of the basic hydraulic units was more precisely defined. In the field inventory the term "glide" used in the B.C. Fish and Wildlife irventory method was partitioned into "run", "flat-run" and "flat". Mean parr densities as determined by the Slaney Steelhead Model, require that these hydraulic units be separated as such. Other additions required for the Slaney Steelhead Model were estimates of the percentage of riffle wetted area comprised of protruding boulders as well as water sample collections for total dissolved solids (TDS) determinations.

Water samples, analyzed for nitrate-nitrogen content and TDS were collected from major locations throughout the system. Due to the extent of the study, it was more feasible to take water samples from a number of representative locations in the watershed rather than at each station.

The habitat types or hydraulic units utilized to describe stream sections as well as the habitat parameters measured within each section, have been described in Section 3.1.3.

3.1.2 Reach Determination

In following the B.C. Fish and Wildlife Branch methodology (de Leeuw, 1981), the streams were divided into homogeneous segments or reaches on the basis of stream slope (% gradient). Six reach categories were defined as follows:

Reach Type	% Gradient
1	0
2	o-o. 5
3	0.5-1.0
4	1.0-3.0
5	3.0-7.0
6	7.0 +

The initial reach divisions were facilitated by the use of topographic contour maps, employing the formula:

$$\frac{(\text{contours per inches}) \times (\text{contour interval in inches})}{\text{Map scale (eg. 50,000)}} \times 100 = \%\ \text{gradient}$$

In the field, modifications to the initial reach partitioning resulted from more accurate aerial photo interpretation as well as on-site visual assessments. Figure 3- 1 provides a summary of the reach divisions for the study area.

It should be noted that Reach 16 on the Similkameen River was divided into two separate segments. The section of Reach 16 just upstream of Reach 17, originally Included in that latter reach, waslater realized ot be more similar to the caynyon-type relief of Reach 16. Consequently, it was incorporated into that latter reach thus producing two separate sections of Reach 16.

One sampling station was established to define the characteristic habitat features of a particular reach. In some cases, generally for reaches covering a greater distance, were assigned to more adequately assess the reach habitat.

3.1.3 Physical Stream Inventory

At each station, the stream habitat was quantified by a representative combination of hydraulic units or basic habitat types (generally twelve per station, with exception< noted). The seven different hydraulic units described are as follows:

Falls: Fast-moving cascading white water flowing over a definite drop in the strearnhed.

Riff le: Generally, high velocity water moving through a shallow section of stream with breaks in the water surface due to protruding or slightly submerged streambed material.

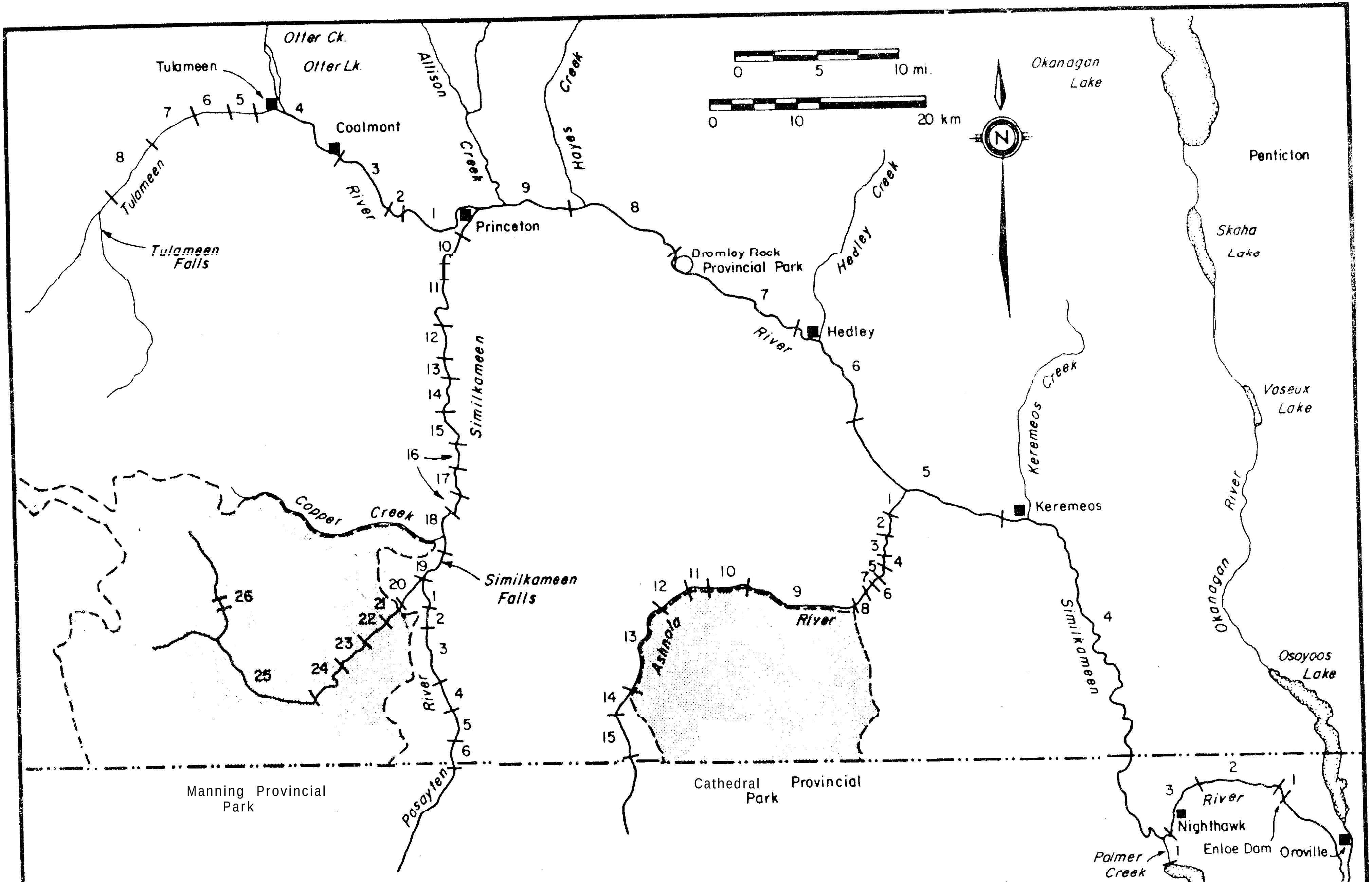

FIGURE 3 - I :Reach Divisions for the Similkameen River Study Area.

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Run: Medium to fast moving: water, generally deeper than riffles. Water surface smoother than for riffles, more rolling waves, not broken by substrate material.

Flat-Run: Medium flowing water. Smooth water surface but water movement evident.

Flat: Glass-like water surface. Reduced water velocity and generally greater depth than flat-run

Pool: A deeper and lower velocity stream section with respect to adjoining hydraulic units.

Slough: A slow to non-flowing stream section, generally of uniform depth. Usually defines an area independently, in absence of other hydraulic units.

On occasion; one hydraulic unit was found within another, for example, a pool within a riffle. In such cases, each was treated as a separate hydraulic unit though noted as nested. Habitat parameters were measured for both and the area of the smaller unit subtrac ted out to obtain the area of the main unit.

When a falls occurred in a sampling, station, only length, width and height measurements were recorded. Its potential as a fish barrier was also noted.

The physical parameters derived from the B.C. Fish and Wildlife Branch methodology (de Leeuw, 198 1) were as follows:

Length - Length of hydraulic unit in metres (m).

Wetted Width - Average stream width at the time of assessment, ie. summer low flow level, measured in metres (m).

Channel Width - Average width of stream channel bounded by rooted vegetation, measured in metres (m).

Area - Length x wetted width, measured in square metres (m2).

Average depth - Mean stream depth in mettes (m).

Average velocity - Average stream velocity measured in metres per second (m /s).

lnstream Log - Area (m2) of submerged or surface log debris, stumps, root masses, fallen trees, etc., generating suitable cover for resident salmonids.

Instream Boulders - Area (m2) of boulders in the stream, submerged and/or breaking the water surface, yielding cover for salmonids.

Instream Vegetation - Area (rn2) of submerged vegetation considered sufficiently abundant to provide adequate cover.

Overstream Vegetation - Area (m^2) of riparian vegetation overhanging the stream within one metre of the water surface, affording suitable cover for salmonids.

Cu tbanks - Wetted area (m^2) cut into banks providing protective trout cover.

Turbidity - Visual clarity or light penetration of the water. If streambed could be seen, a l+ metre rating was assigned. If not, a metre stick was lowered into the water; the point at which the tip disappeared was measured as the turhiditv value (value O-l metre).

% Gradient - Measurement of streambed slope percentage, facilitated by a Suunto optical clinometer, Model Pm-5/360 PC. An object, for example a tree branch, was flagged at eye level from the water surface. The reading was taken at the furthest distance visibly possible from the flag marking, again standing at the water surface level.

Fines - Percentage of fines, materia!s measuring up to 0.1 centimetres (cm) in d ameter, composing the streambed.

Small Gravel - Percentage of small ,gravel substrate, materials 0.1-4.0 cm in diameter.

Large Gravel - Percentage of large gravel substrate, material 4-10 cm in diameter.

Cobble - Percentage of cobble substrate, materia! IO-30 cm in diameter.

Boulder - Percentage of boulder substrate, materia! 30+ cm in diameter.

Bedrock - Percentage of bedrock exposed in the streambed.

Compaction - A relative measure of the degree of "looseness" of the streambed materiai on a scale of 0 (loose) to I (compact). Judgement was based on the ease of dislodging substrate with one's foot for reference as to substrate suitability as spawning gravel. For example, predominantly boulder Sstreambeds were generally recorded as about 0.8-0.9.

Temperature - Measured in degrees Celsius (°C) using a pocket thermometer.

The length and width measurements were taken with either a tape measure, hip chain or range finder. Velocity readings were facilitated by a Teledyne-Gurley flow meter or a Marsh-McBirney current meter. A metre stick was employed to record average depth, instream log area, instream boulder area, instream vegetation area, over-stream vegetation area, cutbank area and turbidity. The percentage composition of substrate material was assessed visually.

Contrarv to the B.C. Fish and Wildlife rnethod (de Leeuw, 1981) the instream log parameter was measured by area (length x width) and not by volume (length x width x depth). This was done to maintain consistency among the potential cover area parameters so that they could be totalled.

The following additional parameters or attributes derived from the Wyoming Game and Fish department methodology (Binns, 1982) were required for the determination of the Habitat Quality Index (HQI):

Pool Cover - Area (m^2) afforded by log debris, fallen trees, root wads, instream vegetation, submerged cutbanks, overhanging vegetation, boulders, streambed pockets etc., considered suitable cover for salmonids. A metre stick was used to determine the areas.

Eroding Bank - Measure of bank stability by recording length (m) of bank actively eroding as a percentage of the hydraulic unit length total.

Nitrate-Nitrogen - Concentration in milligrams per litre (mg/l) of nitrate-nitrogen in the stream, as a measure of productivity. Method described in the Water Quality Section 3.4.

Late summer stream flow (CPF), annual stream flow variation (ASFV) and maximum summer stream temperature determinations were calculated using available published data, as required for the HQI.

The measure of total dissolved solids (TDS) in the streams was required as a predictor of productivity in the Slaney Steelhead Model (see Section 3.5.1) for the estimation of steelhead smolt production. The method of TDS determination is described in Section 3.7.

The extent of dyking along the study sites was also measured in metres and recorded senarately.

In summarizing the data, physical parameters measured were averaged for each type of hydraulic unit present in the sampling station (runs, riffles, pools etc.) and the resulting information was extrapolated to define the habitat of the entire reach.

Although the 1983 summer field program yielded an extensive assessment of fisheries habitat throughout the mainstem Similkameen River and its major tributaries, many miles of accessible strearn habitat contained within the smaller tributaries remained unassessed. Due to the system's 9300 km^2 (3700 mi^2) drainage area and the short low flow period, time did not permit field investigations of the basin's larger creeks or the United States portions of the Pasayten and Ashnola rivers. The extent of the additional streams habitat was estimated from an analysis of limiting factors such as stream slope, flow conditions and the location of fish barriers (natural and manmade). In the case of the U.S. reaches of the Pasayten and Ashnola rivers, estimates of available habitat were made by comparing topographic maps and aerial photographs for the Washington portion with those within British Columbia (since the B.C. reaches were assessed in-field). The lengths of other main small tributaries were measured.

3.2 Fish Population Inventory

3.2.1 Sampling Site Selection

The resident fish population was sampled in each reach within the area described for habitat type. A representative sample site was selected on the basis of the habitat evaluation. Depending on the length of the reach, as with the habitat assessrnent sites, some reaches were assigned more than one station to accurately census the fish population present.

3.2.2 Fish Sampling Methods

Generally, one of two fish sampling techniques was employed at each site depending on the prominent hydraulic unit types. Electrofishing was conducted in the shallow, wadeable reaches of the streams while snorkeling facilitated fish counting in the deeper areas. A beach seine was utilized in one stream, Palmer Creek, a slough area too deep to electrofish and too turbid for visual snorkel counts. Also, angling was conducted in two reaches along the Similkameen River to provide additional biological measurements of fish from pool areas. Lastly, dip nets were implemented to sample trout fry too small to be effectively captured by the electroshocker.

In some instances, a reach was typified by pools as well as runs and riffles. Consequently, both electrofishing and snorkeling techniques were employed to accurately define the resident fish population in those reaches.

The fish sampling methods are briefly described below:

Electrofishing

Electrofishing, based on a total fish removal method (Seber and LeCren, 1967) was the main technique employed for fish censusing. A Coffelt BP-3 electroshocker facilitated fish capture by this method.

In general, a 50 metre length of stream was surveyed, isolating the section by securing fine-meshed nets to the streambed at the upper and lower borders, thus minimizing fish movement in and out of the study area. Shallow riffles or falls often provided natural upstream boundaries. The width of the fishing site varied depending on the width of the stream at a particular station. The entire strearn width was sampled where feasible, generally for the upper stream reaches. Further downstream, as the channel widened, only a portion of the stream width could be blocked off. The area (m^2) fished was noted for each site to permit later calculations.

‘Working in a downstream direction, three separate passes were made through the entire study area with the electroshocker, in an attempt to remove the resident fish population. A fishing efficiency value, defining the proportion of fish captured, was assigned to account for fish observed but not caught.

The fish captured were kept separate for each pass then categorized by species. Fork lengths in millimetres (mm) and weights in grams (g) using a triple beam balance were recorded for all fish species collected. Scale samples were taken from rainbow trout, with the exception of fry, for age determinations. All fish were returned to the stream following data recordings.

Snorkel Counts

In deeper stream sections, it was more feasible to snorkel through a specified area and count the fish present. Again, the fish were separated by species, the average fish length recorded and the sample area (m^2) noted. One or two person(s) performed the counts depending on stream width.

Additional Methods

Fish captured by beach seine, angling or dip net were sampled in the same manner as those caught by electrofisher.

3.2.3 Preliminary Analysis

The resident rainbow trout age structure was assessed by ages determined from scale samples, A binocular dissecting microscope and microfiche projector as well as reference to Greenley (1933) and Alvord (1953), facilitated the scale readings. Age classes were defined as a function of fork length frequencies and summarized by stream- The Similkameen River was assessed as two separate sections, the Similkameen Falls being the dividing factor.

Length/weight curves were derived from collected data to predict the average weights of the rainbow trout from the average lengths observed during snorkeling. The weight xw trout from for the equation to determine standing crop estimates (see Section 3.2.4) Similar plots were generated to estimate the weights of a number of sculpins and longnose dace not recorded in the field during times of high fish captures, due to time constraints.

After plotting length vs. weight values, an equation was developed to best fit a curve to the data. The data sets were separated by stream and by species. The criterion was to select a function which produced a minimum least squares value and a "logical" curve, ie. no reversals or abnormalities in the curve, particularly at the extremeties.

By utilizing a Hewlett-Packard 150 microcomputer, regression analyses were performed on each set of data using a power function, an exponential function, a linear function and various polynomial functions of up to six variables ($x + x^2 + x^3 + x^4 + x^5 + x^6$). Polynomial functions containing up to four variables (but generally three), proved to best fit the data to a curve, therefore, were used for all data sets.

For length/weight relationships, a regression line is normally determined for each age class. However, as a result of limited data for individual age groups, a best-fit curve function was calculated for the population as a whole.

It should also be noted that for these analyses, the Similkameen River was again partitioned at the falls into two distinct sections, above and below. In addition, the length and weight measurements for Iongnose dace from the Pasayten River and the Similkameen above the falls were combined due to limited data sets for each separately.

Fulton's condition factor (Ricker, 1975), one of a number of coefficients applied to measure the "plumpness" or "condition" of individual fish, was calculated from length and weight measures of the rainbow trout for relative comparisons, particularly among individuals of similar size or age class. It is determined as follows:

$$CF = \frac{W \times 100}{L^b}$$

(Ricker, 1975; Klak, 1941)

where:

CF = Condition Factor
W = Weight in grams
L = Length in centimetres
100 = A constant placing the CF value closer to unity
b = 3, used to define isometric growth

3.2.4 Resident Fish Population and Standing Crop Estimates

The fish sampling data was used to determine the resident fish population and standing crop estimates within each reach. In addition, the Habitat Quality Index (HQI) was applied to predict standing crop values for rainbow trout, by reach, based on specific habitat parameters measured.

Popuiation estimates were derived independently for the electrofishing and snorkel count results, using the following equation from Seher and LeCren (1967):

$$n = \frac{c}{p}$$

where: n = an estimate of total population size
c = number of individuals captured
P = an estimate of proportion of fish captured (efficiency value)

In the case of electrofishing, the efficiency value or "P' varied from site to site. Alternatively, the snorkel counts were assumed to be 100% efficient, therefore, the "P" value remained constant. Densities (no./m^2) were subsequently determined from the population estimates for each site.

The standing crop estimates for all major fish species were calculated for each hydraulic unit type sampled within a reach. This was done by dividing the total weight of the fish species caught by the total area sampled. The individual species values were then summed to provide a total standing crop estimate for the reach. When both electrofishing and snorkel count techniques were applied to sample a particular type of hydraulic unit present in a reach, the results were combined for standing crop determinations.

In limited cases, a particular v hydraulic unit could not be sampled due to inaccessibility or time constraints. The estimated standing crop derived for a representative hydraulic unit from a nearby reach was substituted in these cases.

throughout the fishing survey, the run/riffle sequence was a prominent component of the fish habitat present. As such, it was often treated as one hydraulic unit type in the population sampling. Sampling the hydraulic units independently would have been excessively time consuming and would not have justifiably increased the accuracy of the population estimate. Subdampling the two types of hydraulic units simultaneously provided sufficient information on the fish populations within the reaches.

As mentioned previously, fish observed snorkeling were measured for average length only. Consequently, weight values were predicted by applying regression analyses to the length/weight data collected. Data sets were compiled on a stream-specific and species-specific basis. The weight measurements for a number of non-salmonids caught by electroshocker were derived from similar plots. Additional average weight values were obtained from the literature.

Standing crop and population estimates for rainbow trout were not calculated on an age-specific basis due to an insufficient number of fish captured within each age group.

Trout standing crop potential was predicted from nine habitat parameters or attributes, for relative comparisons to the standing crop estimates calcuiated from the actual fish population inventoried. The Habitat Quality Index (HQI), a procedure developed by the Wyoming Game and Fish Department (Binns, 1982) for predicting trout standing crop, was implemented for these purposes.

The attributes measured for the HQI included late summer stream flow (CPF or mean daily flow during this period) as compared to annual mean daily flow, annual stream flow variation (annual peak flow/annual iow flow), maximum summer stream temperature, nitrate-nitrogen content, trout cover, bank erosion, vegetation supported bv substrate, water velocity and wetted stream width.

In essence, the HQI method interprets the actual measurements of nine parameters or attributes as to their suitability, collectively, to support trout populations. Recorded values of the HQI attributes were assigned a rating between 0 (least optimal to support trout) and 4 (optimal to support trout) on the basis of a standardized criterion (Table 3- 1). The resulting ratings were then inserted into the HQI formula to calculate the HQI score or standing crop estimate (Ibs./acre or kg/hectare). The HQI formula (Model II) is presented as follows:

TABLE 3-1

HABITAT QUALITY INDEX (HQI) CRITERION FOR RATING HQI ATTRIBUTES (BINNS, 1982)

Habitat Attribute	0 (Least Optimum)	1	2	3	4 (Optimum)
Late Summer Stream Flow (CPF)	< 10% ADF[2]	10-15% ADF[2]	16-25% ADF[2]	26-55% ADF[2]	>55% ADF[2]
ASFV Ratio[3]	> 500	100-499	40-99	16-39	0-15
Maximum Summer Stream Temperature °F (°C)	< 43°(6°) or > 80°(26.4°)	43-46°(6-8°) or 76-79°(24.2-26.3°)	47-50°(8.1-10.3°) or 71-75°(21.5-24.1°)	51-54°(10.4-12.5°) or 66-70°(18.7-21.4°)	55-65°(12.6-18.6°)
Nitrate-Nitrogen (mg/l)	< 0.01 or > 2.0	0.01-0.04 or 0.91-2.0	0.05-0.09 or 0.51-0.90	0.10-0.14 or 0.26-0.50	0.15-0.25
Cover (%)	< 10	10-25	26-40	41-55	> 55
Eroding Banks (%)	75-100	50-74	25-49	10-24	0-9
Substrate[4] (submerged) aquatic vegetation	Lacking submerged aquatic veg.	Little submerged aquatic veg.	Occasional submerged aquatic veg.	Frequent submerged aquatic veg.	Abundant submerged aquatic veg.
Water Velocity ft/sec (cm/sec)	< 0.25 (<8) >4.0 (>122)	0.25-0.49(8-15.4) 3.5-3.99(106.6-122)	0.50-0.99(15.5-30.3) 3.0-3.49(91.4-106.5)	1.0-1.49(30.4-45.5) 2.50-2.99(76.1-91.3)	1.50-2.49(45.6-76)
Wetted Stream Width feet (metres)	< 2 (0.6) or > 150 (46)	2-6(0.6-2.0) or 75-149(23-46)	7-11(2.1-3.5) or 50-74(15.1-22.9)	12-17(3.6-5.3) or 23-49(6.7-15)	18-22(5.4-6.6)

1 CPF = critical period flow or mean daily flow during late summer period.

2 ADF = mean daily flow for the water year.

3 ASFV Ratio = Annual Stream Flow Variation Ratio = Annual Peak Flow (cfs)/Annual Low Flow (cfs)

4 A visual assessment of attached submerged aquatic vegetation as an estimate of fish food (macroinvertebrate) occurrence.

$$\text{HOI Score} = \text{antilog}_{10}(\log_{10}(y + 1)) - 1$$

$$\log_{10}(y + 1) = (-0.903) + (0.807)\log_{10}(x_1 + 1) + (0.877)\log_{10}(x_2 + 1) + (1.233)\log_{10}(x_3 + 1) + (0.631)\log_{10}(F + 1) + (0.182)\log_{10}(S + 1)$$

where:

- y = Predicted trout standing crop (lbs./acre) (multiply by 1.12085 for kg/hectare)
- x_1 = Late summer stream flow (CPF)
- x_2 = Annual stream flow variation (ASFV)
- x_3 = Maximum summer stream temperature
- x_4 = Nitrate-nitrogen
- F = Food index $(x_3)(x_4)(x_9)(x_{10})$
- S = Shelter index $(x_7)(x_8)(x_{11})$
- x_7 = Cover
- x_8 = Eroding stream banks
- x_9 = Substrate
- x_{10} = Water velocity
- x_{11} = Stream width

Data was obtained mainly from field assessments with additional information provided by published streamflow data from Government gauging stations (WSC, USGS).

3.3 Potential Anadromous Salmonid Spawning Area and Capacity

The probability-of-use criteria, developed by Bovee (1978) for the family Salmonidae, were employed to provide estimates of steelhead trout and chinook salmon spawning area within the Similkameen River system by considering the hydraulic parameters of depth, velocity and substrate. Habitat inventory summaries of data collected during the field program were then applied to the above parameters.

Within each reach, the habitat data for the area present of each different hydraulic unit ie. run, riffle, etc., excluding pools (no spawning potential), were applied to the probability-of-u.se curves, individually. This provided information on the most suitable ctreatn feature (hydraulic unit) present for spawning by the particular species. The areas of spawning substrate and spawnable area (a!! three probability-of-use parameters included), by hydraulic unit, were then summed to provide totals for the whole reach and secondarily, the stream.

Spawner capacity by species for each area of hydraulic unit within each reach was determined by dividing the area requirement for a pair of spawners (13.4 m^2 for spring chinook, and 19.6 m^2 for steelhead, Reiser and Bjornn, 1979) into the calculated spawnnble area and multiplying by two (two fish per pair). The capacities by hydraulic unit were then totalled to provide the value for the whole reach, the stream and for the entire system.

3.4 Potential Anadromus Salmonid Rearing Area

Potential rearing area, within the Similkameen River drainage, for juvenile chinook salmor and steelhead trout was calculated using probability-of-use criteria as outlined by Bovee (1978). Probability-of-use curves for each species were developed by Rovee for the hydraulic parameters of depth, velocity, substrate and temperature. The summary inventory data for each tvpe of hydraulic unit within each Similkameen River system reach was then applied to these curves. A propability-of-use was obtained for each hydraulic parameter. These were then multiplied together to obtain the total probability-of-use value. The total probability was multiplied by the total area of that type of hydraulic unit within the reach to obtain the potential rearing area within that unit.

3.5 Anadromous Salmonid Production Estimates

3.5.1 Slaney Steelhead Trout Mode!

Steelhead trout production estirnates were determined by the Slaney Stee!head Model (Slaey, 1981). The model was used to predictt both mean annual smolt yield/m^2 and mean adult steelhead return, for each reach within thev study area.

The basic mode!, presented in Table 3-2, required a few changes to make it more applicable ta the study area. Slaney's estimate of 10 percent mean smolt-to-adult surviva! rate calculated for the Keogh River (a coastal B.C. stream), was too high to be applied to an interior stream such as the Similkameen River. Therefore, the rates of 1.5 oercent rnean smolt-to-asult survival and 4.0 percent maximum smolt-to-adult surviva l were used. These values were derived for the Wells Hatchery stock of the Methow River, an upper Columbia River tributary, by the Washington Department of Came (Williams, pers. comm., 1983).

The Steelhead Model incorporates a mean increment of 1.1 for repeat spawners. The Washington Department of Game (1984) noted that no repeat spawners returned to the Methow River. Accordingly, the mean increment value for repeat spawners was changed to 1.0 (no repeat spawners) for applicability to the Similkameen River system.

After these changes were incorporated into the model, habitat inventory data provided the remaining parameters required to calculate the mean annual smolt yield/m^2 and mean adult return for each stream reach. The total dissolved solids (TDS) value for each reach was obtained from water samples collected at representative sites within the Similkameen River drainage. Mean annual water temperaures used in the model calculations, were derived from published data (Environment Canada, 1977).

An additional method for calculating potential production estimates was utilized. This method involved using the spatial requirements of juvenile steelhead, ranging from 14.49 m^2 for I+ to 26.14 m^2 for II+ juveniles (Reiser and Bjornn, 1979). The spatial requirement was then divided into the total (gross) stream area to obtain the number of smolts that could be produced from the system. Adult returns were also calculated using 1.5% and 4% smolt-to-adult survival rates.

3.5.2 Chinook Salmon

A suitable mode! for predicting chinook salmon production, comparable tov the Slaney Steelhead Mode!, has yet to be devised. Consequently, chinook salmon smolt production, for the Similkameen River system, was estimated using an average of

TABLE 3-2

PRELIMINARY (REVISED) SLANEY STEELHEAD MODEL (SLANEY, 1981)

MEAN ADULT RUN = S (0.10) (m^2) (1.1)

S = mean annual smolt yield/m^2
0.10 = mean smolt-to-adult survival rate
m^2 = no. of square metres of mainstem and tributaries at median summer flows and utilized by juvenile steelhead trout
1.1 = mean increment of repeat spawners

MEAN ANNUAL SMOLT YIELD/m^2 = S = $H_s\left(\frac{N_s}{0.02}\right)\left(\frac{T}{9}\right)$

N_s = annual smolt yield/m^2 @ TDSx = 0.00049x + 0.0037
T = mean annual stream temperature in °C.
H_s = habitat smolt yield (no./m^2)
= 0.4 (P_{Ri} + P_{Ru} + P_{Fu} + P_P + P_{Fl} + P_{Bw})

0.02 = mean smolt yield of the Keogh River @ TDS = 32 mg/l
9 = mean annual water temperature (°C) of the Keogh River
0.4 = $\frac{\text{mean smolt yield/m}^2}{\text{mean summer parr density/m}^2}$ in the Keogh River
P_{Ri} = mean parr density in Riffles
= (0.0029b + 0.0031c - 0.004) (A_{Ri}/A_s)
P_{Ru} = mean parr density in Runs = (0.135) (A_{Ru}/A_s)
P_{Fu} = mean parr density in Flat Runs = (0.078) (A_p/A_s)
P_P = mean parr density in Pools = (0.064) (A_p/A_s)
P_{Fl} - mean parr density in Flats = (0.017) (A_{Fl}/A_s)
P_{Bw} = mean parr density in Rackwaters = (0.008) (A_{Bw}/A_s)

Constants 0.135 to 0.008 = mean sumrner parr densities from Keogh River; n=116
A_{Ru} to A_{Bw} = areas (m^2) of habitat classes at median summer flows
A_s = total area utilized bv juvenile steelhead at median summer flows
b = % of Riffle wetted area comprised of protruding boulders (+ 30cm in diameter)
c = % of Riffle wetted area comprised of overstream cover i.e. cutbanks, roots, debris, logs and vegetation within 1 metre of the water surface

several production rates from interior streams in British Columbia, Oregon and Idaho. These production rates, based on both stream area and strearn length, were then applied to the Similkameen, Ashnola, Tulameen and Pasayten rivers to obtain two smolt production estimates for each river. Though the two estimates of smolt production were calculated, it is felt that stream length is not as accurate a function of smoit yield as stream area and should be used with caution, for estimating smolt production capability (Stream Enhancement Research Committee, 1980).

The production rates used for estimating chinook smolt production, based on stream length, were obtained from the Lemhi River, Idaho, 5000 smolts/km (Bjornn, 1978) and Deasman River, B.C., 3,130 smolts/km (Stream Enhancement Research Committee, 1980). The resulting average of the two streams, 4050 smolts/km, was used to calculate smolt production by stream length, in the Similkameen River system.

Production rates, based on stream area, were obtained from the Lemhi River, Idaho 0.45 smolts/m^2 (Bjornn, 1978), and 0.70 smolts/m^2 (Oregon Dept. of Fish and Wildlife, 1977), Deadman River, B.C., 0.41 smolts/m^2 (Stream Enhancement Research Committee, 1980), Big Springs Creek, Idaho, 0.474 smolts/^{2}(Oregon Dept. of Fish and Wildlife, 1977) and lookingglass Creek, Oregon, 0.3 12 smolts/m^2 (Oregon Dept. of Fish and Wildlife, 1977), yielding an average of 0.47 smolts/m^2. The average was used to calculate smolt production by stream area in the Similkameen River system.

Adult returns were determined on the basis of estimated smolt production at a 0.3% srnolt-to-adult survival rate. The srnolt-to-adult survival rate was obtained from a preliminary Upper Columbia Basin summer chinook stock assessment undertaken by the Washington Department of Fisheries (1984).

3.6 Hydrology

3.6.1 Field Techniques

The discharges of streams in the study area were measured during the 1983 field program for two reasons. First, they provided actual on-site data which could be used in support of estimated flows for streams without gauging stations, and second, they allow a comparison with long-term averages to determine whether the streamflow conditions experienced during the field investigations were typical, and if not, how thev differed.

Stream discharges were measured by the standard method employed by both the Water Survey of Canada (WSC) and the United States Geological Survey (USGS). The stream cross-section is divided into a minimum of twenty sections, with no one section having more than ten percent of the total stream flow. The depth and mean velocity of each section is measured. The discharge of each section is determined by multiplying together the respective values of width, mean depth and mean velocity. These discharges are summed to obtain a total stream discharge.

Velocities were measured with a Teledyne-Gurley model 622 flow meter attached to a calibrated wading rod. Mean velocity is measured at 0.6 times the depth for water less than one meter, deep, When the depth is greater than one metre, velocity is measured at 0.2 and 0.8 depths, and averaged to obtain a mean water velocity.

Water temperatures were recorded at the time of all stream discharge measurements.

3.6.2 Published Data

Surface water data are collected by two government agencies in British Columbia. The Water Survey of Canada (Environment Canada) and the B.C. Ministry of Environment both monitor stream discharges and !ake levels. Data from both government sources and other contributors are compiled and published by the Water Survey of Canada (WSC) In general, data for WSC stations are of longer continuous duration than those of other contributors.

The Water Survey of Canada has published records for 61 sites in the Similkameen River Basin (Environment Canada, 1982). There are 52 streamflow gauging sites (19 active and 33 discontinued) and nine lake level gauging sites (three active and six discontinued). The period of record and type of data vary from station to station. Many of the gauging stations were established primarily as water management monitoring stations in areas of high agricultural (irrigation) use. These stations operate between April 1st and September 30th only. Surface water data is published yearly, with an historical summary being published every three years.

Surface water discharges in Washington State are monitored by the Water Resources Division of the United States Geological Survey (USGS). Hydrometric stations above the Enloe Dam include the internationaf gauging station near Nighthawk and two discontinued stations on smaller streams.

Figure 3-2 shows the locations of all hydrometric stations.

3.6.3 Data Analyses

The most recent edition of the Historical Streamflow Summary for British Columbia (Environment Canada, 1980) includes data up to the end of 1979. Annual publications were used to update all station records to the end of 1982 (Environment Canada, 1983), For every streamflow monitoring station, either active or discontinued, new values of mean flows and extreme flows were calculated. Mean flows included the average dailv discharge for each month and the year, and the mean annual runoff. Mean values were calculated only when five or more years of data were available. Extreme flows included the maximum daily discharge and the minimum daily discharge. Since most streams in the Similkameen River Basin exhibit two low flow events each year, two sets of low flow data were generated. The two seasonal low flow events are separated by fall rainstorms which tend to peak in late Novernber. For this reason, late summer/fall low flows are defined as those occurring between the spring freshet and November 30th. Winter/spring low flows are therefore defined as those occurring between December 1st and the following spring freshet. Eight years was used as the minimum number of vears necessary for calculating extreme values.

While mean values of stream discharges were calculated as averages of flow data, extreme values involved a statistical probability computation. For each station, and for each of the three types of extreme values, the “Log-Pearson Type III Distribution” was determined using a Hewlett-Packard 150 microcomputer. This allows the prediction of the probability of other extreme values‘ Probability is expressed as the “recurrence interval”, the number of years in which an event (discharge of given

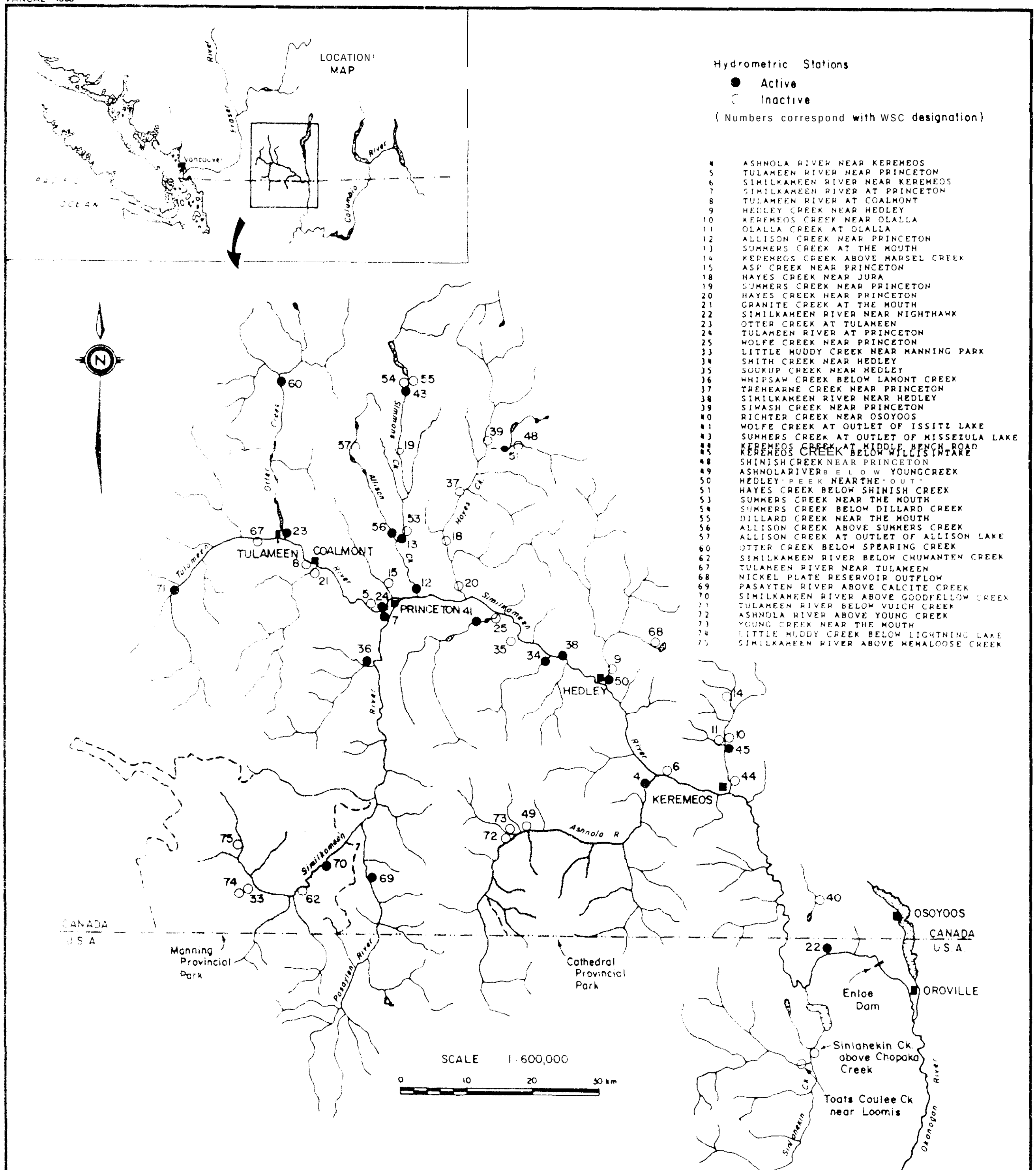

FIGURE 3-2: Location of Hydrometric Stations.

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magnitude) will be equalled or exceeded. For further discussion on probability of streamflow events refer to tinslev, et al. (1982).

Since most regional analyses necessitate the use of flow data expressed as a discharge (or runoff) per unit area, the drainage areas of all monitoring sites were required. WSC indicates the drainage areas of most of its gauging stations in its publications. those not given, and the drainage areas of sites measured by IEC Beak had to be determined. A compensating planimeter was used to measure these catchment areas on 1:50,000 scale topographic maps.

3.7 Water Quality

3.7.1 Field Techniques

During the field investigations, temperatures were monitored by spot measurements made with pocket thermometers at habitat assessment locations. Since each location was visited only once, the spot measurements do not provide a continuous record of temperature at any one location. For this reason, five Peabody-Ryan continuous recording thermographs were installed so that the temperature changes could be more accurately assessed. ‘pot temperatures are sornewhat biassed since they are all measured during the warmer daylight hours. The thermograph results allow diurnal fluctuations to be assessed. Coincident with stream discharge measurements at smaller streams, spot temperatures were recorded providing a list of water temperatures for strearns outside of the habitat assessment reaches.

Water samples were collected at thirteen sites during the late summer fieldwork. These samples were sent to the IEC Beak Analytical Laboratory immediately after collection for analysis of total dissolved solids (TDS) and nitrate-nitrogen. An unpreserved 1000 ml sample was collected for TDS analysis and a 250 ml sample for nitrate-nitrogen analvsis. The nitrate-nitrogen sample was preserved with 2 ml of concentrated sulfuric acid (H_2SO_4).

3.7 2 Published Data

Water qualitv data is collected by various government agencies in Canada and the In i fed States. In British Columbia, the B.C. Ministry of Environment periodically collects water samples throughout the basin for chemical analysis. Water temperature data has been summarized bv the Water Survey of Canada (Environment Canada, 1977) from their streamflow measurement records. In Washington State, the Department of Ecologv (1973) and the 1J.S. Geological Survey (Water Resources Division) (1983) colect and publish water quality and temperature data.

4.0 RESULTS AND DISCUSSION

4. I Habitat Inventory

The physical characteristics of a stream are among the factors considered in determining stream suitability for fish useage. The Similkameen River and its tributaries exhibit a diverse range of physical conditions which is reflected by the equally diverse estimates of standing crops and potential fish production throughout the system.

Figure 4-f illustrates the difference in stream profiles by plotting stream elevations versus distance from the mouth of the Similkameen River near Oroville, Washington. The Similkameen River, in general, increases in gradient towards its headwaters. Noticeable changes in the gradient occur at the confluences with the Tulameen and Pasayten rivers. Above the Tulameen River, the Similkameen becomes steeper. The Similkameen River increases its gradient further just below the Pasayten River, but then flattens out above the confluence.

the valley of the Similkameen River is narrow and steep-sided near the Enloe Dam reservoir, but upstream of Palmer Creek it takes on a flat-bottomed, V-shaped configuration with a floodplain ranging between two and three kilometres in width. The valley, in general, becomes narrower upstream of Keremeos, with many canyon-like sections beyond Princeton, Upstream of the Pasavten River confluence, the valley regains a fiat-bottomed configuration, allowing the river to meander through Manning Provincial Park to its headwaters.

Cobbles and large gravel are the dominant streambed materials in the lower sections of the river and above Similkameen Falls. Bulders form a major fraction of the substrates in the middle sections of the river between Hedley and Similkameen Falls, with a few bedrock controlled sections through the canyons. Although the largest pools occur in the canyons, the greatest percentages of pool cover (highest pool:riffle ratios) exist in the river from Enloe dam upstream to Princeton.

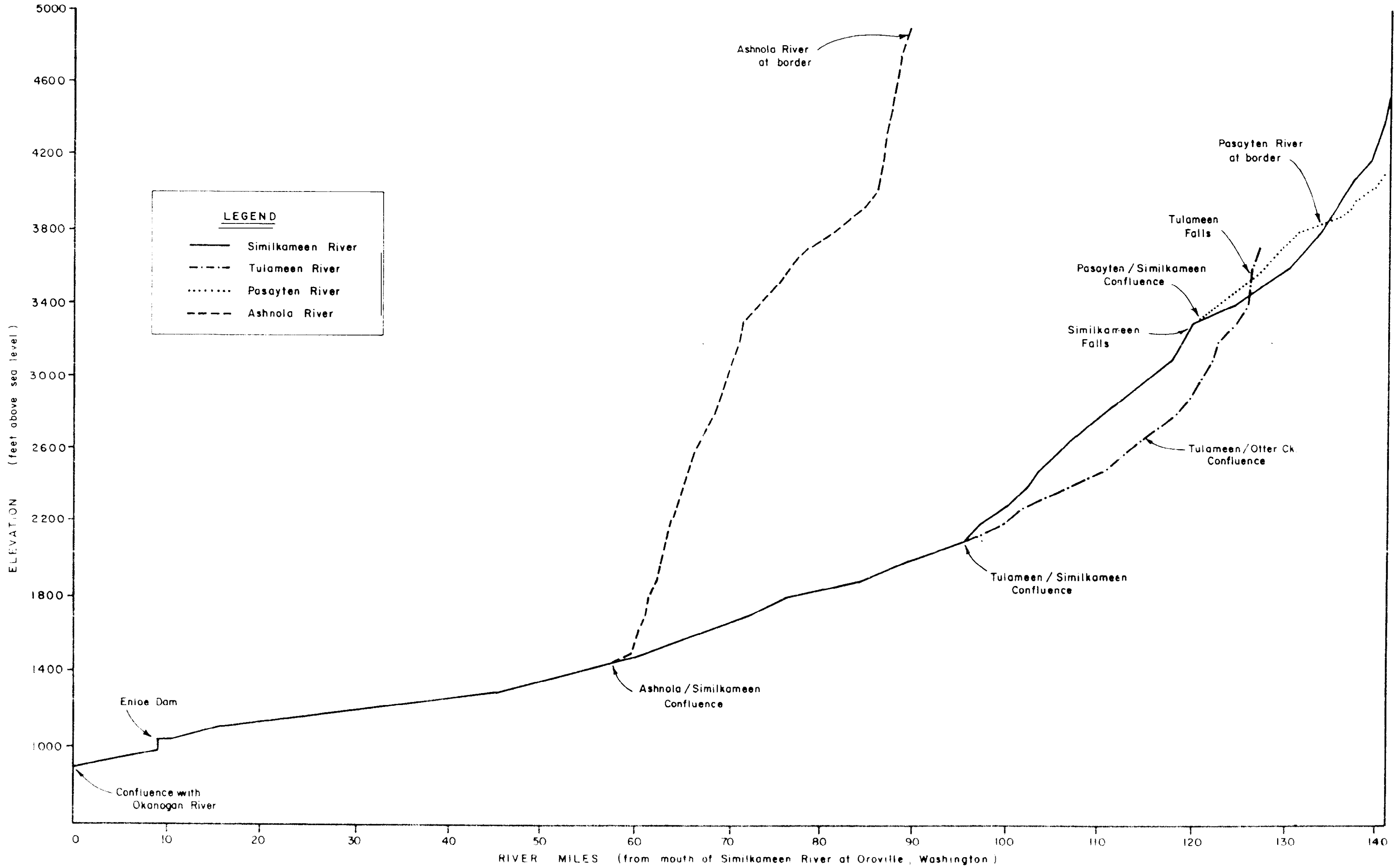

FIGURE 4.1 : Similkameen River System Stream Gradient Profile.

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The Tulameen River has a lower gradient in its lower reaches than the Similkameen upstream of their confluence. The Tulameen, however, increases in gradient so that both rivers reach an equal elevation (approx.3440 feet) at about 127 river miles from the mouth of the Similkameen River.

The valley of the Tulameen River is generally quite narrow and steep-sided with the exception of a relatively wide (1 kilometre) section between the towns of Coalmont and Tulameen. In the lower reaches of the river, cobbles and large gravels prevail. Further upstream, boulders become more common and bedrock controlled sections create chutes and rapids. Pool cover is plentiful through most of the Tulameen River to Lawless Creek (River Mile 22).

The Pasayten River is steeper in its lower reaches than the Similkameen above the confluence. The profiles cross, however, as the Similkameen River rises steeply into its headwaters a short distance upstream.

The Pasayten River's valley is V-shaped in configuration through most of its length except near the international boundary where the river meanders slightly on a floodplain of between 400 and 600 metres in width. Streambed materials are typically cobbles and boulders. Finer materials (large gravels) are more common near the border and in the lowest reach of the river.

The most noticeable feature of Figure 4-l is the profile of the Ashnola River and its deviation from those of the other streams. Above its confluence with the Similkameen, the Ashnola River rises rapidly to its headwaters in Cathedral Lakes Provincial Park. The steep river profile is characterized by canyons, rapids and chutes.

In general, the valey of the Ashnola River is very narrow with steep walls. Between Lakeview and Duruisseau creeks, a valley flat of between 200 and 500 metres allows some lateral shifting of the channel. Reaches 1 and 2 (river mouth to canyon entrance) flow over an alluvial fan which widens to about 3 kilometres at the mouth. Substrate materials are most cornmonlv boulders and cobbles. In the relatively flat river sections between Lakeview and Durcisseau creeks, large gravels occur in a large propor t ion. Above Duruisseau Creek, bedrock is common. Pool cover is quite variable throughou t the Ash nola River. The greatest percentages are found in the reaches between lakeview and Duruisseau creeks.

Figures 4-2 and 4-3 portray the river profiles individually with an accompanying reach-by-reach indication of substrate composition.

A more detailed account of the physical habitat parameters, on a reach-by-reach basis, has been provided in Appendix 1. In addition, Figures A-l through A-28 presented in Appendix 2 indicate the resulting reach divisions, sampling stations, stream morphology and resident fish species over the entire study area. The fish data collected has been assessed in the next section (Section 4.2).

During the 1983 summer program, the field crews assessed approximately 400 kilometres (250 miles) of stream by making detailed biophysical inventories at 77 representative sites. The length of streams inventoried in detail, totaled about 43 kilometres (27 miles), thus the goal of inventorying 10% of the stream length assessed was reached (slightly over 11% was inventoried).

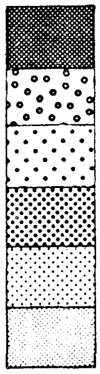
In additon to the nearly 400 km (250 miles) of stream assessed by the field crews, a minimum of 160 km (98 miles) of the Similkameen River system is likely to contain habitat suitable for anadromus fish. These stream reaches include the U.S. portions of the Pasayten and Ashnola rivers and several of the system's larger creeks.

The extent of these additional streams was determined by assessing their slopes, hydrological conditions and the existence of any natura1 or manmade barriers. Steep gradients and poor flow conditions (extreme velocities, summer droughts, etc.) eliminated manv sections of the unassessed streams. Fish blockages such as waterfalls or manmade fish barriers further reduced the amount of accessible stream.

Stream sections which have been identified as likely to have favourable habitat for steelhead trout and/or chinook salmon (other than the field-assessed reaches) and their lengths i ncluds:

SUBSTRATE PROFILE LEGEND
FOR FIGURES 4-2 and 4-3

Substrate Composition



Bedrock

Boulders

Cobbles

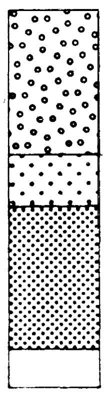
Large Gravel

Small Gravel

Fines

Note: Only the dominant substrates (those totalling at least 75%) are illustrated. The blank represents the remaining substrates. All six substrate classes are not necessarily present.

Example



38% Boulders

14% Cobbles

39% Large Gravel

9% Others

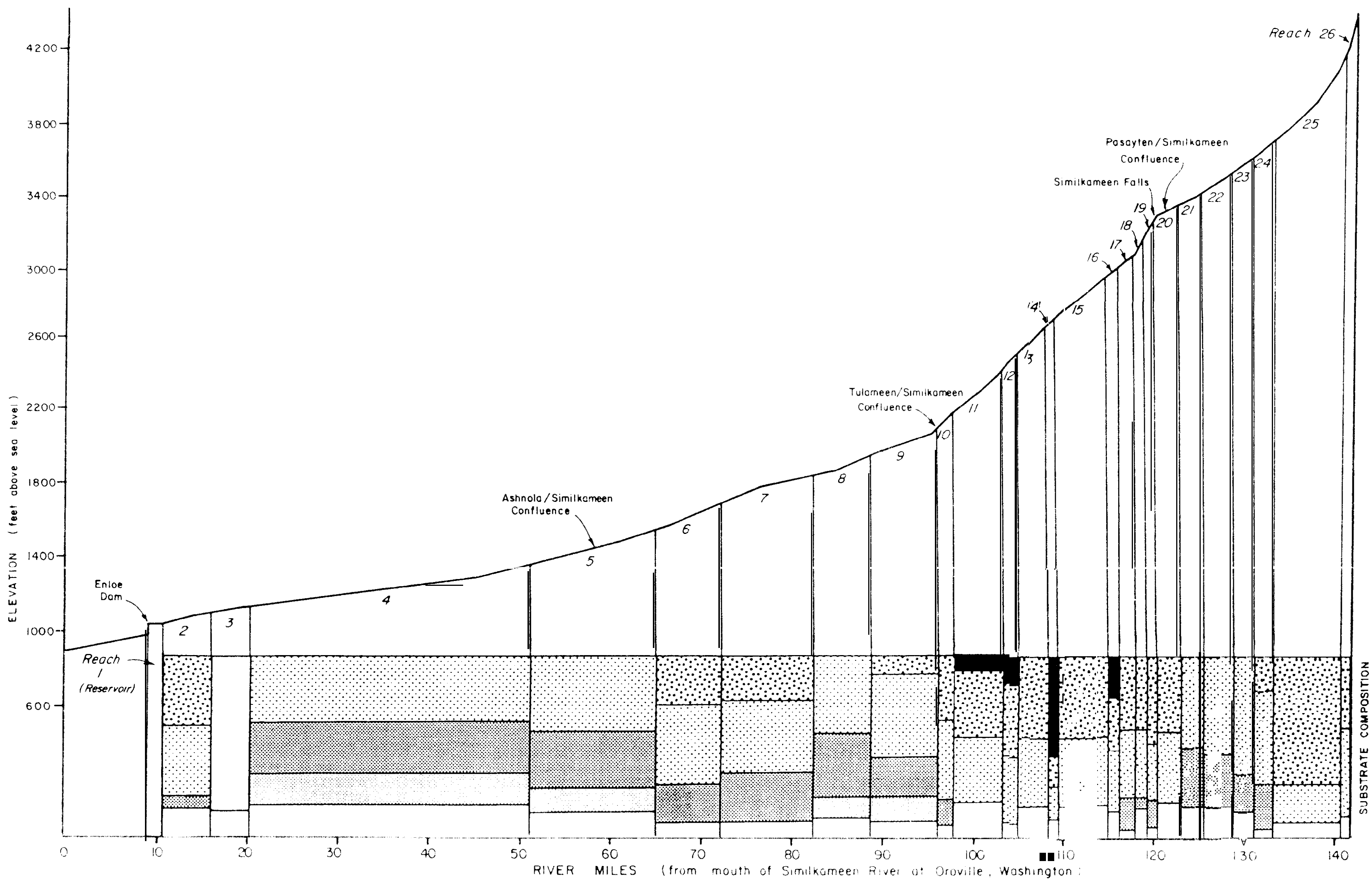


FIGURE 4-2 : Substrate Profile by Reach for the Similkameen River.

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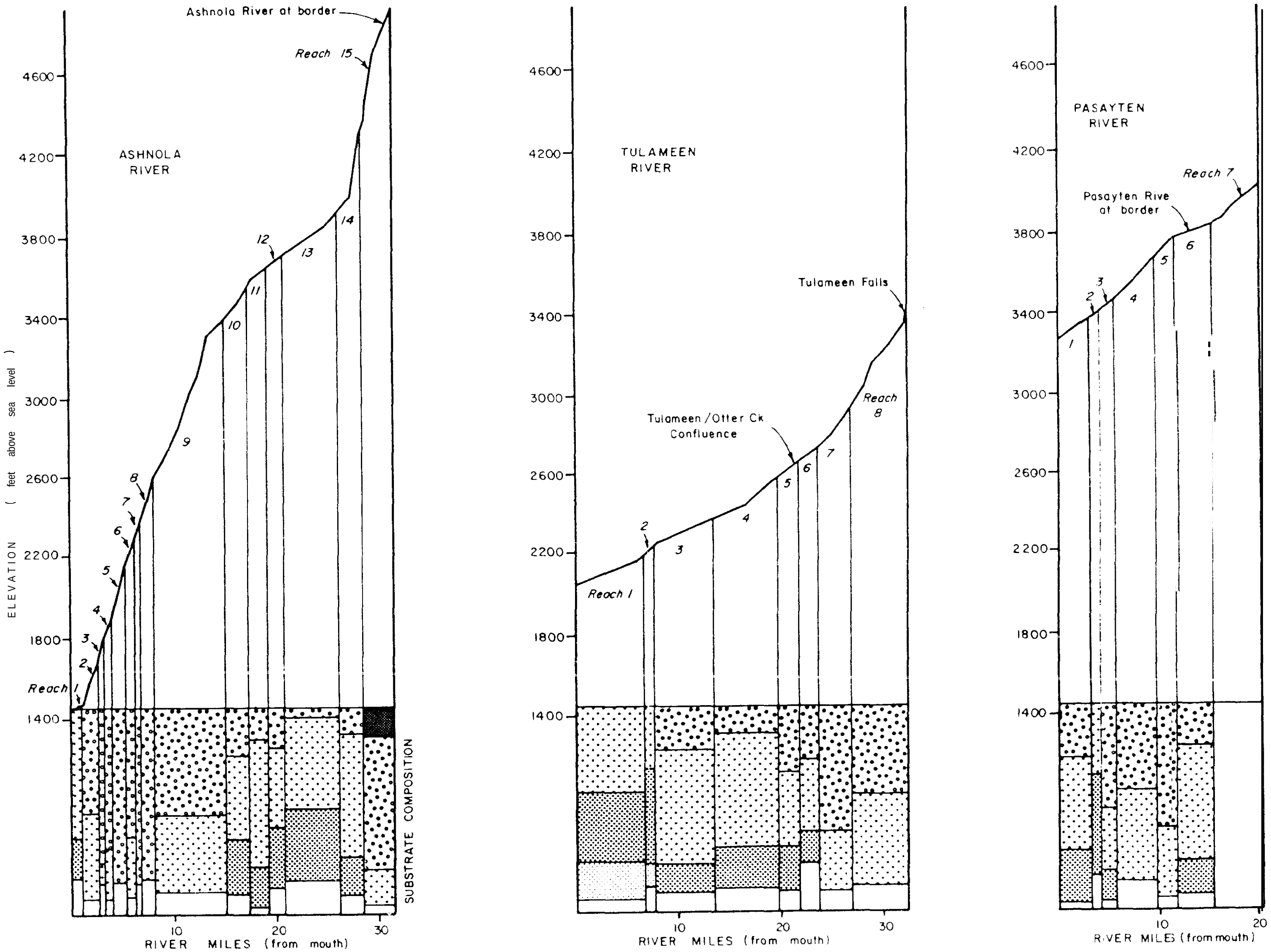

FIGURE 4-3 : Substrate Profile by Reach for the Ashnola, Tulameen and Pasayten Rivers.

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Pasayten River south of border	49 km (30 mi)
Ashnola River south of border	12 km (7 mi)
Allison Creek to 1st fish barrier	19 km (12 mi)
Summers Creek to Missezula Lake	28 km (17 mi)
Yayes Creek to Siwash Creek	30 km (19 mi)
Ycremeos Creek	15 km (9 mi)
Wolfe Creek	7 km (4 mi)
TOTAL	160 km (98 mi)

4.2 Fish Population Inventory

4.2.1 Population Characteristics

Rainbow trout (Salmo gairdneri), which occur naturally in the Similkameen River system: are the main sport species. Their distribution and abundance varied throughout the system with a possible limitation south of the Canada/U.S. border to the Enloe Dam, where none were observed. Other fish caught or observed included mountain whitefish (Prosopium williamsoni), bridgelip suckers (Catostomus columhianus), longnose dace (Rhinichthys cataractae), sculpins (Cottus sp.), northern squawfish (Ptychocheilus oregonensis), and black crappie (Pomoxis nigromaculatus). In addition, a small number of kokanee salmon (Oncorhynchus nerka), either dead or spawned ou t, was observed in Sinlahekin Creek.

Table 4.1 provides a summary of the resident fish numbers and relative abundances captured or observed in the Similkameen River system, during the field study. The Similkameen River below Similkameen Falls, supports the largest diversity of fish, predominantly mountain whitefish and bridgelip suckers. In contrast, the Similkameen River above Similkameen Falls and the Pasavten River, supports only two species, rainbow trout and longnose dace.

In summarizing the information on a stream-by-stream basis, the Similkameen River was divided into two sections at the Similkameen Falls due to of the falls" potential to limit species distribution. Fo- example, only rainbow trout and iongnose dace occurred above the falls in either the Similkameen or Pnsayten rivers, while both species as well as sculpins were observed immediately below the falls.

TABLE 4-1

SUMMARY OF SIMILKAMEEN RIVER SYSTEM, RESIDENT FISH CAUGHT OR OBSERVED DURING 1983 FIELD SEASON

Streams	Resident Fish Species Caught or Observed (No.)							Total No. by Stream
	Rainbow Trout	Mountain Whitefish	Sculpins	Longnose Dace	Bridgelip Suckers	Northern Squawfish	Black Crappie	
Similkameen River Below Falls	87	1,717	261	82	988	58	1	3,194
Similkameen River Above Falls	97			49				146
Ashnola River	182	2	129	9	-	-	-	322
Tulameen River	73	84	71	29				257
Pasayten River	45			10				55
Total No. by Species	484	1,803	461	179	988	58	1	3,974

Figures 4-i through A-28 presented in Appendix 2, illustrate the fish species caught or observed at each station within the study area in addition to reach breaks, sampling sites, stream gradient and substrate composition. For a detailed account of the fish data collected, including numbers caught or counted by specific techniques, length/weight measurements recorded and resulting condition factors and age classes, refer to Appendix 3.

The raibow trout data provided the focal point for the analyses. The incidental species were mainly assessed as to their contribution to the total standing crop, population densities and potential as competitors with rainbow trout, for all the streams studied.

The age structure of the rainbow trout population was constructed from the data collected by electrof ishing. Table 4-2 summarizes the mean fork lengths and weights of each age class, again on a stream-specific basis. Figures 4-4 through 4-8 depict individual age classes as a function of length-frequencies on a stream-specific basis.

Growth appears to be relatively siow in the Similkameen River system, particularly in the Ashnola River. This may be attributed to the generally colder water temperatures and low overall productivity as indicated bv the strearn's TDS and nitrate-nitrogen concentrations. British Columbian Streams in the Thompson River system, an upper tributar of the Fraser River, exhibit much higher growth rates of rainbow trout than found in the Similkameen River by stem (Tredger, 98Oa; Tredger, 1980b). Productivity was sited as a factor influencing the growth rate in the Thompson River streatns.

Although the data collected provides a good basis for age structure of the resident rainbow trout populations, the actual values must be interpreted with caution due to the low numbers of individuals within the age groups. In addition, the electrofishing technique itself introduces some bias by inefficiently representing the young-of-the year and the older age classes.

TABLE 4-2
MEAN FORK LENGTH AND WEIGHT OF RAINBOW TROUT IN THE SIMILKAMEEN RIVER SYSTEM

Similkameen River Above Falls (August 16-25, 1983) Total n = 97

Age Class	n	Mean Fork Length (mm!	S.D.	Length Range	Mean Weight (g)	S . D .	Weight Range
o+	9	23.4	1.6	22-26	-		
l+	31	70.7	6.6	54-85	4.7	1.1	2.5-6.5
2+	38	104.4	10.6	80- 126	13.2	4.4	6.0-24.5
3+	18	153.3	13.5	131-178	41.3	11.7	26.9-68.0
4+	1	205.0		205	72.0		72.0

Similkameen River Below Falls (August 27 - October 10, 1983) Total n = 49

Age Class	n	Mean Fork Length (mm)	S.D.	Length Range	Mean Weitht (g)	S . D .	Weight Range
o+	22	33.3	8.3	22-47	-		
1+	5	70.0	12.0	61-87	4.9	1.9	2.3-7.2
2+	8	106.2	13.2	84- 122	15.5	4.8	8.0-22.5
3+	8	162.	18.4	130-185	47.4	15.5	22.9-66.0
4+	3	222.3	17.6	202-245	116.9	21.3	87.2- 136.4
5+	3	306.7	17.0	290-330	272.0	34.7	230.0-314.9

Pasayten River (August 21-25, 1983) Total n = 45

Age Class		Mean Fork Length (mm)	S.D.	Length Range	Mean Weight (g)	S.D.	Weight Range
o+	1	25.0					
1+	19	64.2	9.5	50-88	4.4	1.2	1.5-7.0
2+	13	107.2	11.9	89-125	14.0	4.4	8.1-20.5
3+	9	146.1	12.8	130-164	32.5	8.5	20.0-51.0
4+	3	190.0	10.6	177-203	73.9	12.1	5%. 5-88.2

TABLE 4-2 (Continued)
MEAN FORK LENGTH AND WEIGHT OF RAINBOW TROUT IN THE SIMILKAMEEN RIVER SYSTEM

Tulameen River (September 2-7, 1983) Total n = 70

Age Class	n	Mean Fork Length (mm)	S.D.	Length Range	Mean Weight (g)	S.D.	Weight Range
o+	12	46.6	4.3	40-52	2.1	0.9	0.5-3.2
I+	12	81.2	5.6	72-92	7.2	1.6	5.3 10.7
2+	24	108.9	9.3	91-123	14.9	3.0	8.8-19.5
3-t	16	142.7	11.5	126-172	31.7	8.7	19.5-50.3
4	6	178.0	10.9	169-200	64.1	**12.0**	56.0-90.0

Ashnola River (September 21 - October, 1983) Total n = 181

:jge Class	n	Mean Fork Length (mm)	S.D.	Length Range	Mean Weight (g)	S.D.	Weight Range
0+	31	43.9	6.5	29-55	1.2”	0.4*	0.6-2.1*
1+	43	72.3	6.4	61-86	4.4	1.2	2.2-6.6
2+	60	101.9	12.2	82-134	11.8	4.0	6.1-20.0
3+	40	138.2	13.1	117-168	28.0	8.9	14.3- 56.3
4+	7	191.9	18.3	169-230	85.0	25.1	61.5-140.0

* based on an n=24, smaller fry were not weighed.

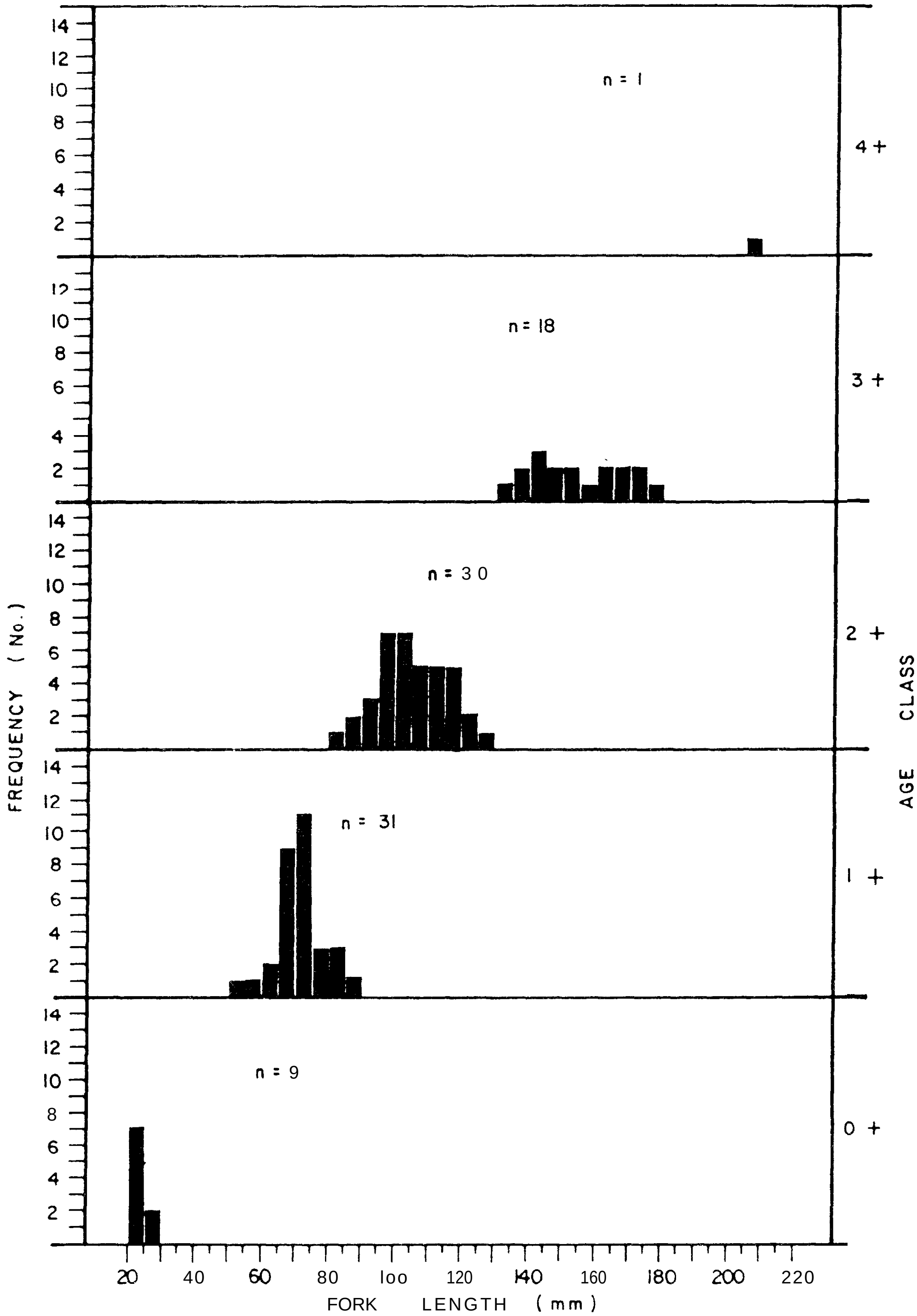

FIGURE 4-4 : Length-Frequencies by Age Class for Rainbow Trout in the Similkameen River (Above Falls).

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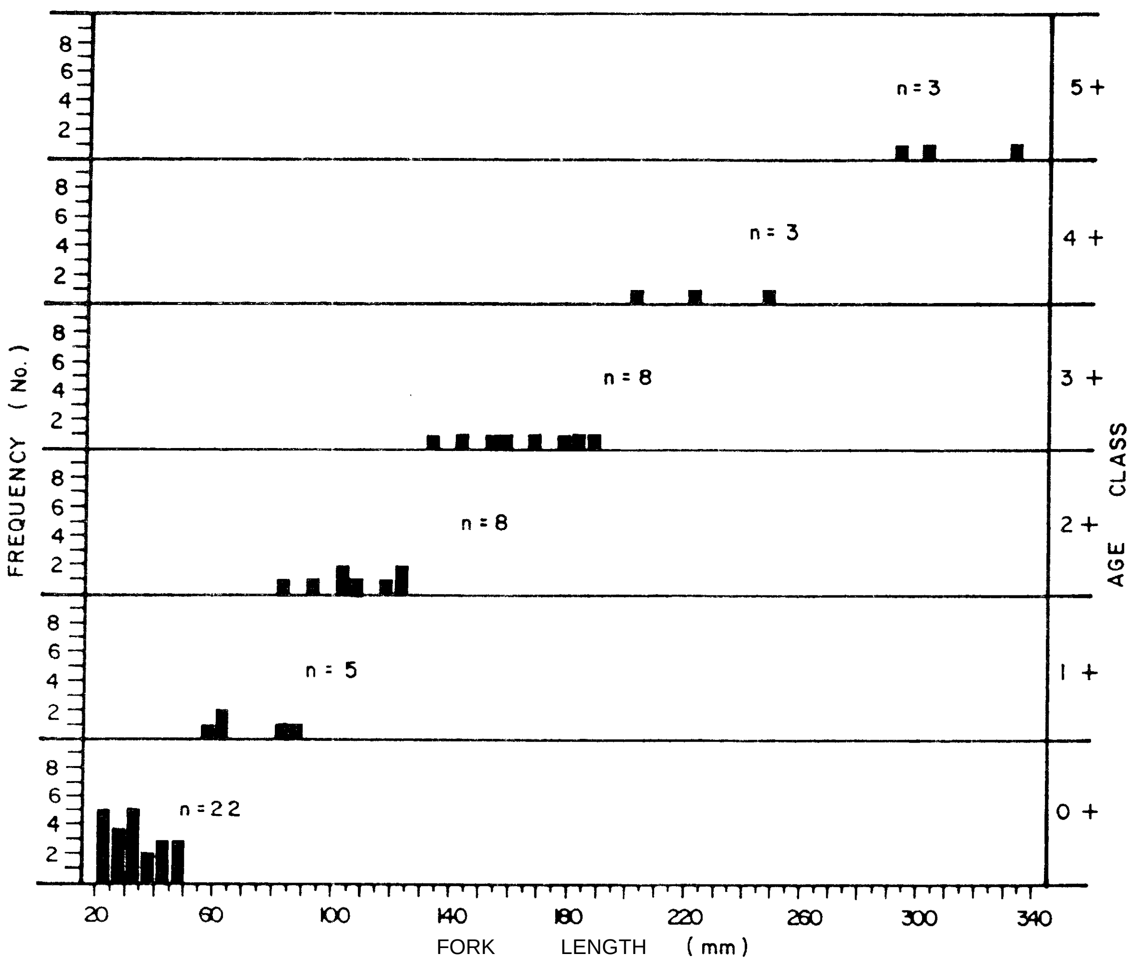

FIGURE 4-5 : Length - Frequencies by Age Class for Rainbow Trout in the Similkameen River (Below Falls).

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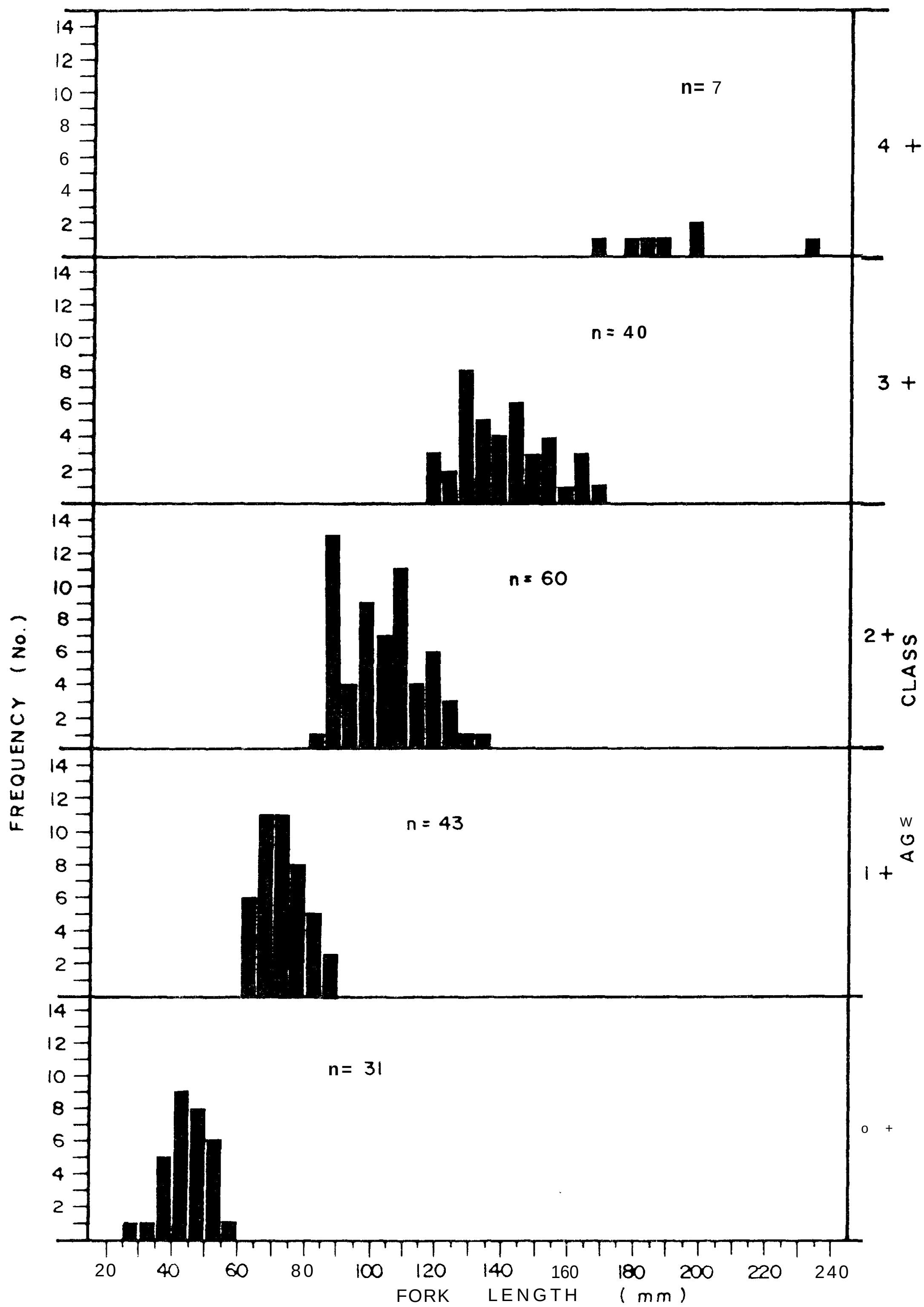

FIGURE 4-6 : Length - Frequencies by Age Class for Rainbow Trout in the Ashnola River.

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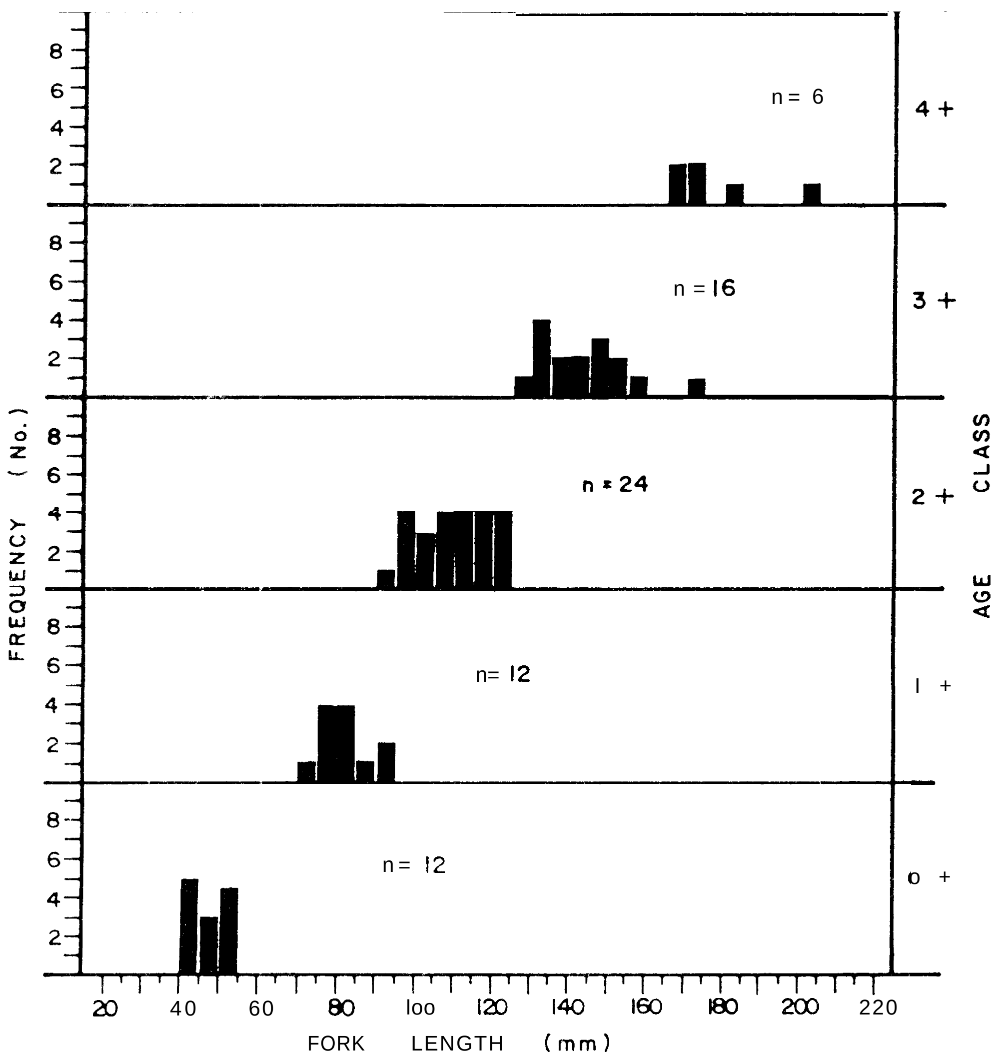

FIGURE 4-7 : Length - Frequencies by Age Class for Rainbow Trout in the Tulameen River.

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	PROJECT	3711.1	
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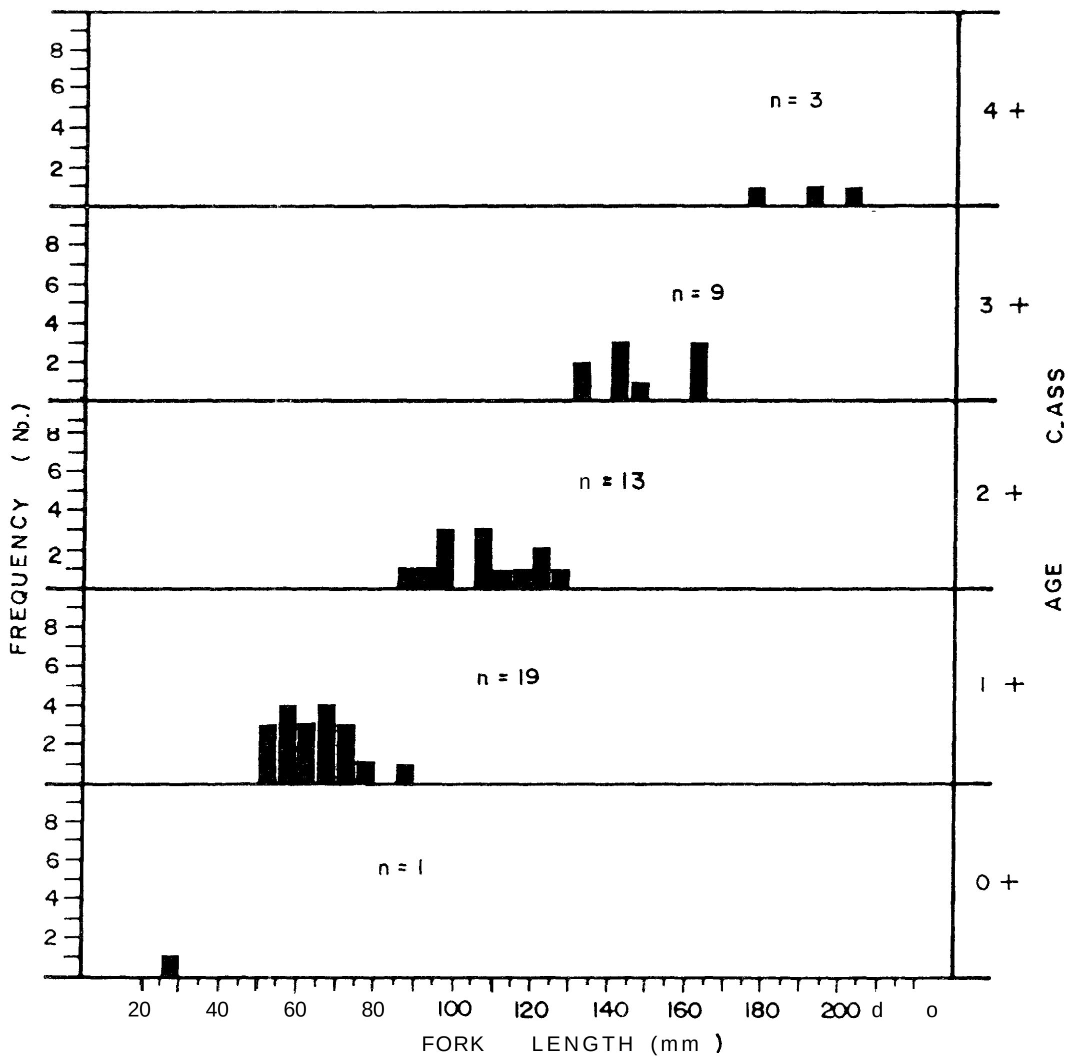

FIGURE 4-8 : Length-Frequencies by Age Class for Rainbow Trout in the Pasayten River.

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	PROJECT	3711.1	
	DWG NO		

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Due to their small size, fry are inconsistently sampled by electroshockers. Electrofihsing success is size dependent, such that, the total body voltage rises as function of length for a specific voltage gradient (Nielson and Johnson, 1983). The electrical current that the fry conduct is not sufficient to stun them, permitting small individuals to readily escape captur.

The rainbow trout fry were not well represented in the early electroshocking samples though many were observed along the stream margins. As size increased in the latter part of the season,,the young-of-the-year catches increased and the fry class was more accurately represented in the electrofishing samples. This inefficiency in fry captire has been noted by others (Goodnight and Bjornn, 1971; Nielson and Johnson, 1983). Dip net captures supplemented the fry data in the present Similkameen River study.

Older fish were also inadequately sampled by electrofishing because of their tendency to be found in deeper habitats out of the realm of most electroshockers, Snorkel cunts provided resident population information but no scale samples for age determi nations. Consequently, the upper size range and age class data were lacking. Angling supplemented age and length/weight data for the older rainbow trout.

In general, the age structure provides an adequate representation of the growth rate in the Similkamee River system. Length-frequency distributions of the rainbow trout population as a whole, in addition to the other species, have been presented in Appendix 4 (Figures A-29 through A-36) on a stream-specific basis.

Weight values for fish observed while snorkeling were predicted from recorded length /weight electroshocking data for standing crop estimations. Length/weight measurements have been plotted by stream and by species, with resulting best-fit regression functions in Appendix 5 (Figures A-37 through A-46). Due to the limited data, the regression analyses were conducted on the species population as a whole rather thab on an age-specific basis.

An average length of 250 mm was estimated for rainbow trout observed at the snorkeling sites. Based on the length (y)/weight (x) regression equations derived for the Similkameen River below the falls (Appendix 5, Figure A-38):

$$y = -11.394 + 0.475x - 5.876E\text{-}03x^2 + 4.038E\text{-}05x^3 - 5.380E\text{-}08x^4$$

and that of the Tularneen River (Appendix 5, Figure A-40):

$$y = -3.501 + 0.175x - 1.955E\text{-}03x^2 + 1.712E\text{-}05x^3$$

the resulting average weights for a rainbow trout averaging 250 mm in length, were 161 grams and 186 grams, respectively.

Since few mountain whitefish were caught during the study, an equation for estimating whitefish weights could not be determined from the length/weight data collected. However, based on a whitefish study by Rawson and Elsey (1950), an average weight of 226.8 grams was calculated for an average length of 250 mm observed for mountain whitefish in the Similkameen River system.

Similarly, bridgelip suckers observed in the snorkel surveys were never captured in the field program. As a result, a length/weight relationship was derived from a study of standing crop determinations of bridgelip suckers in the Columbia River system (Dauble, 1980). This equation is presented below:

$$\log_e W = -12.65 + \log_e L$$

An average observed length of 300 mm was used for bridgelip suckers in the Similkameen River study area, yielding an average weight of 360.4 grams.

Missiong weight values were calculated for individual longnose dace and sculpins by plugging in the length value (x) into the appropriate equation:

for sculpins:

$$y = -0.122 + 5.787E-02x - 1.476E-03x^2 + 2.29E-05x^3$$ (Figure A-42, Appendix 5)

for longnose dace:

$$v = 4.830 + 0.447x - 1.240E-02x^2 + 1.455E-04x^3 - 4.704E-07x^4$$ (Figure A-46, Appendix 5)

The resulting weight estimates were utilized in the standing crop estimates and have been included in the fish data summary in Appendix 3.

4.2.2 Resident Fish Population and Standing Crop Estimates

Based on densities calculated from the fish sampling inventory (Appendices 6 and 7), a total population of rainbow trout in the Similkameen River system was calculated to be 142 318 (Table 4-3). A total rainbow trout standing crop of 3,597 kg (Table 4-3) for the svstem was estimated from average standing crops for each reach (Appendices 8 and 9).

Densities of rainbow trout trhoughout the Similkameen River systern varied from 0 to 0.20 fish/m^2 (0 to 5.75 g/m^2). The densities of rainbow trout in the Similkameen River system were far lower than those found in other Rritish Columbia streams. Nauitch Creek in the Nicola River systern (a tributary of the Thompson River which flows into the Fraser River-) had average rainbow densities of 2.13 fish/m^2 (10.93 g/m^2) (Tredger, I980a). Ptolemy (1982) found in Louis Creek, a tributarv of the North Thompson River, rainbow densities ranged up to 1.95 fish/m^2 (2.28 g/m^2). Me also found that these values compared favourably with other productive rainbow streams such as 2.89 fish/m^2 (10.4 g/m^2) in Deadman River/Criss Creek (Thompson River tributaries) and 3.2 fish/m^2 (19.5 g/m^2) in the Nicola River mainstem.

The low densities of rainbow trout in the Sirnilkameen River system could be due to several factors, the main one being high fishing pressure (Slaney, pers. comm. 1983). Low densities of rainbow were usually found in areas where there was easy access to a stream from a highway. The Ashnola River, which has limited access over most of its length, has higher densities than the rest of the Similkameen River system. The

TABLE 4-3

SUMMARY OF STANDING CROP, FISH POPULATION AND DENSITY OF RAINBOW TROUT IN THE SIMILKAMEEN RIVER SYSTEM

Stream	Stream Section	Density Range (no./m^2)	Standing Crop Range (kg/ha)	Population Estimate (No.)	Total Standing Crop (kg)
Similkameen River	Enloe Dam to Palmer Creek (Reach l-3)	0	0	0	0
	Palmer Creek to Keremeos (Reach 4)	0-0.0005	O-l.7	408	168.3
	eremeos to Princeton (Reach 5- 9)	o-0.20	O-52.1	42,621	1,393.5
	Princeton to Similkameen Falls (Reach 10-19	o-o. 10	O-57.8	13,047	386.1
	Above Similkameen Falls (Reach 20-26)	o-o. 11	0.5-13.8	11,382	206.1
	TOTAL			67,458	**2154**
Ashnola River	Near Mouth (Reach I-2)	0.0 l-0.02	0.1-0.1	894	0.5
	Near Mouth to Above Lakeview Creek (Reach 3-9)	0.0 1-o. 19	4.1-33.7	22,675	**498.5**
	Above Lakeview Creek to Duruisseau Creek (Reach 10-14	0.00 3-o. 1 l	0.8- 19.6	12,546	**275.2**
	Above Duru isseau Creek (Reach 15)	**0.16**	15.5	11,819	114.5
	TOTAL			47,934	888.7

TABLE 4-3 (Continued)

SUMMARY OF STANDING CROP, FISH POPULATION AND DENSITY OF RAINBOW TROUT IN THE SIMILKAMEEN RIVER SYSTEM

Stream	Stream Section	Density Range (no./m ^{2})	Standing Crop Range (kg/ha)	Population Estimate (No.)	Total Standing Crop kg)
Tulameen River	Princeton to River Mi. 6.5 (Reach 1)	0	0	0	0
	River Mi. 6.5 to Lawless Creek (Reach 2-5)	0.00 l-0.0 l	0.2-3.9	3,061	144.9
	Lawless Creek to Falls (Reach 6-8)	0.02-O. 13	4.7- 13.4	16,044	276.9
	TOTAL			19,105	421.8
Pasayten River	Mouth to River Mi. 3.5 (Reach l-2)	0.0 1	3.1	1,353	41.9
	Above River to Mi. 3.5 (Reach 3-6)	0,904-9.04	0.2-6.5	6,468	90.8
	TOTAL			7,821	132.7
	SIMLLKAMEEN RIVER SYSTEM TOTAL			142,3 18	3,597.2

estimated rainbow trout population of the Ashnola River was 47,934 or 34% of all the rainbow in the system. Also, the upper Tulameen River, which has very little access compared to the rest of the Tulameen River, has a density range of 0.02 to 0.13 fish/m^2 (0.47 to 1.34 g/m^2) with the rest of the river having densities ranging from 0 to 0.0 1 fish/m^2 (0 to 0.39 g/m^2). High fishing pressure could be causing the low rainbow densities due to selective angling pressure on catchable-sized (200+ mm) rainbow trout and low juvenile recruitment due to depressed spawning stocks. Other factors for the low density observed may include interspecific competition, low nutrient concentrations in the streams and anchor ice (C. Bull, pers. comm., 1983).

The highest densities of rainbow trout in the mainstem Similkameen River, below Similkameen Falls, were found between Keremeos and Princeton, B.C. (Table 4-3). An estimated population of 42,621 rainbow trout was calculated for this stretch of river. This represents 30% of the population of rainbow in the entire system. Of the total population for the system, 40% (56,076) is in the Similkameen River below the falls. The majority of the remaining fish (13,047) in the Similkameen River, below the falls, were estimated to be in the Similkameen River from Princeton to the falls. Only 408 rainbow trout were estimated from Keremeos, R.C. to the Enloe Dam in Washington.

The second largest estimated population of rainbow trout in the system was in the AThnola River, where rainbow population densities ranged from 0.0 1 to 0.19 fish/m^2. This population makes up 34% (47,934) (Table 4-3) of the total rainbow trout population for the Similkameen River system. The majority of the trout in the Ashnola River are found above the lower two reaches of the river. Only an estimated 894 rainbow out of a total of 47,934 are in the first two reaches of the Ashnola River.

The same pattern can be found in the Tulameen and Pasayten rivers. Low trout densities or a small proportion of the rainbow trout population are found at or near the mouths of the rivers. Only 19,105 rainbow trout were estimated for the Tulameen River and densities ranged from O-O.13 fish/m*. The Pasayten River had an estimated population of 7,821 rainbow trout and a densitv range of 0.004 to 0.04 fish/m^2).

of the total population for the Similkameen River svstern, 19,203 rainbow were estimated to be above Sirnilkameen Falls, including the Pasayten River. An estimated 14% of the total population of the Similkameen River system is above Similkarneen Fails.

Rainbow trout standing crops varied widely from 0 to 57.8 kg/ha (Table 4-3), throughtout the Similkameen River system. The majority of rainbow trout standing crop (54% or 1947.9 kg) was supported by the Similkarneen River below the falls, with 25% (88.7) kg) supported by the Ashnola River, 12% (422.0 kg) by the Tulameen River and 9% (338.8 kg) by the Pasaten River and the Similkameen River above the falls. As with the population estimates, the majority of standing crop of rainbow trout (1,393.5 kg or 39%) for the Sirnilkameen River system is between Keremeos and Princeton, B.C.

Measured estimates of rainbow trout standing crops (Appendix 9) were compared to trout standing crops estimated using the Habitat Quality Index (HQI) (Binns, 1982) (Appendix 10 in Appendix 11. Average standing crops, both measured and calculated, for each stream section were cornpard in Table 4-4. Averages values were used to reduce sampling variation.

in the rnajority of cases, the measured standing crops were about the same or less than the HQI estimates. The measured standing crops were noticeably higher than the predicted values in the middle Ashnola and upper Tulameen rivers. Throughout the mainstem Similkameen River, the HQI predicted and the measured standing crops were sornparable. Only in the lower most reaches (Keremeos to Enloe Dam), were the HQI values much higher than the measured values. This same trend could be seen in the Ashnola, Tulameen and Pasayten rivers. The Pasayten River measured standing crops were far lower than the predicted ones for the whole river. The upper most section of the Ashnola River (Reach 15) had the highest predicted and rneasured standing crops in the study area (15.5 kg/ha).

Mountain whitefish were found mainly in the Sirnilkarneen River below the fails (Table 4- 5). Of a total whitefish population for the system of 353,164, 99.7% (352,095) were found in the region from Palmer Creek to Similameen Falls and of these, 304,912

TABLE 4-4

SUMMARIZED COMPARISION BETTEEN ESTIMATD (HQI) AND MEASIJRED RAINBOW TROUTSTANDINGCROP

Stream	Stream Section	Standing Crop Estimate (kg/ha) Ave. HQI	Ave. Measured
Similkameen River	Enloe Dam to Palmer Creek (Reach l-3)	6.0	0
	Palmer Creek to Keremeos (Reach 4)	6.0	0.7
	Keremeos to Princeton (Reach 5-9)	6.6	6.2
	Princeton to Similkameen Falls (Reach 10-19)	4.2	6.4
	Above Similkameen Falls (Reach 20-26)	7.0	5.4
Palmer Creek	Palmer Creek (Reach 1)	6.0	0
Sinlahekin Creek	Sinlahekin Creek (Reach l-4)	7.7	0
Ashnola River	Near Mouth (Reach l-2)	7.0	0.1
	Near **Muth** to Above Lakeview Creek (Reach 3-9)	8.1	14.0

TABLE 4-4 (Continued)

SUMMARIZED CMPARISION BETWEEN ESTIMATED (HQI) AND MEASURED RAINBOW TROUT STANDING CROP

Stream	Stream Section	Standing Crop Estimate (kg/ha) Ave. HQI	Ave. Measured
Ashnola Kiver	Above Lakeview Creek to Duruisseau Creek (Reach 10- 14)	8.4	8.6
	Above Duruisseau Creek (Reach 15)	15.0	15.5
Tulameen River	Princeton to River Mi. 6.5 (Reach 1)	1.0	0
	River Mi. 6.5 to Lawless Creek (Reach 2-5)	2.4	2.4
	Lawless Creek to Falls (Reach 6-8)	4.0	9.6
pasay ten River	Mouth to River Vi. 3.5 (Reach 1--2	7.0	3.1
	Above River Mi. 3.5 (Reach 3-6	7.0	1.8

TABLE 4-5

SUMMARY OF STANDING CROP, FISH POPULATION AND DENSITY OF MOUNTAIN WHITEFISH IN THE SIMILKAMEEN RIVER SYSTEM

Stream	Stream Section	Density Range (no./m^2)	Standing Crop Range kg/ha)	Population Estimate (No.)	Total Standing Crop kg)
Similkameen River	Enloe Dam to Palmer Creek (Reach l-3)	0	0	0	0
	Palmer Creek to Keremeos (Reach 4)	o-0.02	O-568.4	23,480	4 1,094.8
	Keremeos to Princeton (Reach 5-9)	O-l.96	O-4455.0	304,9 I2	114,380.8
	Princeton to Similkameen Falls (Reach 10-19)	O-O.29	O-661.5	23,703	15,630.8
	Above Similkameen Falls (Reach 20-26)	0	0	0	0
	TOTAL			355095	**171,106.4**
Ashnola River	Near Mouth (Reach l-2)	o-0.0 1	O-O.6	324	1.9
	Near Mouth to Above Lakeview Creek (Reach 3-9)	0	0	0	0
	Above Lakeview Creek to Duruisseau Creek (Reach 10- 14)	0	0	0	0
	Above Duruisseau Creek (Reach 15)	0	0	0	0
	TOTAL			324	1.9

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TABLE 4-5 (Continued)

SUMMARY OF STANDING CROP, FISH POPULATION AND DENSITY OF MOUNTAIN WHITEFISH IN THE SIMILKAMEEN RIVER SYSTEM

Stream	Stream Section	Density Range (no.,/m ^{2})	Standing Crop Range (kg/ha)	Population Estimate (No.)	Total Standing Crop (kg)
Tulameen River	Princeton to River Mi. 6.5 (Reach 1)	0	0	0	0
	River Mi. 6.5 to Lawless Creek (Reach 2- 5)	o-0.03	0.64.8	745	284.0
	Lawless Creek to Falls (Reach 6-8)	0	0	0	0
	TOTAL			745	284.0
Pasayten River	Mouth to River Vi. 3.5 (Reach I-2)	0	0	0	0
	Above River Mi. 3.5 (Reach 3-6)	0		0	0
	TOTAL			0	0
SIMILKAMEEN RIVER SYSTEM TOTAL				353,164	171,392,3

(86%) were estimated to he between Keremeos and Princeton, B.C. Only 324 whitefish were estimated to be in the Ashnola River and all of these were near the mouth (Reaches l-2). Seven hundred and forty-five whitefish were estimated for the Tulameen River, in the middle reaches. No whitefish were found above Similkameen Falls, either in the Similkameen River itself or in the Pasayten River. Densities ranged from 0 to 1.96 fish/m^2 throughout the system. In the Similkameen River system, the largest populations of whitefish were found in pools downstream of Princeton (Appendices 6 and 7).

Bridgelip Suckers were found only in Reach 2 of the Tulameen River and in the Similkameen River from Reach 9 downstream with the exception of a few fish in Reach 13 (Table 4-6). Of the 145,542 suckers estimated for the system 145,498 were in the Similkameen River below the falls. Densities ranged from 0 to 0.28 fish/m^2. A total population of 44 suckers for the Tulameen River was estimated, with densities ranging from 0 to (3.002 fish/m^2.

Sucker standing crops varied from 0 to 2059 kg/ha and a total sucker standing crop was estimated at 152,763 kg for the Similkameen River itself. The largest standing crops of suckers were found in Reaches 8 and 9 (Appendices 8 and 9). A total standing crop for Reach 2 of the Tulameen River was estimated to be 28 kg (6.3 kg/ha).

There were no sculpins observed above Similkameen Falls, including the Pasayten River (Table 4-7, Appendices 6 and 7). Sculpins were, however, found in all other streams studied, although they were nonexistent or in comparatively low numbers (densities ranging from 0 to 0.1 fish/m^2) in the upper most reaches of those streams. A sculpin population of 482,218 was estimated for the entire Similkameen River system, of which 439,656 (91%) were in the Similkameen River, 23,344 (5%) in the Ashnola River and the remaining 19,215 (4%) in the Tulameen River. The majority (48%) of the sculpins were estimated to be between Keremeos and Palmer Creek, and another 22% between Keremeos and Princeton.

Sculpin densities ranged from 0 to 0.45 fish/m^2 (averaging 0.05 fish/m^2) in the Similkameen River, 0 to 0.09 fish/m^2 (averaging 0.03 fish/m^2) in the Ashnola River and 0 to 0.06 fish/m^2 (averaging 0.02 fish/m^2) in the Tulameen River (Appendix 6).

TABLE (c-6

SUMMARY OF STANDING CROP, FISH POPULATION AND DENSITY OF BRIDGELIP SUCKERS IN THE SIMILKAMEEN RIVER SYSTEM

Stream	Stream Section	Density Range (no./m^2)	Standing Crop Range (kg/ha)	Population Estimate (No.)	Total Standing Crop (kg)
Similkameen River	Enloe Dam to Palmer Creek (Reach l-3)	o-0.900 1	o-o.3	15	4.4
	Palmer Creek to Keremeos (Reach 4)	0.002-0.04	O-277.8	28,074	27,537.7
	Keremeos to Princeton (Reach 5-9)	O-0.28	o-2059.4	117,365	125,18 5.0
	Princeton to Similkameen Falls (Reach 10-19)	o-0.00 1	o-4.1	44	35.8
	Above Similkameen Falls (Reach 20-26)	0	0	0	0
	TOTAL			**145,498**	152,762.9
Ashnola River	Near Mouth (Reach l-2)	0	0	0	0
	Near Mouth to Above Lakeview Creek (Reach 3-9)	0	0	0	0
	Above Lakeview Creek to Duruisseau Creek (Reach IO- 14)	0	0	0	0
	Above Duruisseau Creek (Reach 15)	0	0	0	0
	TOTAL			0	0

TABLE 4-6 (Continued)

SUMMARY OF STANDING CROP, FISH POPULATION AND DENSITY OF BRIDGELIP SUCKERS IN THE SIMILKAMEEN RIVER SYSTEM

Stream	Stream Section	Denstity Range (no./m^2)	Standing Crop Range (kg/ha)	Population Estimate (No.)	Total Standing Crop (kg)
Tulameen River	Princeton to River Mi. 6.5 (Reach 1)	0	0	0	0
	River Mi. 6.5 to Lawless Creek (Reach 2- 5)	o-0.002	O-6.3	44	27.6
	Lawless Creek to Falls (Reach 6-8)	0	0	0	0
	TOTAL			44	27.6
Pasayten River	Mouth to River Mi. 3.5 (Reach l-2)	0	0	0	0
	Above River Mi. 3.5 (Reach 3-6)	0	0	0	0
	TOTAL			0	0
SIMILKAMEEN RIVER SYSTEM TOTAL				145,542	155790.5

[illegible]

TABLE 4-7

SUMMARY OF STANDING CROP, FISH POPULATION AND DENSITY OF SCULPINS IN THE SIMILKAMEEN RIVER SYSTEM

Stream	Stream Section	Density Range (no./m²)	Standing Crop Range (kg/ha)	Population Estimate (No.)	Total Standing Crop kg)
Simifkameen River	Enloe Dam to Palmer Creek (Reach I-3)	o-o. 17	o-4.5	69,370	183.6
	Palmer Creek to Keremeos (Reach 4)	o-o.4 5	040.8	229,694	551.3
	Keremeos to Princeton (Reach 5-9)	o-o. 13	O-7.2	106,099	561.4
	Princeton to Similkameen Falls (Reach 10-19)	O-0.08	0.8-9.5	34,493	287.0
	Above Similkameen Falls (Reach 20-26)	0	0	0	0
	TOTAL			439,656	1583.3
Ashnola River	Near Mouth (Reach l-2)	0.02-0.09	1.2-7.3	3,407	26.5
	Near Mouth to Above Lakeview Creek (Reach 3-9)	O-0.08	o-7.7	8,559	69.5
	Above Lakeview Creek to Duruisseau Creek (Reach 10-14)	0.0 l-0.07	1.6-5.8	11,378	88.6
	Above Duruisseau Creek (Reach 15)	0	0	0	0
	TOTAL			23,344	184.6

TABLE 4-7 **(Continued)**

SUMMARY OF STANDING CROP, FISH POPULATION AND DENSITY
OF SCULPINS IN THE SIMILKAMEEN RIVER SYSTEM

Stream	Stream Section	Density Range (no./m^2)	Standing Crop Range (kg/ha)	Population Estimate (No.)	Total Standing Crop (kg)
Tula meen River	Princeton to River Mi. 6.5 (Reach 1)	0.0 1	0.9	3,447	31.0
	River Mi. 6.5 to Lawless Creek (Reach 2-5)	O-0.06	0.1-3.9	15,247	166.3
	Lawless Creek to Falls (Reach 6-8)	o-0.0 1	o-o.9	524	6.2
	TOTAL			19,218	203.5
Pasayten River	Mouth to River Mi. 3.5 (Reach l-2)	0		0	0
	Above River Mi. 3.5 (Reach 3-6)	0		0	0
	TOTAL			0	0
SIMILKAMEDN RIVER SYSTEM TOTAL				482,218	1971.4

Sculpin standing crops in the Similkameen River, below the falls, ranged between 0 and 10.8 kg/ha, avaraging 2.2 kg/ha. A range of 0 to 3.9 kg/ha, with an average standing crop of 1.4 kg/ha, was estimated for the Tulameen River. A total standing crop of 197 I.4 kg for the Similkameen River system was also calculated. Of the total, 1583,3 kg was estimated for the mainstem Similkameen River, below the falls.

Longnose dace, like rainbow trout, were found in each of the streams studied, although they were only found in the lower reaches of the Ashnola, Tulameen and Pasayten rivers.Of an estimated population of 326,911 longnose dace, 310,585 were estimated for the Eimilkameen River, 294,2 I ! were below the falls and 16,373 above (Table 4-8). ‘There were 1,877 dace estimated for the Ashnola River, 12,971 for the Tulameen River and a total of 1,479 for the Pasayten River. Densities ranged from 0 to 0.48 dace/m^2 throughout the system, the lower densities being mainly in the Pasayten, Tulameen and Ashnola rivers (Table 4-8, Appendix 6).

It was also noted that in areas where there were large numbers of longnose dace, there were low numbers of rainbow trout and visa versa. between Palmer Creek and Keremeos, there were an estirnated 245,000 longnose dace and only 408 rainbow trout but in the Ashnola River from near the mouth to above Lakeview Creek there were 22,675 rainbow trout yet no longnose dace. Tredger (1980a) suggests that rainbow trout are a dominant species over longnose dace and that a high density of trout standing crop may be the cause of an absence of dace. However, where there are few rainbow trout, the longnose dace will flourish.

Tredger (198Oa) found that rainbow trout were the dominating species in Nuiatch Creek, occurring in absence of longnose dace, though the dace, were common throughout the rest of the system. He suggested that this may be common in smaller saturated streams where all available space is used by the dominant species. In larger or under-utilized streams, there would be space available for the subordinate species. This might explain the pattern of distribution of the major species of fish in the Similkameen River system.

TABLE 4-8

SUMMARY OF STANDING CROP, FISH POPULATION AND DENSITY OF LONGNOSE DACE IN THE SIMILKAMEEN RIVER SYSTEM

Stream	Stream Section	Density Range (no./m²)	Standing Crop Range (kg/ha)	Population Estimate (No.)	Total Standing Crop (kg)
Similkameen River	Enloe Dam to Palmer Creek (Reach l-3)	o-0.07	o-1.2	28,564	49.0
	Palmer Creek to Keremeos (Reach 4)	O-O.48	O-6.0	245,007	306.3
	Keremeos to Princeton (Reach 5-9)	o-0.0 5	O-3.0	18,923	108.7
	Princeton to Similkameen Falls (Reach 10- 19)	o-0.0 1	o-1.3	1,717	12.6
	Above Similkameen Falls (Reach 20-26)	o-o. 11	o-4.7	16,373	64.3
	TOTAL			310,585	540.9
Ashnola River	Near Mouth (Reach l-2)	0.02-0.0 5	1.3-2.8	1,877	11.1
	Near Mouth to Above Lakeview Creek (Reach 3-9)	0	0	0	
	Above Lakeview Creek to Duruisseau Creek (Reach 10-14)	0	0	**0**	**0**
	Above Duruisseau Creek (Reach 15)	0	0	0	0
	TOTAL			1,877	**11.1**

TABLE **4-8 (Continued)**

SUMMARY OF STANDING CROP, FISH POPULATION AND DENSITY OF LONGNOSE DACE IN THE SIMILKAMEEN RIVER SYSTEM

Stream	Stream Section	Density Range (no./m ^{2})	Standing Crop Range kg /ha)	Population Estimate (No.)	Total Standing Crop (kg)
Tulameen River	Princeton to River Mi. 6.5 (Reach 1)	**0.02**	**2.6**	**6,893**	**89.6**
	River Mi. 6.5 to Lawless Creek (Reach 2-5)	**o-0.04**	**o- 5.0**	**6,078**	**72.1**
	Lawless Creek to Falls (Reach 6-8)	0	0	0	0
	TOTAL			**12,971**	**161.7**
Pasaytn River	Mouth to River Mi. 3.5 (Reach l-2)	0.0 1	0.1-0.4	1,353	**2.3**
	Above River Mi. 3.5 (Reach **3-6)**	**o-0.002**	**o-o. 1**	**126**	**0.6**
	TOTAL			**1,479**	**2.9**
SIMILKAMEEN RIVER SYSTEM TOTAL				**326,911**	**716.6**

The smaller strearns, such as the Similkameen River above the falls, the Pasayten, Ashnola, and Tulameen rivers, had rainbow trout throughout the majority of the reaches (Table 4-3) whereas the Ashnola River had no suckers, whitefish or dace except near the mouth of the river. The Similkameen River above the falls and the Pasaytn River had no suckers, sculpins, or whitefish and the Tulameen River had all of the species but usually in very small numbers and in very limited areas. Since the Tuiameen River is the largest of the tributaries, there are probably areas available for the subordinate species. In the mainstem Similkameen River, large areas were available for all the subordinate species, wheras, in the tributaries there appears to be only enough space for the dominant rainbow trout. Since longnose dace were found both above and below Similkameen Falls, water velocity does not appear to be the factor which limits the distribution of the subordinate species in the upper reaches of the Ashnola, Pasayten and Tulameen rivers.

Rainbow trout, when found with other species of fish, have comparatively low standing crops (Table 4-9). The species of fish with the largest standing crops in the Similkameen River system are mountain whitefish (171,106 kg) and suckers (152,763 kg). The species with the largest calculated populations are sculpins (482,218) and whitefish (353,164).

Incidental species of fish caught or observed included northern squawfish (Ptvchocheilus oregonensis) and black crappie (Pomoxis nigrornaculatus). These fish caught or seen in the lower reaches of the rnainstem Similkameen River. Since few of these fish were caught or seen, population estimates and standing crops could not accurately be calculated.

4.3 Potential Anadromous salmonid Spawning Area and Spawner Capacity

4.3.1 Steelhead Trout

Aquatic habitat inventory data collected during the 1983 field program, specifically depth, velocity and substrate, were evaluated using the available probability-of-use criteria for winter steelhead spawning (Bovee, 1978). Using these probabilities, it was possible to determine the area of spawning substrate and spawnable area for each type

TABLE 4-9

SIMILKAMEEN RIVER SYSTEM FISH STANDING CROP

Stream	Reach No.	Station No.	Standing Crop (kg/ha)					
			Rainbow	Whitefish	Sculpin	Dace	Sucker	Total
Similkameen	1	NS[1]						
River	2	1	0	0	4.5	1.2	0	5.7
	3	1	0	0	0	0	0.3	0.3
	4	5	0	568.4	0	0	277.8	846.2
		4	1.7	50.5	0	0	12.2	64.4
		3	0.5	78.6	0	0	33.8	112.9
		2	0	0	10.8	6.0	0	16.8
		1	1.1	107.6	0	0	215.9	324.6
	5	2	0	0	5.0	0	0	5.0
		1	0	0	5.8	1.2	0	7.0
	6	2	2.3	36.9	7.2	3.0	65.9	115.3
		1	0	45.4	1.8	0.3	84.1	131.6
	7	2	4.8	25.9	0.6	0	22.9	54.2
		1	0.6	25.9	0.6	0	22.9	50.0
	8	1	0	324.0	0	0	2059.4	2383.4
		2	0	324.0	0.2	0	2059.4	2383.6
	9	2	52.1	4455.0	1.5	0.1	1158.4	5667.1
		1	2.1	0	0.9	0.1	0.1	3.2
	10	2	3.2	661.5	1.4	0.5	0	666.6
		1	2.7	661.5	2.4	0.2	0	666.8
	11	1	2.7	661.5	1.5	0.3	0	666.0
		2	0	0	0.8	0	0	0.8
	12	1	57.8	117.6	9.5	1.3	0	186.2
	13	1	6.6	51.8	2.9	0	4.1	65.4
	14	1	6.3	33.6	2.9	0	0	42.8
	15	1	0	0	1.7	0	0	1.7
	16	1	0.9	19.3	1.7	0	0	21.9

TABLE 4-9 (Continued)

SIMILKAMEEN RIVER SYSTEM FISH STANDING CROP

Stream	Reach No.	Station No,	Standing Crop (kg/ha) Rainbow	Whitefish	Sculpin	Dace	Sucker	Total
Simiikameen River	17	1	0.9	19.3	3.4	0	0	23.6
	18	1	0.6	0	2.3	0.1	0	3.0
	19	2	0.9	0	6.3	0	0	7.2
		1	0.5	0	0	0	0	0.5
	20	1	1.0	0	0	4.7	0	5.7
	21	1	3.1	0	0	1.2	0	4.3
	22	1	6.8	0	0	0.7	0	7.5
	23	1	2.2	0	0	0.9	0	3.1
	24	1	0.9	0	0	0	0	0.9
	25	2	11.7	0	0	1.7	0	13.4
		1	3.9	0	0	0	0	3.9
	26	1	13.8	0	0	0	0	13.8
Ashnola Rivet	1	1	0.1	0.6	7.3	1.3	0	9.3
	2	1	0.1	0	1.2	2.8	0	4.1
	3	1	15.5	0	1.0	0	0	16.5
	4	1	12.4	0	0.4	0	0	12.8
	5	1	18.7	0	0	0	0	18.7
	6	1	9.7	0	0	0	0	9.7
	7	1	7.7	0	0	0	0	7.7
	8	1	11.4	0	2.6	0	0	14.0
	9	3	4.1	0	0.3	0	0	4.4
		2	33.7	0	7.7	0	0	41.4
		1	12.9	0	1.1	0	0	14.0
	10	1	1.4	0	2.6	0	0	4.0
	11	1	19.6	0	1.6	0	0	21.2
	12	1	0.8	0	1.7	0	0	2.5
	13	3	8.9	0	2.3	0	0	11.2
		a	14.3	0	5.8	0	0	20.1
		1	3.7	0	2.2	0	0	5.9
	14	1	11.3	0	3.2	0	0	14.5
	15	1	15.5	0	0	0	0	15.5

TABLE 4-9 (Continued)

SIMILKAMEEN RIVER SYSTEM FISH STANDING CROP

Stream	Reach No.	Station No.	Standing Crop (kg/ha)					
			Rainbow	Whitefish	Sculpin	Dace	Sucker	Total
Tulameen River	1	1	0	0	0.9	2.6	0	3.5
	2	1	3.9	64.8	0.1	0	6.3	75.1
	3	1	2.9	0	2.9	0	0	5.8
	4	2	0.2	0	3.3	0.1	0	3.6
		1	3.1	0	3.9	3.4	0	10.4
	5	1	2.9	0	0.3	5.0	0	8.2
	6	1	4.7	0	0.9	0	0	5.6
	7	1	11.4	0	0	0	0	11.4
	8	1	13.4	0	0.1	0	0	13.5
Pasayten River	1	1	3.1	0	0	0.1	0	3.2
	2	1	3.1	0	0	0.4	0	3.5
	3	1	1.5	0	0	0.1	0	1.6
	4	1	0.2	0	0	0	0	0.2
	5	1	0.7	0	0	0	0	0.7
	6	1	6.5	0	0	0	0	6.5

[1] Not Sampled.

of hydraulic unit (ie. runs, riffles), excluding pools (no spawning potential). Appendix presents the calculations and results by hydraulic unit, reach and stream as well as the spawner capacities determined by dividing the spawnable area by the suggested area requirement of a winter steelhead spawning pair, that is, 19.6 m^2 (Reiser and Bjornn, 1979). Table 4- 10 summarizes the results by stream and major stream section. Figure 4-9 illustrates the distribution of spawner capacity in relation to elevation or stream gradient profile.

Tie Similkameen River contains nearly 80% (4,231,200 m^2) of the entire system's spawning substrate (5,316,800 m^2), with half (2,168,OOO m^2) of the amount occurring between Palmer Creek and Keremeos,B.C. and ***over 30%*** (1,684,OOO m^2) between Keremeos and Princeton, B.C. The stream section from the Enloe Dam upstream to Palmer Creek is void of spawning substrate due to the slough-like reach near Nighthawk, Washington (Reach 3), the swift, large substrate containing section above the dam (Reach 2) and the Enloe Reservoir (Reach 1). Less than one percent of the spawning substrate is contained within the confined stream section upstream of Princeton to Simifkameen Falls (Reaches 10-19) with the remaining 6.4% found above the falls.

The Ashnola River contains only slightly more than 5% of the svstem's spawning gravel ***(257,000*** m^2), with the majority (4.8%) being located between Lakeview and Duruisseau creeks, stream reaches IO-14 (253,000 m^2).

The Tulameen River contains the largest percentage of the system's spawnable substrates (14% or 733,300 m^2) next to the Similkameen River itself. The Tulameen River's portion is equally divided between the stream section (Reach 1) from Princeton to river mile 6.5 (6.5% or 343,400 m^2) and the section upstream to about Lawless Creek (Reaches 2 to 5) (7.1 % or 375,500 m^2). The remainder (less than 1%) is present in the confined stream section to Tulameen Falls.

The final main tributary, the Pasayten River, contains only about 1% or 65,200 m^2 of the system's spawning gravels with the majority, 0.8% in reaches 1 and 2 (the mouth to river mile 3.5). The combined areas of spawnable substrate material in the Pasayten and Similkameen rivers above Similkameen Falls amounts to 405,200 m^2, or about 8% of the system's total area.

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TABLE 4-10

SUMMARY OF SIMILKAMEEN RIVER SYSTEM STEELHEAD TROUT SPAWNING SUBSTRATE, SPAWNABLE AREA AND SPAWNER CAPACITY BY STREAM SECTION

Stream	Stream Section (Reaches)	% of Similkameen River System: Area of Spawning Substrate	% of Similkameen River System: Spawnable Area/Spawner Capacity[2]	Spawner Capacity: No.	Spawner Capacity: % Within Stream
Similkameen River	Enloe Dam to Palmer Ck. (1-3)	0 (0)	0 (0)	0	0
	Palmer Ck. to Keremeos (4)	40.8 (2,168,000)	4.7 (45,000)	4,572	8
	Keremeos to Princeton (5-9)	31.7 (1,684,000)	38.0 (365,000)	37,228	69
	Princeton to Similkameen Falls (10-19)	0.7 (38,800)	1.0 (9,600)	976	2
	Above Similkameen Falls (20-26)	6.4 (340,000)	11.5 (110,000)	11,228	21
	TOTAL	79.6 (4,231,200)	55.2 (529,600)	54,004	
Ashnola River	Near Mouth (1-2)	0.6 (32,200)	0.9 (8,400)	856	6
	Near Mouth to above Lakeview Ck. (3-9)	L 0.13 (1,800)	L 0.1 (30)	2	L 1
	Above Lakeview Ck. to Duruissieu Ck. (10-14)	4.8 (253,000)	12.9 (124,000)	12,628	94

TABLE 4-10 **(Continued)**

SUMMARY OF SIMILKAMEEN RIVER SYSTEM STEELHEAD TROUT SPAWNING SUBSTRATE, SPAWNABLE. AREA AND SPAWNER CAPACITY BY STREAM SECTION

Stream	Stream Section (Reaches)	% of Similkameen River System[1]: Area of Spawning Substrate	% of Similkameen River System[1]: Spawnable Area/Spawner Capacity[2]	Spawner Capacity: No.	Spawner Capacity: % Within Stream
Ashnola River (Continued)					
	Above Duruisseau Ck. (15 and above)	0 (0)	0 (0)	0	0
	TOTAL	5.4 (287,000)	13.8 (132,430)	13,486	
Tulameen River	Princeton to River Mi. 6.5 (1)	6.5 (343,600)	12.2 (117,400)	11,984	41
	River Mi. 6.5 to Lawless Ck. (2-5)	7.1 (375,500)	17.4 (167,300)	17,072	58
	Lawless Ck. to Falls (6 to Falls)	0.3 (14,200)	0.4 (4,100)	420	1
	TOTAL	13.9 (733,300)	30.0 (288,800)	29,476	
Pasayten River	Mouth to River Mi. 3.5 (l-2)	0.8 (44,000)	0.7 (6,800)	698	68
	Above River Vi. 3.5 (3 and above)	0.4 (21,200)	0.3 (3,200)	326	32
	TOTAL	1.2 (65,200)	1.0 (10,000)	1,024	

TABLE 4- IO (Continued)

SUMMARY OF SIMILKAMEEN RIVER SYSTEM STEELHEAD TROUT SPAWNING SUBSTRATE, SPAWNARLE AREA AND SPAWNER CAPACITY BY STREAM SECTION

Stream	Stream Section (Reaches)	% of Similkameen River System[1]: Area of Spawning Substrate	% of Similkameen River System[1]: Spawnable Area/Spawner Capacity[2]	Spawner Capacity: No.	Spawner Capacity: % Within Stream
Similkameen River System Above Similkameen Falls	Similkameen River	6.4 (340,000)	11.5 ~110,000)	11,228	92
	Pasayten River	1.2 (65,200)	1.0 (10,000~	1,024	8
	TOTAL	7.6 (405,200)	12.5 (120,000)	12,252	
Similkameen River System	TOTAL	(5,316,800)	(960,830)	97,990	

1 Approximate area (m^2) in brackets.

2 Percent spawnable area and percent spawner capacity are equal since spawnable area divided by 19.6, the suggested average area (m^2) required for each spawning pair (Reiser and Bjornn, 1979), times two, equals spawner capacity. Values for spawnable area (m^2) are in brackets and spawner capacity (no.) in the next column.

3 L = less than.

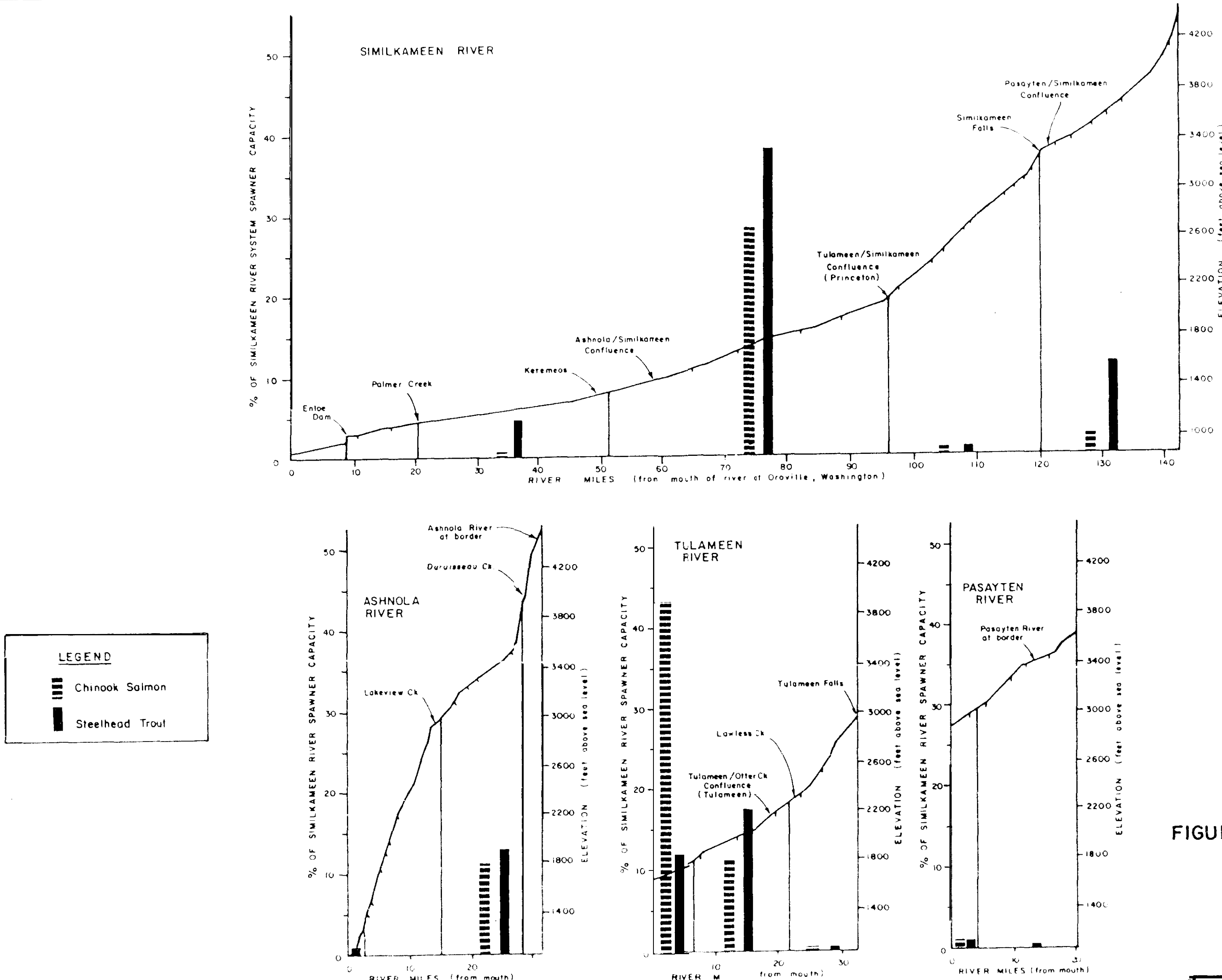

FIGURE 4-9 : Steelhead Trout and Chinook Salmon Spawner Capacity Distribution Within the Similkameen River System.

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Spawnable area, that portion of the area within a particular reach which meets the criteria for the parameters of depth, velocity and substrate for steelhead trout spawning, is distributed differently throughout the Simifkameen River system.

The Similkameen River contains an estimated 55.2% or 529,600 m^2 of the available spawnable area in the entire system (961,000 m^2). Contrary to the percent spawning substrate, the majority of spawable area, 38% or 345,000 m^2, is present in the stream section between Keremeos and Princeton. of the remaining area (17.2%), the percentage distributions are in sections from Enlow Dam to Palmer Creek (0%), Palmer Creek to Keremeos (4.7%). Princeton to Similkameen Falls (1.0%) and above the falls (11.5%).

It should be noted, however, that even though 40.8% of the spawning substrate is present between Palmer Creek and Keremeos (Reach 4), only 4.7% (45,000 m^2) of spawnable area is estimated to be present. Reach 4, contains extensive spawning gravel throughout, however, it is characterized by the extensive presence of dyking which is intended to stabilize the stream within its present channel. As a result, a deep, fast section of stream is created at the dyked bank, while the remainder of the stream cross-section is relatively shallow and slow. Since the field habitat sampling criteria measured "average" depth and velocity, the resulting values may have tended to over estimate these parameters for the extensive areas in this reach (the largest single reach in the system) which occurred away from the dyking and were ideal for spawning. An estimated 25% or 542,000m^2 of additional spawnable area could be present in this reach. This would alter the proportion (%) of the entire system's area to 39% and dramaticallv increase the actual spawnable area to 1,052,000 m^2 and resultant spawner capacity of this section. The contributions to the entire systern's percent spawnable area or spawner capacity for the Similkameen, Ashnola, Tulameen and Pasayten rivers, therefore, would change to 71, 9, 19 and less than 1%, respectively. The portion of the system above Similkameen Falls would be 8%.

An additional increase in the potential spawnahle area and resultant spawner capacity may also be justified in light of some data bias in the probability-of-use curves for steelhead trout spawning noted by Bovee (1978). Bovee points out that the depth curve for spawning is more appropriate for small streams and that for larger streams, the depth curve does not tail off at depths greater than the optimum. This situation would have the greatest effect on the spawnable area and spawner capacity calculations for the Similkameen River below Princeton. The water depth in this long section of stream is often the greatest limiting factor to spawnable area (Appendix 1).

Spawnable area in the remainder of the system, excluding the Similkameen River below Princeton, occurs in the same relative proportion as the spawning substrate area. However, the Ashnola and Tulameen rivers have two to three times the percentage of total spawning substrate area to spawnable area, indicating that at the time of measurement, a greater proportion of the area of spawning substrate meets the depth and velocity criteria for spawning. Contributions to the system's total spawnable area from the Tulameen River is 288,800 m^2 (30%), from the Ashnola River, 132,500 m^2 (14%) and 10,000 m^2 (1%) from the Pasayten River.

The spawner capacity calculated for the entire Similkameen River system was about 98,000 steelhead trout. Of this total, approximately 54,000 would utilize the Similkameen River mainstem, mainly between Keremeos and Princeton (37,000). The other main spawning areas would he above Similkameen Falls (11,000) and between Palmer Creek and Yeremeos (4,400). As previously noted, the actual spawner capacity of the latter stream section could increase to 40,000 if the vast areas of potentially suitable spawning area,unaccounted for by the general field sampling techniques, were included.

The Ashnola River has the capacity for nearly 13,500 steelhead trout spawners with the majority, 12,400, utilizing the area above Lakeview Creek to Duruisseai Creek. A small number (900) could also use the area just upstream of the Similkameen River conf Iuence.

Approximately one-third,30,000 spawners, could utilize the Tulameen River, virtually all between Princeton and Lawless Creek (Reaches 1 to 5).

The Pasayten River contributes an area for approximately 1,000 spawners, with the majority (700) located within the first 3.5 river miles. It also contributes less than 9% of the combined spawner capacity of 2,000 for the river- system above Similkameen Fall.

It should be noted here that steelhead in the Sirnilkameen River system are expected to spawn during April and May, and not in the fall, The amount of stream area available for steelhead spawning during April and May was estimated from the habitat assessment results for August, September and October. Differences in the quantity of spawnable area between the two periods will result from greater discharges in the spring, however, this difference is not likely to be significant.

The months of April and May are characterized by the end of the winter low flow period and the start of spring snowmelt. The onset of the freshet usually occurs in early May. Mean discharges for the Cimilkameen River (at Princeton, Hedley and Nighthawk) for April and May average 2.5 and 11 times, respectively, the mean discharge for the habitat assessment period (mid-August to mid-October). For the Tulameen River (at Princeton), the April and May discharges are 4 and 16 times greater, respec tivelv.

The increase in discharge, to about four times the assessment period flows, would not likely cause a significant reduction in spawning area (in fact, the spawnable area might be increased). The greater discharge would result in increased widths, depths and velocities. The area available for spawning would likely increase slightly at first as depths and widths increased, but as the discharge increased further, velocities and depths would exceed the critical levels for spawning. A limited amount of spawning would occur in May depending on the onset timing of the freshet.

Steelhead trout are expected to migrate upstream into the Similkameen River between October and December. This period is typically characterizecx by the end of the dry, summer season and an increase in precipitation throughout the basin, especially at the higher elevations. As a result, early October stream discharges are usually quite low, but increase by the end of the month and through November as the streams are fed by rain in the headwaters. Precipitation changes to snowfall by December with a resulting decline to baseflow.

The Sirnilkameen River, as it was observed and assessed during the fate summer/early fall of 1983, presented no obstacles or harriers to adult steelhead migration with the possible exceptions of Similkameen Falls and the lower steep section of the Ashnola River, Observed water depths and velocities should allow easy access to the spawning areas. Discharges through the latter half of the field program were only slightly higher than the mean annual fall low flow. In other words, the river discharges that were observed are fairly representative of typical fall low flow conditions. River discharges will increase by November so that water levels are greater than those observed. Even in an extremely low flow year, steelhead should move upstream without any problems. The 100-year return period low flow for the fall has been calculated to be about one-third of the mean annual fall low flow. Even this decrease of two-thirds of the average low flow event is made up of decreases in depth, width and velocity, so that the decrease in depth itself, even for this extreme event, is much less than two-thirds (probably closer to one-third). Steelhead trout should face no limitations with respect to low river discharges (and hence insufficient depths) while migrating upstream.

Reiser and Bjornn (1979) and Rovee (1978) have determined critical temperature ranges for spawning steelhead trout. The range of water temperatures in which steelhead are most likely to spawn successfully is between 3.9 and 12.8°C (39-55°F), with the greatest probability near 8.3°C (47°F). An examination of mean monthly water temperatures (refer to Table 4-24) reveals that water temperatures for the lower Tulameen River and the Similkameen River below Princeton typically fall in the range of 5 to 9°C (41 to 48°F) during the steelhead spawning period (April and May). Extreme water temperatures for April and Nay recorded by the Water Survey of Canada (Environment Canada, 1977) in these stream sections (which correspond with the main areas of steelhead spawning) are 1.0°C (low) and 15.5°C (high). Extreme temperatures for the lower Tulameen River itself are 3.5°C (low) and 10.5°C (high), a range which is very similar to the recommended range for spawning. Water temperatures appear to be quite favourable for steefhead spawning, especially in the Tulameen River.

4.3, 2 Chinook Salmon

The estimated area of spawning substrate for spring chinook salmon (Appendix 13), determined from field habitat measurements and probability-of-use criteria (Bovee, 1978), indicates that 80% (4,038,0c]O m^2) of the Similkameen River system's neatly 5 million square rnetres is present in the mainstem Similksmeen River, mainly (75%) between Palmer Creek and Princeton, Reaches 4 to 9 (Table 4-1 I). The remaining amount is present above Sirnilkameen Falls (5.2%) and between Princeton and the falls (less than 1%) with no spawning, substrate locatd from Enloe Dam to Palmer Creek.

The Ashnola River contains about 4.8% (234,800 m^2) of the system's total spawning substrate area, almost exclusively (4.4%) within the stream section above Lakeview Creek to Duruisseau Creek (Reaches 10 to 14).

The second largest concentration of spawning gravel (660,400 m^2) is located in the Tulameen River (I 3.6%), mainly between the Similkameen River confluence and Lawless Creek, Reaches 1 to 5 (13.4%).

The Pasayten River contributes less than one percent or- 45,100 m^2 of the system's spawning gravel area, with the majority, 35,300 m^2, within the first 3.5 river miles.

Spawnable area, that is, the area meeting the spawning requirements of depth and velocity as well as substrate, is only about 8% (366,900 m^2) of the available area of spawning substrate. Of this total, 55% or 203,100 m^2, is located within the Tulamecn River. Nearly 44% (160,800 m^2) is present between the Simillkameen River confluence and Tulameen river mile 6.5 (Reach I).

Another 32% or 118,500 m^2 are located in the mainstem Similkameen River, mainly between Keremeos and Princeton (28%). Reach 4 of the Simifkameen River, between Palmer Creek and Keremeos, contains onlv 1% of the spawnable area, but 45% of the system's spawning substrate. However, as discussed in Section 4.3.1, due to the constraints of the field sampling method (ie average measurements of velocity and depth) and the stream profile in this reach resulting from the extensive dyking (is.

TABLE 4-11

SUMMARY OF SIMILKAMEEN RIVER SYSTEM, CHINOOK SALMON SPAWNING SUBSTRATE, SPAWNABLE AREA AND SPAWNER CAPACITY BY STREAM SECTION

Stream	Stream Section (Reaches)	% of Similkameen River System[1]: Area of Spawning Substrate	% of Similkameen River System[1]: Spawnable Area/Spawner Capacity[2]	Spawner Capacity: Spring Chinook (no.)[3]	Spawner Capacity: % Within Stream
Similkameen River	Enloe Dam to Palmer Ck. (l-3)	0 (0)	0 (0)	0	0
	Palmer Ck. to Keremeos (4)	44.5 (2,163,000)	0.8 (3,000)	444	3
	Keremeos to Princeton (5-9)	30.7 (1,493,000)	28.3 (104,000)	15,502	88
	Princeton to Similkameen Falls (10-19)	0.3 (131,000~	0.6 (2,300)	342	2
	Above Similkameen Falls (20-26)	5.2 (251,600)	2.5 (9,200)	1,372	7
	TOTAL	80.7 (4,038,600)	32.2 (118,500)	17,660	
Ashnola River	Near Mouth (l-2)	0.4 (21,200)	0.1 (300)	48	1
	Near Mouth to above Lakeview Ck. (3-9)	0 (900)	0 (0)	0	0
	Above Lakeview CK. to Duruisseau Ck. (10-14)	4.4 (212,700)	11.2 (41,200)	6,150	99

TABLE 4-I l **(Continued)**

SUMMARY OF SIMILKAMEEN RIVER SYSTEM, CHINOOK SALMON SPAWNING SUBSTRATE, SPAWNABLE AREA AND SPAWNER CAPACITY BY STREAM SECTION

Stream	Stream Section (Reaches)	% of Similkameen River System[1]: Area of Spawning Substrate	% of Similkameen River System[1]: Spawnable Area/Spawner Capacity[2]	Spawner Capacity: Spring Chinook (no.)[3]	Spawner Capacity: % Within Stream
	Above Duruisseau Ck. (15 and above)	0 (0)	0 (0)	0	0
	TOTAL	4.8 (234,800)	11.3 (41,500)	6,198	
Tularneen River	Princeton to River Vi. 6.5 (1)	7.0 (340,400)	43.8 (160,800)	23,994	79
	River Vi. 6.5 to Lawless Ck. (2-5)	6.4 (309,600)	11.2 (41,100)	6,138	20
	Lawless Ck. to Falls (6 to Falls)	0.2 (10,400)	0.3 (1,200)	180	1
	TOTAL	13.6 (660,400)	55.3 (203,100)	30,312	
Pasavten River	Mouth to River Vi. 3.5 (l-2)	0.7 (35,300)	1.0 (3,600)	538	95
	Above River Mi. 3.5 (3 and above)	0.2 (9,800)	L 0.1[4] (200)	26	5
	TOTAL	0.9 (45,100)	1.0 0,800)	564	

TABLE 4-l I (Continued)

SUMMARY OF SIMILKAMEEN RIVER SYSTEM, CHINOOK SALMON SPAWMNG SUBSTRATE., SPAWNABLE AREA AND SPAWNER CAPACITY BY STREAM SECTION

Stream	Stream Section (Reaches)	% of Similkameen River System[1]: Area of Spawning Substrate	% of Similkameen River System[1]: Spawnable Area/Spawner Capacity[2]	Spawner Capacity: Spring Chinook (no.)[3]	Spawner Capacity: % Within Stream
Similkameen River System Above Similkameen Falls	Similkameen River	5.2 (251,600)	2.5 (9,200)	1,372	71
	Pasayten River	0.9 (45,100)	1.0 (3,800)	564	29
	TOTAL	6.1 (296,700)	3.5 (13,000)	1,936	
Similkameen River System	**TOTAL**	(4,978,900)	(366,900)	54,734	

1 Approximate area (m^2) in brackets.

2 Percent spawnable area and percent spawner capacity are equal since spawnable area divided by a pair's spawning area requirement, times two, equals spawner capacity. Spawnable area in m^2 appears in brackets.

3 Spawning area requirement of 13.4 m^2/pair for spring chinook (Reiser and Bjornn, 1979).

4 Less than.

deep, fast sections along the dykc), large additional areas of the reach, estimated at 25%, appeared to be potentially suitable for spawning. This would increase the spawnable area in that reach from 3000 m^2 to 544,000 m^2 or from 0.18% to 60% of the system's spawnable area. It is evident that this reach, the largest in the entire system,,has the potential to at least double the entire system's spawnable area and therefore, spawner capacity estimates. More specific instream flow measurements are required to fully quantify the potential of this stream section. The re maining spawnable area in the Similkameen River, a total of 3.1% of the system, is located upstream of Princeton, with ?. 5% (9,200 m^2) of that above Similkarneen Falls. Figure 4-9. In the previous section, illustrates the distribution of chinook spawning capacity in realation to stream profile.

The Ashnola River contributes 11.3% (41,500 m^2) of the spawnable area in the whole system, essentially above Lakeview Creek to Duruisseau Creek (Reaches 10 to 14).

The Pasayten River adds ony 3,800 m^2 (1%) of spawnable area to the system total and it is found within the first 3.5 river miles. The Pasayten River contributes one quarter of the 13,000 m^2 (4%) located above Similkameen Falls.

Spawner capacities, that is the potential number of spawners, were derived by dividing the spawnable area by the respective area requirements for a pair of spring chinook spawners, 13.4 m^2 (Reiser and Bjornn, 1979), then multiplying the result by 2 (2 fish per pair).

The Cimilkarneen River mainstern has the capacity for nearly 18,000 spring chinook salmon,,of which about 15,500 chinook could utilize the stream section between Keremeos and Princeton (Reaches 5 to 9). only 444 spring chinook are predicted to use the large Reach 4 between Palmer Creek and Yererneos. However, as previously noted, the potential spawnable area is probaly an additional 25% of the spawning substrate area. This would increase the spawning capacity of the reach to about 81,000 and the entire system's capacity from 55,000 to 135,000 chinook salmon. Capaciity is available upstream of Princeton for about 1,700 spring chinook, mostly above Similkarneen Falls (1,372, spring chinook).

The spawnable area in the Ashnola River could accommodate 6,198 spring chinook, virtually all above Lakeview Creek to Duriusseau Creek (99% of the Ashnola River's capacity).

The Tulameen River has the largest spawner capacity of the entire system (excluding the potential of Similkameen River Reach 4) with area for 30,312 spring chinook. The majority, 44% of the Similkameen River system or 23,994 spawners could utilize the 6.5 river mile section, Reach 1, above Princeton. Twenty percent, 6,138 spring chinook of the Tulameen River spawner capacity is contained in the stretch from river mile 6.5 to Lawless Creek (Reaches 2 to 5).

The Pasayten River contributes sufficient spawnabie area to accommodate only 538 spring chinook salmon spawners, almost entirely within the first 3.5 river miles (Reaches 1 and 2). It also contributes only 29% of the capacity of the Similkameen River system above Similkameen Falls.

It is likely that the spawning area and spawner capacity estimates are conservative. In addition to the favourable spawning area within the 400 km (250 mi) of stream assessed in the present study, there remains an additional 160 km (98 mi) of stream not yet surveyed (as outlined in Section 4.1) which could provide potential spawning gravel. Thus, the total spawning potential of the Similkameen River system above Enloe Dam is iikelv higher than the estimates presented.

Roth spring and summer chinook salmon runs occur in other upper Columbia River tributaries. The upstream migration of adult chinook salmon into the Similkameen River system is expected to occur from late spring through the summer. Spring chinook will enter the river during the high runoff period of May and June followed by the summer chinook run in late July and August.

Since the Similkameen River is wide and of relatively low gradient from the Enloe Dam to the major identifies spawning area, the high discharges of the freshet will not produce water velocities impassible to the spring chinook. The large channel cross-section will provide sufficient areas of lower velocities along the perimeters for the upstream migration. Summer chinook, migrating upstream in July and August, will encuonter no streamflow limitations to their movement. Discharges in all streams within the svstem will be decreasing, but still higher than those experienced during the late summer/early fall field assessment period. no areas of difficult upstream migration, with the exception of Similkameen Falls and possibly the steep lower reaches of the Ashnola River, were observed during the field survey.

Chinook spawning periods in other upper Columbia River streams have been reviewed (French and Wahle, 1959; French and Wahle, 1965). In the Wenatchee River system, located just downstream of Rocky Reach Dam, spring chinook spawning occurs between early August and late September with summer chinook spawning in the Wenatchee River mainstem, occurring from early to late October. Upstream of Rocky Reach Dam, spring chinook spawn in late August in the Entiat River and mid-August through eariv September in the Methow River system. Summer chinook salmon spawn in early October in the Methow River and late October in the Entiat River. In the Simi lkameen River below Enloe Dam and the Okanogan River up to Oroville, summer chinook Spawn in the latter part of October.

In the upper Columbia River svstem (French and Wahle, 1965), spring chinook salmon were found to spawn when water temperatures ranged from 9° - 13°C (48° - 55°F). Summer chinook salmon would spawn in water temperatures ranging from 10° - 13° (50-55°C).

A range of water temperatures considered most suitable for successful spawning of chinook salmon (both spring and summer runs) have been determined by Reiser and Bjornn (1979) and Bovee (1978). The recommended ternnerature range is between 5.6 and 21.1°C (42 to 70°F) with the greatest probability-of-use at about 16.6°C (62°F). Glean water temperatures for the lower Tulameen River and the Similkameen River below Princeton (identified as the main spawning areas) fall in the range of about 7 to 18°C (4 5 to 64°F) during the months of August, September and October (see Table 4-19) Extreme spot temperatures recorded by the Water Survey of Canada in these areas range from 1.0°C (34°F) to 22.0°C (72°F) from August to September.

te temperatures from August to mid-September are favourable for chinook salmon spawn ing However,late September to november, which is the period of summer chinook spawning in other upper Columbia River tributaries (Washington Department of Fisheries, 1984), experiences colder water temperatures in the potential spawning areas. Extreme high temperatures in November rarely meet the lowest recommended water temperatures for chinook spawning, as the mean temperature for the month drops below 3°C (37°F).

The Sirnilkameen River system meets the water temperature criteria for spring chinook, however, low water temperatures in late September and November may limit spawning of summer chinook salmon.

4,4 Potential Anadromous Salmonid Rearing Area

4.4.1 Steelhead Trout

Potential rearing area for steelhead trout was estimated at about 1,802,000 m^2 for the entire Similkameen River study area (Table 4- 12) (Appendix 14). Figure 4-10 depicts the distribution of potential rearing area in the Similkameen River system, with reference to streambed profile. Sixty-seven percent (1,217,200 m^2) of the entire rearing area is located in the mainstem Similkameen River below Similkameen Falls, with 33% (594,700 m^2) in the portion of the Similkameen River between Kererneos and Princeton, B.C.

The Tulameen River contains a total of 18'% (319,400 m^2) of the potential rearing area, with the majority present in the lower reaches.

Of the 3.5% (63,600 m^2) in the Ashnola River, 2.2% (40,200 m^2) is contained in the upper middle reaches between Lakeview and Duruisseau creeks. The limiting factors to potential rearing area in the Ashnols River are the high water velocities and low temperatures.

Above Similkameen Fails, there is a calculated 11% (202,400 m^2) the total potential rearing area in the system of which 3% (47, 300 m^2) is in the Pasayten River and 8% (155, 100 m^2) in the Similameen River.

TABLE 4-12

SUMMARY OF SIMILKAMEEN RIVER SYSTEM JUVENILE STEELHEAD TROUT POTENTIAL REARING AREA

Stream	Stream Section (Reaches)	Potential Rearing Area (m^2)	% of Similkameen River System
Similkameen River	Enloe Dam to Palmer Creek (i-3)	186,647	10.3
	Palmer Creek to Yeremeos (4)	314,055	17.4
	Yeremeos to Princeton (5-9)	594,715	33.0
	Princeton to Similkameen Falls (10-19)	121,791	6.7
	Above Similkameen Falls (20-26)	155,119	8.6
	TOTAL	1,372,327	76.0
Ashnola River	Near Mouth (1-2)	409	0.02
	Year Mouth to Above Lakeview Creek (3-9)	11,940	0.7
	Above Lakeview Creek to Duruisseau Creek (10-14)	43,167	2.2
	Above Duruisseau Creek (15 and above)	11,055	0.6
	TOTAL	63,571	3.5

TABLE 4- 12 (Continued)

SUMMARY OF SIMILKAMEEN RIVER SYSTEM JUVENILE STEELHEAD TROUT POTENTIAL REARING AREA

Stream	Stream Section (Reaches)	Potential Rearing Area (m^2)	% of Similkameen River System
Tulameen River	Princeton to River Mi. 6.5 (1)	94,971	5.3
	River Mi. 6.5 to Lawless Creek (2-5)	165,300	9.2
	Lawless Creek to Falls (6 to Falls)	59,137	3.3
	TOTAL	319,408	17.8
Pasay ten River	Mouth to River Mi. 3.5 (1-2)	22,786	1.3
	Above River Mi. 3.5 (3 and above)	24,472	1.4
	TOTAL	47,258	2.7
Similkameen River System Above Similkameen Falls	Similkameen River	155,119	8.6
	Pasay ten River	47,258	2.7
	TOTAL	202,377	11.3
SIMILKAMEEN SYSTEM TOTAL		1,802,564	100.0

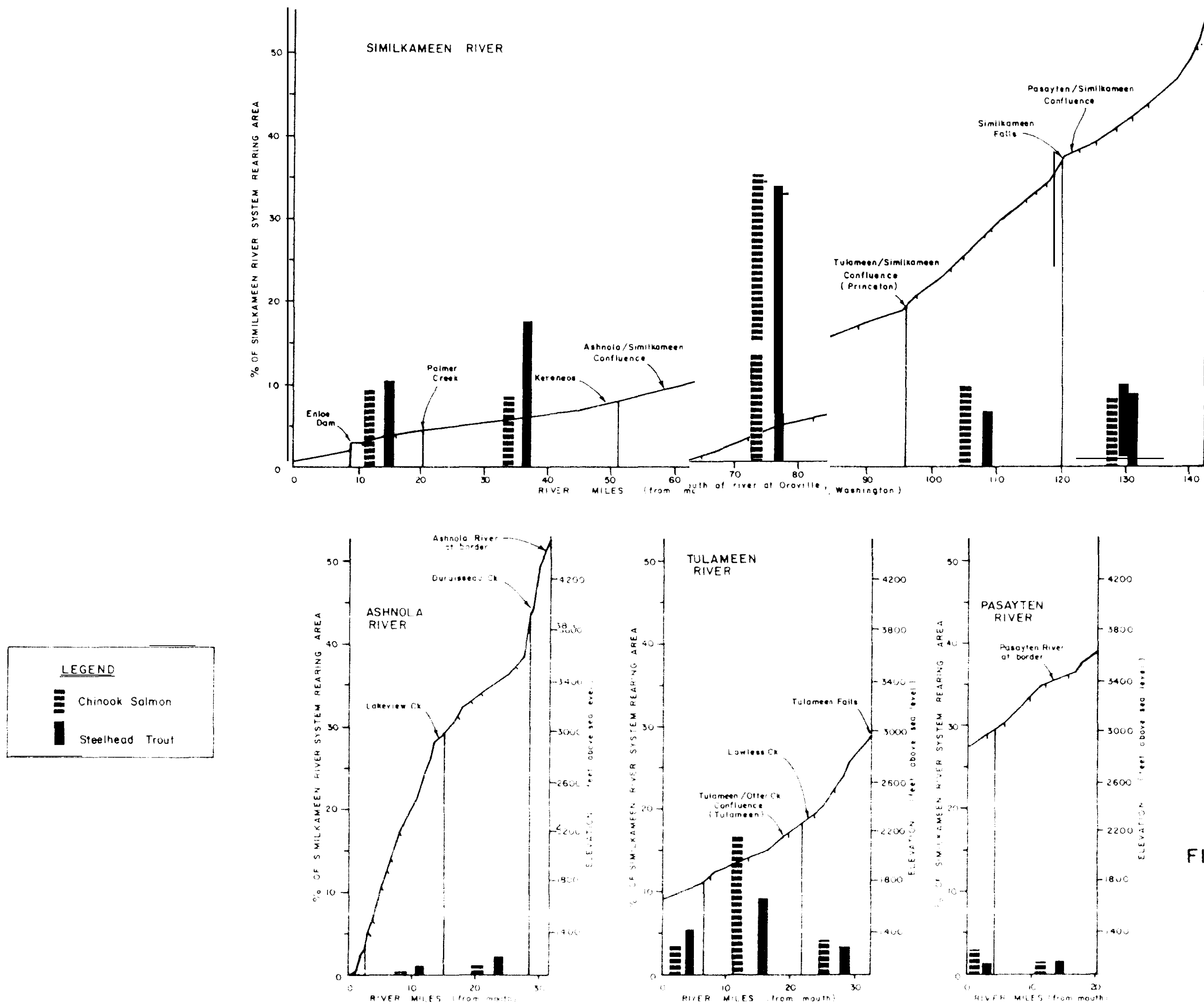

FIGURE 4-10: Steelhead Trout and Chinook Salmon Rearing Area Distribution Within the Similkameen River System.

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By comparing Figures 4-9 and 4-10 it can be seen, especially in the Similkameen River, that the majority of rearing area is found in the same sections as the majority of spawning. It should also be mentioned at this point that the spawning and rearing area figures were based on only the sections of the Similkameen River drainage that were habitat inventoried. There is an estimated 98 rniles of stream (mainly upper Ashnola and Pasayten rivers) that remains to be inventoried. Therefore, the calculated estimates for spawning and rearing area in the system are probably conservative.

4.4.2 Chinook Salmon

The Similkameen River system exhibits a total potential rearing area of 698,600 m^2 for chinook juveniles (Table 4-13). The rearing capacities for individual streams and sections has been graphically illustrated in Figure 4-10 (previous section) with reference to stream profile. Seventy-one percent (496,820 m^2) of the potential rearing area for chinook juveniles was estimated to be in the mainstem Similkameen River, half of that being between Keremeos and Princeton, B.C. A total of 63% of the potential rearing area is in the Similkameen River below the falls.

Twenty-four percent of the system's potential rearing area is in the Tulameen River (167,910 m^2), with 70% (1 15,730 m^2) of that in the middle reaches.

Above Similkameen Falls there is an estimated 84,360 m^2 of potential rearing area or 12% of the potential rearing area available in the whole system. Eight percent of this area is located in the Similkameen River and 4% in the Pasayten River.

Only 1% of the total potential rearing area is estimated to be in the Ashnola River predominantly in the upper middle reaches between Lakeview and Duruisseau creeks. The lack of potential rearing area in the Ashnola River is a result of the high water velocities consistently found throughou t the river as Well as low water temperatures. High water velocities are a limiting factor to chinook juvenile rearing area throughout the whole Similkameen River svstem.

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TABLE 4-13

SUMMARY OF SIMILKAMEEN RIVER SYSTEM
JUVENILE CHINOOK SALMON POTENTIAL REARING AREA

	Stream Section (Reaches)	Potential Rearing Area (m^2)	% of Similkameen River System
Simi l kameen River	Enloe Dam to Palmer Creek (1-3)	67,390	9.6
	Palmer Creek to Keremeos (4)	59,050	8.5
	Keremeos to Princeton (5-9)	243,400	34.8
	Princeton to Similkameen Falls (19-19)	69,190	9.9
	Above Similkameen Falls (20-26)	57,790	8.3
	TOT AL	496,820	71.1
Ashnola River	Year Mouth (l-2)	0	0
	Year Mouth to Above Lakeview Creek (3-9)	1,430	0.2
	Above Lakeview Creek to Duruissiau Creek (10-14)	5,630	0.8
	Above Duru isseau Creek (15 and above)	240	L0.1
	TOTAL	7,300	1.0

TABLE 4-13 (Continued)

SUMMARY OF SIMILKAMEEN RIVER SYSTEM
JUVENILE CHINOOK SALMON POTENTIAL REARING AREA

	Stream Section (Reaches)	Potential Rearing Area (m^2)	% of Similkameen River System
Tulameen River	Princeton to River Mi. 6.5 (1)	24,460	3.5
	River Mi. 6.5 to Lawless Creek (2-5)	115,730	16.6
	Lawless Creek to Falls (6 to Falls)	27,720	4.0
	TOTAL	167,910	24.1
Pasayten River	'Mouth to River Mi. 3.5 (1-2)	19,120	2.7
	Above River Mi. 3.5 (3 and above)	7,450	1.1
	TOTAL	26,570	3.8
Similkameen River System Above Similkameen Falls	Similkameen River	57,790	8.3
	Pasayten River	26,570	3.8
	TOTAL	84,360	12.1
SIMILKAMEEN SYSTEM TOTAL		698,600	100

As with steelhead, the majoritv of rearing area is in the same sections (Figures 4-9 and 4-10) as the majority of spawning area or just downstream. Also, as with the steelhead, the 98 miles of unassessed stream habitat in the Similkameen River system was not taken into account in the above calculations which could yield additional rearing areas.

4.5 Anadromous Salmonid Production Fstimates

4.5.1 Steelhead Trout

The Slaney Steelhead Trout Model predicts that a total of 609,600 smolts would be produced by the Similkameen River study area (Table 4-14). The mean adult return, at 1,5% smolt-to-asult survival, would be 9,200 and at 4.0% survival, 24,400. Detailed calculations are presented in Appendix 16.

Production estimates vary widely throughout the Similkameen River system. For example, Sinlahekin Creek, the most "productive" stream with regard to total dissolved solids (TDS) having a concentration of 200 mg/l and an estimated mean annual temperature of 8.0°C, has an estimated smolt yield as high as 0.21 smolts $/m^2$. A less productive stream such as the Pasayten River, with a total dissolved solids value 0f 60 mg/l and an estimated mean annual temperature of 4.0°C, has an estimated smolt yield as low as $0.02/m^2$.

Slanev's model predicts that over 33% (205,021) of the steelhead smolts produced in the entire drainage would be produced in the mainstem Sirnilkameen River, between Keremeos and Princeton, B.C. (Reaches 5-9). Almost 80% (475,347) of all the steelhead smolts produced in the system would eminate from the Similkameen River below the Similkameen Falls (Reaches 1-19). of the remaining smolts produced, a predi cted 9% (55,337) would be produced from the Tulameen River, 4% (26,199) from the Ashnola River, 4% (21,842) from Sinlahekin Creek, 3% (17,l 52) frorn the Similkameen River above the falls and 2% (11,441) form the Pasayten River. A total production of 28,593 (5%) smolts is predicted from the Similkameen River system aove Cimilkameen Falls.

TABLE 4-14
SUMMARY OF MEAN ANNIJAL SMOLT YIELD AND MEAN ADULT RETURN
ESTIMATES BY STREAM REACH USING THE SLANEY STEELHEAD MODEL

Stream	Stream Section (Reaches)	Area (m^2)	Mean Annual Smolt Yield: Range ($/m^2$)	Mean Annual Smolt Yield: Total No.	Mean Annual Smolt Yield: % of Similkameen River System	Mean Adult Return at Smolt-to-Adult Survival Rate: 1.5%	Mean Adult Return at Smolt-to-Adult Survival Rate: 4.0%
Similkameen River	Enloe Dam to Palmer Creek (l-3)	771,057	0.02-0.13	59,978	9.8	900	2,399
	Palmer Creek to Keremeos (4)	2,522,153	0.07	171,254	28.1	2,569	6,850
	Keremeos to Princeton (5-9)	2,698,541	0.05-0.13	205,021	33.6	3,075	8,202
	Princeton to Simiikameen Falls (10-19)	1,093,880	0.02-0.06	39,094	6.4	586	1,562
	Above Similkameen Falls (20-26)	496,096	0.02-0.06	17,152	2.8	25%	686
	TOTAL	7,681,727		492,499	80.7	7,388	19,699
Palmer Creek	Near Mouth to Palmer Lake	72,000	0.03	2,232	0.4	34	89
	TOTAL	72,000		2,232	0.4	34	89

TABLE 4-14 (Continued)
SUMMARY OF MEAN ANNUAL SMOLT YIELD AND MEAN ADULT RETURN ESITMATES BY STREAM REACH USING THE SLANEY STEELHEAD MODEL

Stream	Stream Section (Reaches)	Area (m^2)	Mean Annual Smolt Yield: Range ($/m^2$)	Mean Annual Smolt Yield: Total No.	Mean Annual Smolt Yield: % of Similkameen River System	Mean Adult Return at Smolt-to-Adult Survival Rate: 1.5%	Mean Adult Return at Smolt-to-Adult Survival Rate: 4.0%
Sinlahekin Creek	Near Mouth to Toats Coulee Creek (1)	69,976	0.21	14,772	2.4	222	591
	Near Cecile Creek to Connors Lake (3-4)	49,940	0.13-0. 5	7,070	1.2	106	283
	TOTAL	**119,916**		**21,842**	**4.0**	**362**	**874**
Ashnola River	Near Mouth (1-2)	56,967	0.03	1,736	0.3	26	69
	Near Mouth to Above Lakeview Creek (3-9)	338,988	0.02-0.05	9,608	1.[illegible]	144	382
	Above Lakeview Creek to Duruisseau Creek (10-14)	325,453	0.03-0.04	11,280	1.9	170	451
	Above Duruisseau Creek (15 and above)	73,866	0.05	3,575	0.[illegible]	[illegible]	143
	TOTAL	**795,274**		**26,199**	**4.4**	**394**	**1,045**

TABLE 4-14 **(Continued)**
SUMMARY OF MEAN ANNUAL SMOLT YIELD AND MEAN ADULT RETURN
ESITMATES BY STREAM REACH USING THE SLANEY STEELHEAD MODEL

S trearn	Stream Sec tion (Reaches)	Area (m^2)	Mean Annual Smolt Yield: Range ($/m^2$)	Mean Annual Smolt Yield: Total No.	Mean Annual Smolt Yield: % of Similkameen River System	Mean Adult Return at Smolt-to-Adult Survival Rate: 1.5%	Mean Adult Return at Smolt-to-Adult Survival Rate: 4.0%
Tulameen River	Princeton to River Vi. 6.5 (1)	344,658	0.07	24,884	4.1	373	995
	River Mi. 6.5 to Lawless Creek (2-5)	598,442	0.02-0.08	22,643	3.7	339	905
	Lawless Creek To Falls (6 to Falls)	247,222	0.02-0.0 5	7,850	1.3	117	314
	TOTAL	1,190,322		55,377	9.1	829	2,214
Pasay ten River	Mouth to River Vi. 3.5 (l-2)	135,296	0.02	2,7 16	0.3	40	108
	Above River Mi. 3.5 (3 and above)	408,412	0.02-0.03	8,725	1.4	131	349
	TOTAL	543,708		11,411	1.8	171	457
SIMILKAMEEN RIVER SYSTEM TOTAL		10,40&947	0.02-o-21	609,590		9,178	24,378

An adult steelhead escapement to the Similkameen River can be predicted from the number of smolts determined by Slaney's model using smolt-to-adult survival rates. From the smolts predicted by Slaney's model, an "average" (at 1.5% smolt-to-adult survival) mean adult return to the Similkameen River, below the falls, of 7,100 steelhead, almost 80% of the total run of 9,200, would be assumed. Of the approximately 830 steelhead adults predicted to return to the Tulameen River, almost half of these would return to the first reach, near Princeton, B.C. About 390 steelhead would return to the Ashnola River with the majority of these moving up into the higher reaches (W-14). Sinlahekin Creek (excluding Reach 2, which wasn't sampled) would have an estimated steelhead adult return of 328. However, seventy percent of the juveniles in this creek would have been predicted to have reared in Reach 1, which is characterized by a shifting sand bottom. No spawning would occur in this reach. A predicted 258 steelhead adults would return to the Similkameen River, above the falls, distributed evenly throughout all reaches. Only an estimated 171 adults are predicted to return to the Pasayten River.

Slaney's Steelhead Model predicts an adult return of 34 from the estimated 2,232 smolts, to Palmer Creek, however, due to low velocities and unsuitable spawning substrate (silt bottom), no spawning would occur in Palmer Creek and therefore no smolts would be produced.

During an exceptional ear, with 4.0% smolt-to-adult survival, close to 20,000 adult steelhead would be expected to return from smolts produced in the Similkameen River below the falls. There would be an almost 40% increase in adult returns in the entire system if smolt-to-adult survival increased from 1.5% to 4.0%. A total of approximately 24,400 would return to the whole system.

In addition to the steelhead model calculations, a range of steelhead smolt production was estimated by dividing the spatial requirements of I+ and II+ smolts, 14.49m^2 and 26.14m^2, respectively (Reiser and Bjornn, 1978) into the total area of the Similkameen River system assessed (10,402,947m^2). The range of optimal smolt production was calculated to be 397,970 smolts to 717,940 smolts. This range is based only on the habitat that was assessed during the 1983 field season, therefore, these calculations do not take into account the minimum 98 miles (160 km) of Similkameen River system yet to be assessed.

The estimated range of adult returns would be between 5,970 and 10,769 steelhead at 1.5% smolt-to-adult survival, and at 4% smolt-to-adult survival, this range would be from 15,919 to 28,718.

The balance between the Similkameen River system's steelhead trout spawning area, rearing habitat and production was determined by estimating the age II+ smolt production to be expected from the full seeding of the available spawnable area (total spawner capacity). A mean fecundity of 5,500 eggs determined for the Lemhi River, Idaho (Bjornn,1978) was used for the estimated 49,000 females (assuming 50:50 male/female ratio). The necessary survival rates to the various life stages were obtained from studies conducted in the Nicola River system (an interior B.C. stream) (Sebastian, 1982). The survival rates used were: egg to fry (15%) fry to fall II+ (50%). the calculations provided an estimated 1.5 million age II+ smolts from the 270 million deposited eggs. These 1.5 million age II+ smolts would be required to rear in the 1,802,600 m^2 rearing area within the system. However, smolt productions estimates predict that the system can only produce 7 18,000 steelhead juveniles. Therefore, rearing area appears to be a limiting factor to trout production in the Similkameen River system.

4.5.2 Chinook Salmon

Estimates of chinook salmon smolt production by stream length and area for the Similkameen River system, varied dramatically. The smolt production estimates by stream length were always lower than those estimated using stream area (Table 4-15). The chinook smolt production estimate for the Similkameen River system using stream length was 1,559,250 smolts whereas using stream area the estimate was 4,77 5,540. In the smaller streams, the Ashnola River, Pasayten River and Similkameen River above the falls, the smolt production estimates based on stream length and area were more similar than for the Similkameen River below the falls and Tulameen River, much larger streams. It appears that using stream length (smolts/km) is more applicable to small stream5 than to larger streams.

TABLE 4-15
ESTIMATED CHINOOK SMOLT PRODUCTION BY STREAM LENGTH AND AREA FOR THE SIMILKAMEEN RIVER SYSTEM

Stream	Stream Length (km)	Smolts /km[1]	Estimated Smolt Production	Adult Return Estimate[2]	Stream Area (m^2)	Smolts[3] /m^2	Estimated Smolt Production	Adult Return Estimate[2]
Similkameen River Below Falls	93	4050	781,650	2,550	7,133,580	0.47	3,352,780	10,060
Similkameen River Above Falls	35	4050	141,750	430	496,320	0.47	233,270	700
TOTAL	**228**		**923,400**	**2,980**	**7,629,900**		**3,586,050**	**10,760**
Ashnola River	64	4050	259,200	780	796,270	0.47	374,250	1,120
Tulameen River	53	4050	214,650	640	1,190,860	0.47	559,700	1,680
Pasayten River	40	4050	162,000	490	543,710	0.47	255,540	770
SIMILKAMEEN RIVER SYSTEM TOTAL	**385**		**1,559,250**	**4,890**	**10,160,740**		**4,775,540**	**14,330**

1 Mean Smolts per km calculated using Bjornn (1978) and Stream Enhancement Research Committee (1980).

2 Adult return estimated at 0.3% smolt to adult survival (Wash. Dept. Fish., 1984).

3 Mean smolt per m^2 calculated using Bjornn (1978), Stream Enhancement Research Committee (1980) and Oregon Dept. of Fish and Wildlife (1977).

It has been suggested that stream area is more appropriate for estirnating smolt production capability (Stream Enhancement Research Committee, 1980). Therefore, using stream area, the estimated chinook smolt production for the Similkameen River would be 3,586,050 smolts (3,352,780 smolts below Similkameen Falls and 233,270 smolts above). The Tulameen River, with an estimated chinook smolt production of 559,700, would be the most productive stream other than the mainstem Similkameen River below the falls. The next most productive chinook smolt streams would be the Ashnola River (374,259 smolts) followed by the Pasayten River (255,540 smolts). The Similkameen River system above the falls, including the Pasayten River, would yield roughly 488,8 10 chinook smolts.

Adult returns were estimated from the above smolt production estimates. A return of 14,330 adult chinook salmon would be expected in the Similkameen River system. Of the total return of adults, 10,060 would return to the Similkameen, below the falls, 1,680 to the Tulameen River, 1,120 to the Ashnola and 1,470 to the Similkameen River system above the falls (including the Pasayten River).

The balance between chinook salmon spawning and rearing habitat and production was determined by estimating the number of smolts expected to be produced from the Similkameen Rivers system's full spawner capacity compared with the calculated smolt production estimate, A fecundity for spring chinook in the Yakima River (a Columbia River tributary) of 3,500 (Major and Mighell, 1969) for the estimated 27,500 Sirnilkameen River system females (assuming a 50:50 ratio). From the resultant 96 million eggs, an estimated 10 million migrants was calculated using a mean egg to migrant survival of 10% (Major and Mighell, 1969 and Rjornn, 1978). These 10 million age I+ smolts would have to rear in the estimated 698,600m^2 of suitable area. However, chinook salmon smot production estimates predict that a maxirnum of 4,776,OOO smolts would be produced from the svstem. As with steelhead trout, rearing area appears to be a limiting factor to chinook salmon production.

4.6 Hydrology

4.6.i General

The Similkameen River above the Enloe Dam drains about 9250 square kilometres (3600 square miles) of the Pacific Yorthwest. Approximately 82 percent of the basin is in Canada. The Similkameen River originates near the international boundary at Manning Provincial Park and flows northward to Princeton where it is joined by the Tula meen River. From here, it changes direction to trend south-easterly to the border near Nighthawk, Washington. South of the horder, the river turns east where it is joined by Palmer Creek. It then flows towards its confluence with the Okanogan River near Oroville, Washington. The Enloe Dam is situated about six kilometers (four miles) upstream from Oroville (8.8 river miles from the confluence),

Major tributaries of the Similkameen River are the Tulamen, Pasayten and Ashnola rivers. The Tulameen River flows from the west to its confluence with the Similkameen at Princeton, B.C. The Pasayten River, most of which is in Washington State, flows north into Canada joining the Similkameen River just upstream of Similkameen Falls. The Ashnola River, also originating south of the border, trends northeastery from Cathedral Lakes Provincial Park to the Similkameen River near Keremeos, B.C. Several major creeks drain the large,relatively dry area north of Princeton. These include Otter, Allison, Summers and Haves creeks.

Obedkoff (1973) divided the Similkameen River Basin into two "relatively distinct and homogenous hydrological zones". The high elevation areas of the western portion of the basin produce most of the runoff, dominantly from snowmelt, and has therefore been designated the "wet zone" With exception for only a few areas, the eastern region of the basin is quite dry. The semi-arid climate is again a function of its elevation. This lowe-lying region is the "dry" zone. Elevation, therefore? is the key determinant in regional patterns of runoff. Figure 4- I1 approximates the zona! boundaries.

Most of the wet zone is located in the very wet Cascade Mountain Range and, owing to the high elevation of this area, most of its precipitation occurs as snow.

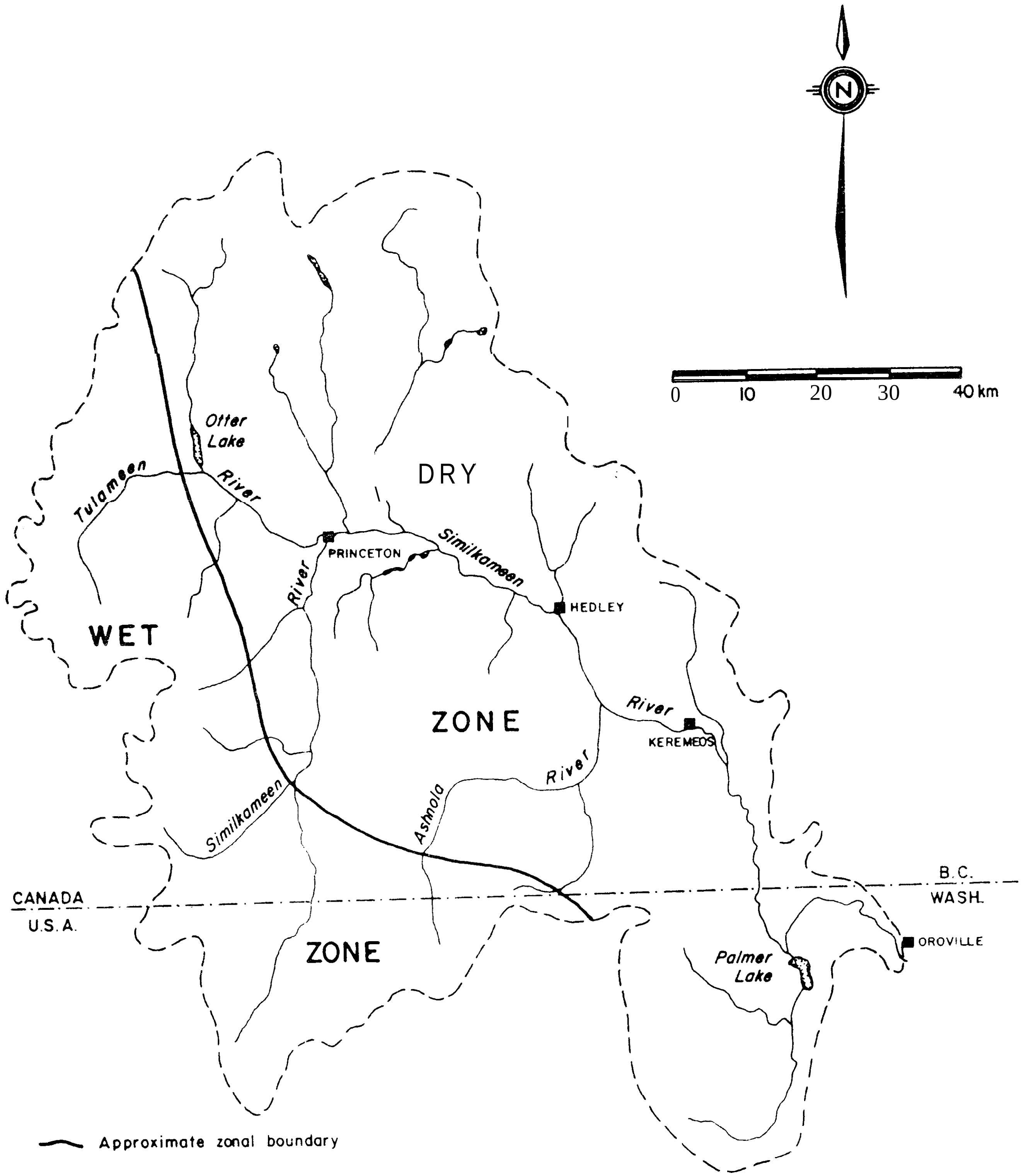

FIGURE 4-11: Hydrological Zones.

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Consequently, the wet zone contributes a proportion of the entire basin's runoff which greatly exceeds its proportion of the basin's total area. Most of the runoff occurs in late spring and summer as the high elevation snowpack melts. Most small streams in the wet zone contain surface flow all year, while rnany of those in the dry zone are intermittent.

Water resources problems are generally restricted to the agriculturally productive areas of the lower Similkameen Basin. Water shortages commonly occur due to Iow natural runoff corresponding with the peak demand for irrigation waters. Licensed water use during the summer low flow period is considered to be at capacity (Turner, 1983. Groundwater withdrawals do not presently require licensing in British Colu nbia, therefore the impact of their removal is not quantifiable.

The high runoff and short response time of the steep tributaries in the wet zone procuce a high susceptibility of the lower Similkameen River to flooding. Dyking and other mitigativeemeasures have been studied (eg. Talbot, 1979) and implemented. Several studies have investigated the feasibility of constructing reservoirs for the dual purpose of flood reduction and storage for irrigation (Sherwood, 1983).

Problems associated with freezing conditions may have an impact on the fisheries resource,,but their extent is unknown. Anchor ice and ice scour are known to occur (Bull, 1981; Gough, pes. comm., 19839.

4.5.2 Mean Flows

Mean monthly and annual discharges were calculated for all gauging stations with five or more years of data. Mean annual runoff was also calculated and expressed both as a volume and a unit volume (volume per square kilometre). For some of the smaller catchments, records are collected for spring and summer rnonths only. Annual runoff values for these gauging sites were estimated.Table A-1 (in Appendix 17) summarizes all mean flow data for streamflow gauging stations within both the Canadian and American portions of the Similkameen Basin.

In addition to the hydeometric data available for gauging stations within the Similkameen Basin, some streamflow data for catchments around its perimeter were also used. Table A-2 (in Appendix 17) summarizes mean annual flow data for these stations.

Since many of the gauging stations record water already accounted for by one or more upstream gauges, runoff values were reduced by any runoff from upstream catchments. Therefore, each gauging station represented a net catchment area and a net runoff specific to the region upstream of the gauge, but excluding all other gauged catchments. All runoff values were converted to unit runoffs by dividing by their catchment areas. This process was repeated for the sixteen catchments peripheral to the Similkameen Basin (see Table A-Z in Appendix 17). With all catchments and their respective unit discharges drawn on a map, a mosaic of 55 regions was generated. Isolines were drawn through these areas to produce a map of annual runoff. Figure 4-12 shows the regional pattern of streamflow generation.

It can be seen from the table of mean monthly flows (Table A-1 in Appendix 17), that the greatest amount of runoff occurs during the months of May and June. Although the other months generally show a decline to baseflow, many of the gauging stations show a secondary rise in Yovember and December, occurring as a result of fall rainstorms.

Some typical mean annual discharges for the Similkameen River and its tributaries are:

Tulameeen River at Princeton	23.3 m 3/s (823 cfs)
Pasayten River above Calcite Creek	7.9 m^3/s (279 cfs)
Ashnola River near Kererneos	8.3 m^3/s (293 cfs)
Similkameen River at Princeton	24.6 m^3/s (869 cfs)
Similkameen River near Nighthawk	66.3 m^3/s (2340 cfs)

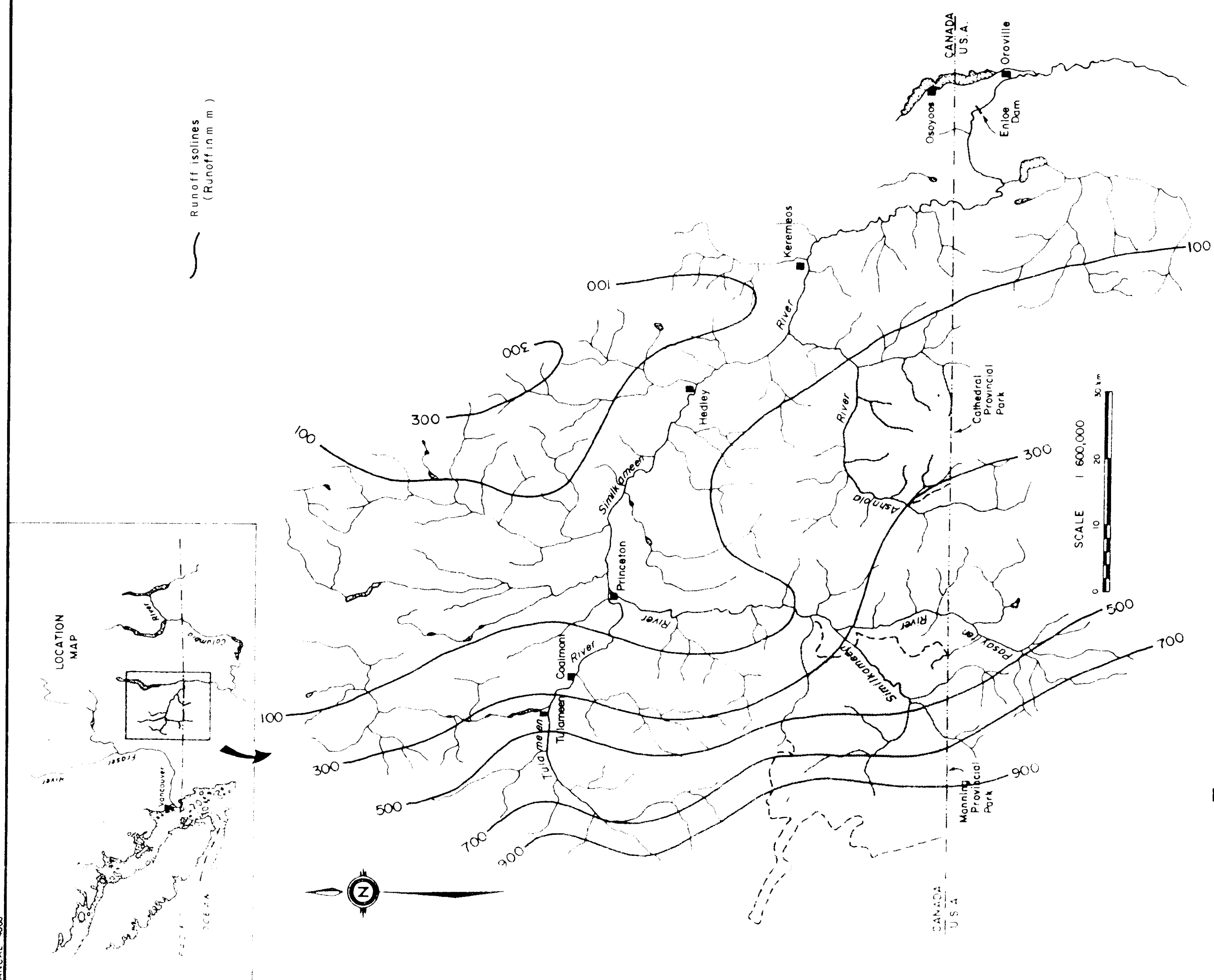

FIGURE 4-12:
Mean Annual Runoff.

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4.6.3 Peak Flows

With only a few exceptions, all peak discharges in the Sirnilkameen River Basin are the result of melting snow and ice during the late spring and early summer months. Since temperature and snow depth are primarily a function of elevation, and because a wide rarage of elevations exist throughout the basin, peak discharges vary greatly in quantity and, to a lesser degree, time of occurrence.

During late December, 1980, warm temperatures and heavy rain, associated with the inland penetration of a frontal system from the coast, resulted in a flood discharge greater than that of the spring freshet. However, such events are uncommon. With the exception of the December,1980 flood, no annual maximum discharge occured during the winter months in over 40 recorded years for the Similkameen River at Princeton.

Discharge peaks which occur as a result of fall rainstorms can be of comparable magnitude to those resulting frorn summer snowmelt. However, the fall peaks are of a “flashy” nature -rising and dropping back down in a matter of a few days. In terms of monthly average flows, these fall rises are of relatively small magnitude compared to the high discharges of the freshet, which are sustained for several weeks.

Maximum daily discharges were listed for every gauging station having a minimum of eight years of data. For each of the twenty-four sets of peak flow data, two descriptive values were calculated. First, the mean annual flood was determined simply by averaging the values.These values can be compared to assess variations in typical flood magnitude. Second, an extreme flood value was calculated using a probability analysis. Floods with a statistical probability of recurring once in 100 years (return period of 100 years, or probability of 0.01 of being met or exceeded in anv one year) were determined. This procedure was conducted so that extreme floods could be cornpared. Maximum recorded discharges for different stations are not truly comparable unless the stations all have the same number of vears of records. Since the length of record for stations in the Similkamcen Basin vary greatly, the statistical analvsis was used to generate comparable data by predicting floods of common recurrence interval (return period).

Although many procedures exist for the prediction of extreme values, the most commonly used, and that most accepted by government agencies in both Canada and the United States, is the Log-Pearson Type III distribution. For further discussion of theoretical distributions of extreme events please refer to a text of hydrological analyses, such as Linsley, et al., (1982).

Mean annual floods and the loo-year return period floods are summarized in Table A-3 (Appendix 17). Flood values are expressed both as discharges and unit discharges. A regional analysis of the data was then performed. On log-log paper, unit discharges were plotted against their respective values of drainage area. Typically, for a series of gauging stations within a hydrologically homogeneous region, an envelope curve or best-fit line could be drawn. The Similkameen River and its tributaries, however? exhibit such a diverse response to floods that a scatter of points resulted. This is due to the fact that two basic and distinct hydrologic regions exist in the basin (Obedkoff, 1973). Areas to the west and south are very wet, while most of the remaining catchment area is quite dry. Further complication results as some streams integrate the effects of the two regions by originating in one zone and flowing through the other. An additional reason for the lack of clear regional relationships is that some gauges are at the outlets of lakes, which have a regulating effect on floods. For these reasons, a plot of unit discharge versus drainage area is not given for all points. However, a plot of mainstem floods for the Similkameen, Tulameen, Pasayten and Ashnola rivers alone, did produce a significant regional pattern (Figure A-47 in Append ix 18).

As is expected, the smaller the catchment area, the more intense the unit discharge becomes. The near linear relationship (Figure A-47 in Appendix 18) was used to predict mean and extreme floods in mainstem reaches assessed during the 1983 summer fieldwork. These flow predictions, summarized in Table 4-16, approximate flood conditions through several reaches based on unit discharges at gauging stations.

The greatest record4 flood in the Similkameen Basin was that of 1 June, 1972. The discharge at the gauging station near Nighthaw,, Washington recorded a daily average flow of 1270 m^3/s (44,830 cfs). This flood was an extreme event with a calculated return period of about 180 years.

TABLE 4-16
FLOOD FLOWS BY REACH

Stream & Reach	Mean Annual Flood: Unit Discharge+ (l/s/km²)	Mean Annual Flood: Discharge Range Through Reach (m³/s)	100-Year Return Period Flood: Unit Discharge+ (l/s/km²)	100-Year Return Period Flood: Discharge Range Through Reach (m³/s)
Similkameen River				
Chuwanten Creek to Pasayten River	166	61 - 76	310	112 - 145
Tulameen River to Ashnola River	73	345 - 426	179	805 - 1064
Ashnola River to Enloe Dam	53	452 - 488	127	1050 - 1166
Pasay ten River				
International Boundary to Similkameen River	113	53 - 66	198	90 - 116
Tulameen River				
Vuich Creek to Otter Creek	212	54 - 96	402	103 - 198
Otter Creek to Similkameen River	113	170 - 199	223	321 - 392
Ashnola River				
International Boundary to Similkameen River	76	18 - 80	226	48 - 237

• Unit discharge calculated for gauging station site within the reach.

4.6.4 Low Flows

Low flows occur during two periods in the Similkameen Basin. The first low flow period occurs at the end of the summer and early fall as the high elevation snowpack is depleted. Fall rains bring a rise to many of the streams before discharges drop back to base flows during the winter. The latter low flow period is commonly associated with ice conditions throughout most of the basin.

Streams in the dry region of the basin (generally to the east) do not exhibit both low flow events since fall precipitation is much lower than in the western, wet regions. Consequently, the decreasing discharges of these streams following the summer peak are not separated from the winter low flow by fall rainstorms. Both periods, however, have been examined for all streams since the two periods are of different significance with respect to the life cycles of the fish.

For the purpose of this report, the fall low period is defined as that occurring after the summer freshet and before the end of November. The winter low flow period is that occurring from the beginning of December to the onset of the next year's freshet.

Minimum daily discharges were tabulated for both low flow periods. As was done for pea!< flows, both an average and an extreme value were calculated. A minimum of eight years data was the criterion for useage in statistical analyses. Sixteen gauging stations met this criterion. Tables A-4 and A-5 in Appendix 17) summarize mean and loo-return period low flows and their corresponding values of unit discharge for the two periods.

When unit discharges were plotted against their respective values of drainage area, a very poor regional relationship evolved. Typically, as the size of a catchment decreases, the unit low flow becomes more extreme, or smaller (similarly, as the catchment size decreases the unit peak flow is also expected to become more extreme, or larger). This relationship is dependent on hydrological conditions being similar for all data stations used..As mentioned before, the Similkameen River Basin is not hydrologically homogeneous, and therefore, is not easily interpreted by regional analyses. Since many of the smaller catchments are located in a relatively wet region (while the largest ones incorporate a vast area of semi-arid land), their unit discharges are higher than those of the larger catchments.

Although a regional pattern for all sixteen gauging stations used in the low flow analysis was not evident, a relationship could be drawn for gauging stations on the Similkameen, Pasayten, Tulameen and Ashnola rivers alone. These relationships are illustrated in Figures A-48 and A-49 in Appendix 18). The relationships were used to predict low flows through several reaches of the Similkameen River and its major tributaries. These low flows are summarized in Tables 4-17 and 4-18.

4.6.5 Regional Hydrology

The fact that records for the nearly fifty streamflow gauging sites in the Similkameen Basin cannot be interpreted by standard regional analyses is a clear indicator of the complexity of the area's hydrology. Streams reflect their location within either the wet zone or the dry zone, or various integrations of flows from both zones. Although lakes are not abundant in the basin, several of the gauging stations are located at lake outlets, with a resulting regulated effect on stream discharges. While the streamflow data for all gauging stations could not be described by regional analyses, data for the main rivers alone, could. Relationships based on stream discharges and drainage areas were produced for the Similkameen, Pasayten, Tulameen and Ashnola rivers. These streams were the areas of detailed fisheries assessment during the 1983 field program.

Figure 4-13 shows hydrographs for ten gauging stations in the Similkameen River Basin. The three hydrographs at the top of the figure are for wet zone gauging stations with drainage areas of less than 600 square kilometres The middle figure shows hydrographs for three dry zone streams with drainage areas less than 700 square kilometres The bottom diagram displays the hydrographs of four gauging sites with large drainage areas (greater than 1000 square kilometres).

The most obvious common factor among all Similkameen Basin streams is the occurrence of the annual freshet, producing most of the year's runoff in May and

TABLE 4-17
FALL MINIMUM DAILY DISCHARGES

Stream and Reach	Mean Annual Low Flow		100-Year Return Period Low Flow	
	Unit Discharge* (l/s/km²)	Estimated Discharge Range Through Reach (m³/s)	Unit Discharge* (l/s/km²)	Estimated Discharge Range Through Reach (m³/s)
<u>Similkameen River</u>:				
Chuwanten Creek to Pasayten River	3.14	1.1 - 1.6	1.49	0.6 - 0.7
Pasayten River to Tulameen River	2.10	3.6 - 3.9	0.789	1.3 - 1.5
Tulameen River to Ashnola River	1.36	6.3 - 9.0	0.656	3.0 - 3.7
Ashnola River to Enloe Dam	1.32	11.3 - 12.1	0.446	4.0 - 4.1
<u>Pasayten River</u>:				
International Boundary to Similkameen River	3.09	1.3 - 1.9	1.46	0.7 - 0.9
<u>Tulameen River</u>:				
Vuich Creek to Otter Creek	2.20	0.5 - 1.2	0.500	0.2 - 0.4
Otter Creek to Similkameen River	1.22	1.6 - 2.1	0.585	0.8 - 1.0
<u>Ashnola River</u>:				
International Boundary to Similkameen River	1.68	0.3 - 1.8	0.576	0.1 - 0.6

* Unit discharge calculated for gauging station site within the reach.

TABLE 4-18
WINTER MINIMUM DAILY DISCHARGES

Stream and Read	Mean Annual Low Flow		100-Year Return Period Low Flow	
	Unit Discharge* (l/s/km^2)	Estimated Discharge Range Through Reach (m^3/s)	Unit Discharge* (l/s/km^2)	Estimated Discharge Range Through Reach (m^3/s)
Similkameen River:				
Chuwanten Creek to Pasayten River	2.19	0.9 - 1.1	0.600	0.23 - 0.35
Pasayten River to Tulameen River	1.16	2.1 - 2.5	0.298	0.48 - 0.55
Tulameen River to Ashnola River	1.02	5.1 - 5.8	0.361	1.3 - 1.7
Ashnola River to Enloe Dam	0.747	6.2 - 6.9	0.227	1.9 - 2.1
Pasayten River:				
International Boundary to Similkameen River	1.64	0.8 - 1.0	0.434	0.19 - 0.27
Tulameen River:				
Vuich Creek to Otter Creek	2.21	0.6 - 1.3	0.473	0.12 - 0.27
Otter Creek to Similkameen River	1.30	1.9 - 2.3	0.325	0.49 - 0.57
Ashnola River:				
International Boundary to Similkameen River	0.891	0.2 - 0.9	0.599	0.10 - 0.59

* Unit discharge calculated for gauging station site within the reach.

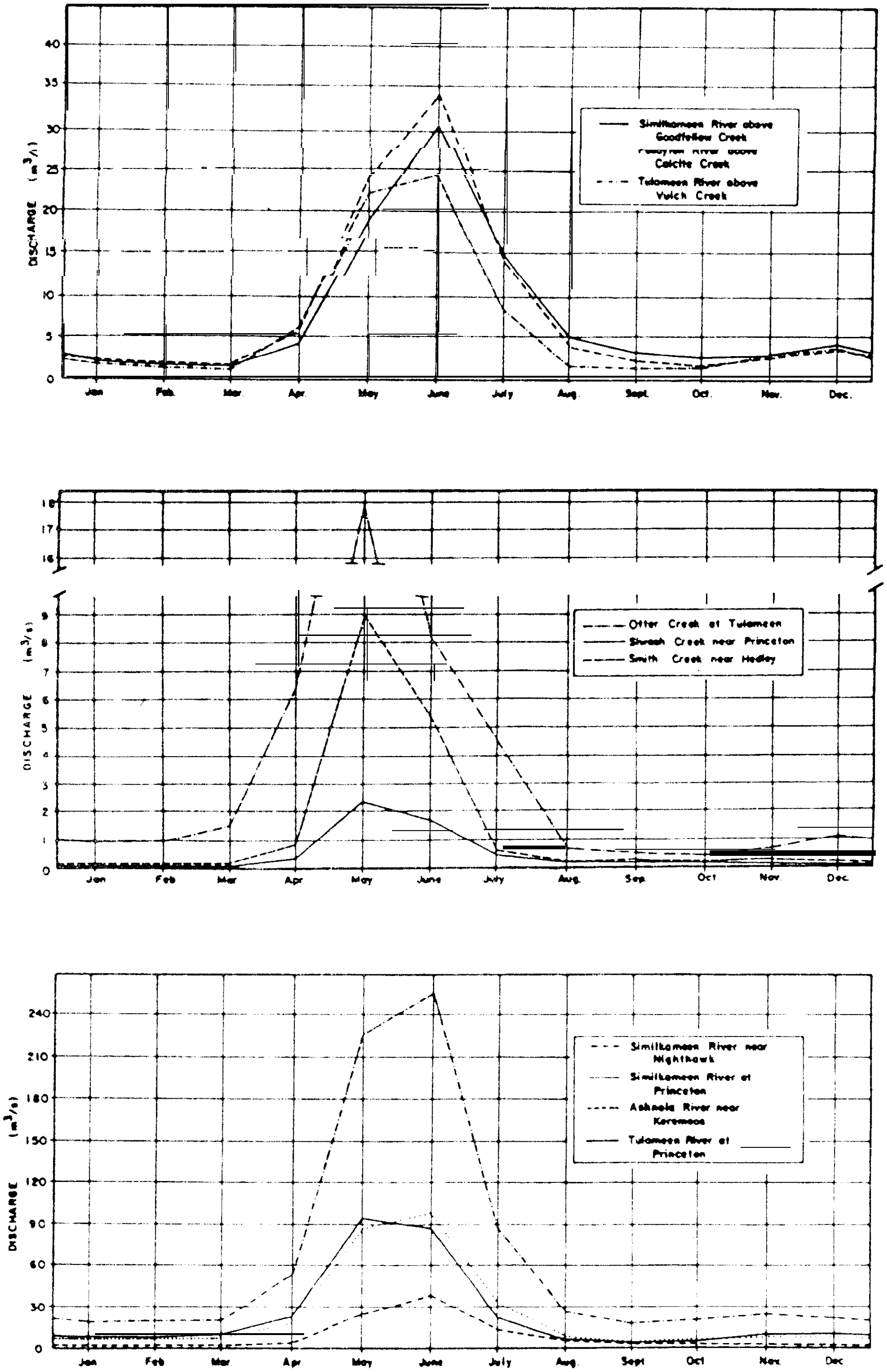

FIGURE 4-13 : Hydrographs - Mean Monthly Discharges
Similkameen River and Yri butaries.

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June. Flows decrease to a more constant baseflow from August through to the following March. Outside of this general similarity, however, the hydrographs illustrate differences in the hydrological regimes of various sub-regions of the basin.

Dry zone streams tend to reach their peak annual discharges in May while wet zone streams generally peak during June. The wet zone snowpack is much greater and mean temperatures are lower, therefore runoff from snowmelt in the wet zone peaks later than that of the dry zone, where the snowpack is depleted earlier. A second significant difference is the presence of a small rise in mean monthly discharges in wet zone catchments in November and December. This reflects the response of the wet zone streams to late fall rainstorms which are not typical of the dry zone's climate.

The hydrographs for the major tributaries (Figure 4-13, bottom) show the degree to which the main tributaries contribute to the mean flows at the lowest gauging station on the river near Nighthawk, Washington.

It should be noted that the wet and dry zones are not clearly separated by a narrow boundary. Streams near the division between the zones (see Figure 4-11) may possess traits of both zones. Otter Creek at Tulameen exemplifies this. Although the unit annual runoff is relatively low and the peak discharge usually occurs in May (factors characteristic of dry zone streams), the stream also responds to late fall rainstorms, as is typical of wet zone streams. Other exceptions include Hedley and Keremoes creeks which show peak discharge in June as a result of a high stream elevation areas north and east of Hedley which have snowpack lasting longer into the summer than that of the surrounding region.

4.6.6 1983 Hydrological Conditions

In general, 1983 was a fairly typical year in terms of runoff. Figure 4-14 shows the hydrograph of mean daily discharge for the Simikameen River near Hedley Also shown on this figure, are the mean monthly discharges for that site. The only noticeable deviations from the means occurred in June (the snowpack was slightly less than average and was depleted early), and in October and November which had slightly lower and slightly higher than average flows, respectively.

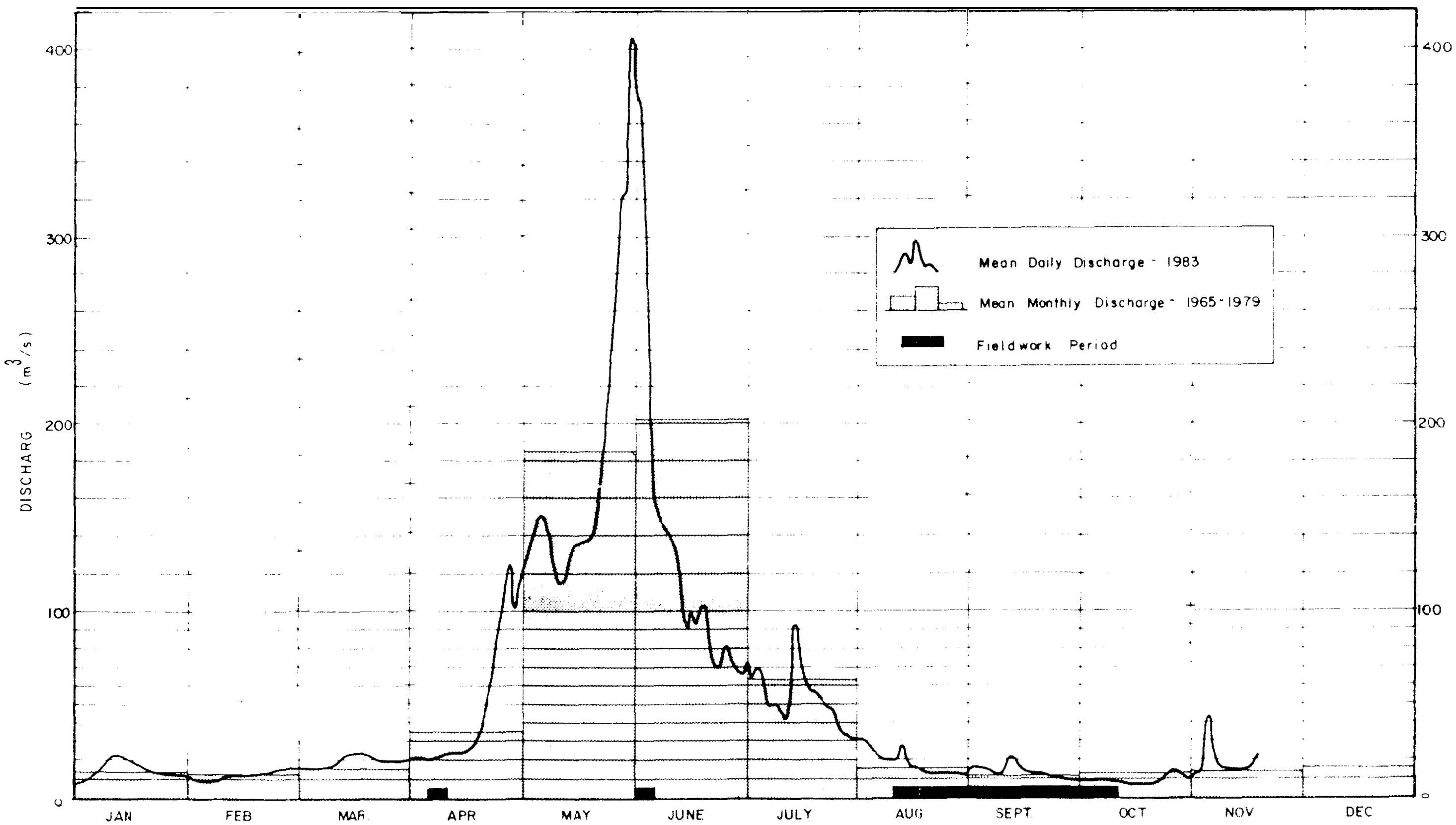

FIGURE 4-14:

1983 Hydrograph -
Simılkameen River Near Hedley.

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Stream discharges during the field investigations, especially the late summer fieldwork, were quite representative of typical flows. Two rises in the hydrograph during August and September fieldwork period were the result of short duration, summer thunderstorms, events which are typical throughout the entire Similkameen River Basin. Stream discharges measured during the summer fieldwork are summarized in Table A-6 in Appendix 18).

4.7 Water Quality

4.7.1 Temperature

Mean monthly and mean annual temperatures are summarized for sixteen sites throughout the Similkameen Basin. Table 4-19 lists the data in order of decreasing mean annual water temperature. Wolfe and Otter creeks are warmest since they are at the outlets of lakes within relatively warm, dry areas of the basin. As would be expected, higher elevation streams in the wetter zone to the west, experience cooler temperatures (eg. Tulameen River below Vuich Creek and Whipsaw Creek below Lamont Creek). The tempertures of the main tributary waters reflect a mixing of warmer and cooler waters from their tributaries. In general, temperatures increase along the Similkameen River towards the Enloe Darn.

It should be noted that the data summarized in Table 4-19 represent a summary of spot temperatures and not dailv averages. A bias towards slightly warmer temperatures is, therefore, inherent in this data, since the measurements were made during the warmer daylight hours. This is especially apparent for small streams in which water temperature is more closely related to air temperature.

Table 4-20 summarizes the spot temperatures recorded during the habitat assessments and Table 4-21 lists temperatures recorded at other sites where stream discharges were measured.

TABLE 4-19
MEAN STREAM TEMPERATURES

Stream	Mean Monthly Temperature (°C)												Mean Annual Temperature (°C)
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dee.	
Wolfe Creek at Outlet of Issitz Lake	1.5	2.5	5.0	7.0	9.5	13.0	17.0	17.0	14.0	10.0	5.0	2.0	8.6
Otter Creek at Tulameen	2.0	2.5	3.5	4.5	7.5	12.0	17.0	17.5	14.5	10.0	6.0	2.s	8.3
Sinlahekin Creek above Chopaka Creek	1.2	1.6	3.8	7.0	10.5	13.4	14.8	14.4	12.3	9.0	5.5	2.7	8.0
Sirnilkameen River near Nighthawk	0.7	6.8	4.1	6.8	9.1	10.9	16.1	17.8	14.6	8.6	2.9	1.4	7.9
Keremeos Creek near Olalla	2.0	3.0	5.0	7.0	9.0	11.5	12.0	11.5	9.5	7.5	5.0	2.5	7.1
Similkameen River near Hedley	0.2	0.8	2.8	5.8	6.4	8.0	15.4	16.3	12.3	8.3	2.2	0.4	6.6
Tulamcen River at Princeton	0.4	0.6	2.5	1.0	6.0	8.5	15.3	16.2	12.3	6.7	1.9	0.8	6.4
Sirnilkameen River at Princeton	0.4	0.9	1.4	5.5	6.1	7.9	13.7	15.4	12.9	6.7	1.5	1.0	6.1
Ashnola River near Keremeos	0.4	0.8	2.6	6.4	6.6	8.6	12.3	13.3	10.7	5.4	2.4	0.4	5.8
Toats Coulee Creek near Loomis	0.0	0.0	0.4	3.2	6.6	9.6	II.5	11.8	10.3	7.6	4.2	1.1	5.5
Siwash Creek near Princeton	0.0	0.0	0.0	2.0	5.0	8.5	13.0	15.0	10.0	5.0	2.5	0.0	5.1
Soukup Creek near Hedlcy	0.5	0.5	1.0	3.0	5.5	8.0	11.0	II.5	8.5	6.0	2.5	1.0	4.9
Smith Creek near Hedley	0.0	0.0	0.5	2.5	5.0	8.0	12.0	12.0	8.5	6.0	2.0	0.0	4.7
Whipsaw Creek below Lamont Creek	0.0	0.0	6.0	2.5	4.5	8.0	12.0	11.0	8.0	5.0	2.0	0.5	4.5
Tulameen River below Vuich Creek	0.0	0.0	0.3	2.5	4.6	6.2	10.7	10.3	7.7	4.0	0.7	0.3	4.0

TABLE 4-20
TEMPERATURES AT HABITAT ASSESSMENT REACHES

Stream and Reach*		Date (day/month/year)	Time (hours)	Temperature (°C)
Similkameen River				
Reach	1 (reservoir)	10/10/83		
	2	10/10/83	1610	11.0
	3	9/10/83	1730	10.5
	4 (5)	6/10/83	1200	9.5
	4 (4)	4/10/83	1400	10.5
	4 (3)	4/10/83	1100	9.5
	4 (2)	3/10/83	1130	9.5
	4 (1)	2/10/83	1230	8.5
	5 (2)	20/9/83	1600	8.5
	5 (1)	20/9/83	1130	8.0
	6 (2)	18/9/83	1330	10.5
	6 (1)	17/9/83	1530	12.0
	7 (2)	16/9/83	1430	13.0
	7 (1)	15/9/83	1530	13.0
	8 (2)	14/9/83	1600	14.0
	8 (1)	15/9/83	1200	10.0
	9 (2)	14/9/83	1100	11.5
	9 (1)	13/9/83	1300	12.0
	10 (2)	13/9/83	1000	10.0
	10 (1)	12/9/83	1630	13.5
	11 (2)	11/9/83	1400	11.0
	11 (1)	10/9/83	1200	9.0
	12	9/9/83	1330	10.5
	13	12/9/83	1200	10.0
	14	8/9/83	1230	9.5
	15	30/8/83	1600	14.0
	16	30/8/83	1130	12.0
	17	29/8/83	1600	13.0
	18	27/8/83	1715	12.5
	19 (2)	25/8/83	1600	15.0
	19 (1)	27/8/83	1130	12.0
	20	14/8/83	1515	18.0
	21	14/8/83	1500	16.0
	22	14/8/83	1130	14.0
	23	13/8/83	1730	15.5
	24	14/8/83	1110	12.0
	25 (2)	13/8/83	1625	15.0
	25 (1)	12/8/83	1100	11.0
	26	12/8/83	1640	14.5

Stream and Reach*		Date (day/month/year)	Time (hours)
Sinlahekin Creek			
Reach	1	9/10/83	1230
	3	7/10/83	1715
	4	7/10/83	1515
Ashnola River			
Reach	1	1/10/83	1235
	2	1/10/83	1030
	3	30/9/83	1400
	4	30/9/83	1130
	5	29/9/83	1015
	6	28/9/83	1340
	7	28/9/83	1130
	8	27/9/83	1615
	9 (3)	27/9/83	1150
	9 (2)	26/9/83	1430
	9 (1)	26/9/83	1100
	10	25/9/83	1530
	11	25/9/83	1340
	12	23/9/83	1400
	13 (3)	23/9/83	1130
	13 (2)	22/9/83	1350
	13 (1)	22/9/83	1100
	14	21/9/83	1630
	15	21/9/83	1200
Tulameen River			
Reach	1	7/9/83	1200
	2	6/9/83	1800
	3	5/9/83	1650
	4 (2)	5/9/83	1130
	4 (1)	4/9/83	1615
	5	4/9/83	1200
	6	3/9/83	1600
	7	3/9/83	1100
	8	2/9/83	1450
Pasayten River			
Reach	1	23/8/83	1300
	2	23/8/83	1330
	3	24/8/83	1200
	4	15/8/83	1600
	5	15/8/83	1200
	6	15/8/83	1315

*-reach sections are given in parentheses where applicable.

TABLE 4-21

TEMPERATURES RECORDED AT STREAMFLOW METERING SITES

STREAM	DATE	TIME (hours)	TEMP. (°C)
Sirnilkameen River above Memaloose Creek	18 August	1730	13.5
Memaloose Creek above Similkameen River	18 August	1800	10.5
Similkameen River above Paysayten River	23 August	1600	15.0
Pasayten River above Similkameen River	23 August	164.5	15.0
Copper Creek at mouth	27 August	1450	11.0
Lawless Creek at mouth	3 September	1800	13.0
Granite Creek at mouth	5 September	1440	12.0
Chu wan ten C reek at mouth	8 September	1630	8.6
Willis Creek above Wolfe Creek	13 September	1700	9.0
Wolfe Creek at mouth	14 September	1615	12.0
Hayes Creek near mouth	15 September	1655	10.5
Arcat Creek near mouth	16 September	1745	11.0
Whistle Creek at mouth	18 September	1620	8.0
Smith Creel-c at mouth	18 September	1715	7.0
Allsion Creek at mouth	19 September	1130	7.0
Wall Creek at mouth	21 September	1500	6.5
4shnola River below Wall Creek	21 September	1400	8.0
Young Creek near mouth	23 September	1315	7.5
Ewart cree < at mouth	27 September	1430	7.5
Hedley Creek near mouth	2 October	1630	7.0
Yeremeos Creek above Yeremeos	3 October	1500	13.0
Sinlahekin Creek above Palmer Lake	6 October	1630	10.5
Palmer Creek below Palmer Lake	6 October	1530	13.0
Sinlahekin Creek near Blue Lake	7 October	1330	5.0

4.7.2 Nitrate-Nitrogren and Total Dissolved Solids

Nitrate-nitrogen and total dissolved solids (TDS) are two water quality parameters which can be used as a measure of the productivity of aquatic environments. Nitrates stimulate plant growth, therefore, aquatic organisms may flourish in their presence (Environmetn Canada, 1979), TDS have also been used as a measure of instream nutrients (Stream Enhancement Research Committee, 1980).

Concentrations of nitrate-nitrogen and TDS increase during periods of low surface runoff, when the proportion of flow originating from groundwater is high. Overland runoff also contributes to dissolved materials by washing the land surfaces. In addition to natural sources, industrial discharges, municipal sewage and agricultural lands (fertilized with inorganic nitrates) are sources of nutrients.

Tables 4-22 and 4-23 summarize the water quality data published by government agencies and that collected by IEC Beak, respectively. The government data indicates only two sites which have nitrates and TDS values significantly higher than all others. These are Allison and Wolfe creeks. The results of samples collected during the 1983 field survey, reveal three sites of relatively high nutrient loads. The Tulameen River below Otter Creek, Otter Creek and Sinlahekin Creek are the only sites with concentrations above detection limits.

The water quality results appear to indicate that the streams which drain the warm, drv areas of the basin are higher in nutrients. This is probably due to the fact that thses streams contain a greater percentage contribution of groundwater (they are not "flushed" with purer surface water to the same extent as in the wetter higher elevation streams). aslo,,these streams are in areas corresponding with the agricul tural regions of the basin..Contributions from fertilizers account for some of the nitrate-nitrogen found in these streams. Several sewage treatment plants operate in the Similkameen River Basin. The plants located in Princeton and at Manning Park are monitored by the B.C. Ministry of Environment. Although their influence is not great, it is noticeable (see Table 4-22).

TABLE 4-22

SUMMARY OF NITRATE - NITROGEN AND TOTAL DISSOLVED SOLIDS

DATA COLLECTED BY THE B.C. MINISTRY OF ENVIRONMENT

	Nitrate - Nitrogen (mg/l)				Total Dissolved Solids (mg/l)			
Stream and Location	No. of values	Maximum	Minimum	Average	No. of values	Maximum	Minimum	Average
Similkameen River:								
- near Nighthawk, Wash.[1]	32	0.016	L0.005	0.005	32	134	50	99
- 7 miles south of Cawston, B.C.	26	0.014	L0.005	0.007	35	163	40	97
- 3.6 km downstream of Keremeos, B.C.	19	0.023	L0.005	0.007	20	131	36	93
- at red bridge upstream of Keremeos, B.C.	19	0.020	L0.005	0.006	19	180	36	94
- at Hedley, B.C.	0	-	-	-	60	272	36	102
- upsteam of Allison Creek	16	0.020	L0.005	0.007	17	144	31	79
- downstream of Princeton STP[2]	16	0.016	L0.005	0.005	15	130	38	87
- upstream of Princeton STP[2]	15	0.018	L0.005	0.006	15	120	36	83
- at Princeton, B.C.	14	0.050	L0.005	0.009	99	120	31	75
- downstream of Newmont Mines Tailings impoundment	1	L0.005	L0.005	L0.005	1	47	47	47
- upstream of Newmont Mines Tailings impoundment	2	0.005	L0.005	0.005	2	42	33	38
- at Similkameen Falls	19	0.020	L0.005	0.007	21	99	28	59
- downstream of Manning Park STP[2]	5	0.011	L0.005	0.008	6	98	63	86
- upstream of Manninig Park STP[2]	5	L0.005	L0.005	L0.005	6	93	51	70
Tulameen River:								
- at Hwy. 5 bridge in Princeton, B.C.	22	0.016	L0.005	0.007	106	146	30	88
- at Coalmont, B.C.	22	0.011	L0.005	0.005	26	103	34	75
Allison Creek:								
- near the mouth	22	0.088	0.011	0.050	24	308	187	266
- at bridge on 5 mile road	15	0.063	0.011	0.036	18	287	185	255
Wolfe Creek:								
- upstream of east tailings dam	-	-	-	-	76	418	101	283
- downstream of east tailings dam	25	0.072	L0.005	0.008	87	517	124	318
Hayes Creek:								
- at road bridge	13	0.025	L0.005	0.008	29	114	28	74
Hedley Creek								
- at mouth	14	0.005	L0.005	0.005	28	58	15	34

[1] - Data collected by U.S.G.S.

[2] - STP = Sewage Treatment Plant

TABLE 4-23

NITRATE-NITROGEN AND TOTAL DISSOLVED SOLIDS (TDS)

ANALYSIS OF WATER SAMPLES COLLECTED

DURING 1983 SUMMER LOW FLOW PERIOD

Stream and Sample Location	Date (1983)	Time (hrs)	Parameter (mg/l) Nitrate-Nitrogen	TDS	Temp. at Collection (°C)
Similkameen River					
- above Pasayten River	Sept.8	1520	0.004	65	10.5
- below Friday Creek	Sept.8	1200	0.004	65	9.5
- below Princeton	Sept.8	0830	0.004	76	9.0
- at Yetemeos	Oct.2	1515	0.004	81	11.0
- above Enloe Dam	Oct.1 1	1130	0.004	140	9.0
Pasayten Rivet					
- near mouth	Sept.8	1520	0.004	60	11.0
Tulameen River					
- above Otter Creek	Sept.7	1700	0.004	71	13.0
- above Princeton	Oct.2	1815	0.008	87	10.0
- at Princeton	Sept.8	1000	0.036	110	10.0
	Oct.2	1800	0.010	93	10.0
Otter Creek					
- near mouth	Sept.7	1700	0.018	88	16.0
Ashnola River					
- near mouth	Oct.2	1555	0.004	63	8.0
Palmer Creek					
-below Pafmet Lake	Oct.10	1230	0.004	160	12.5
Sinlahekin Creek					
- above Palmer Lake	Oct. 10	1245	0.014	200	8,5

5.0 SUMMARY AND CONCLUSIONS

1. This report presents the results of a habitat inventory conducted on the Similkameen River systern in British Columbia and Washington State, between August 10 and October 10, 1983. The general study objectives were to:

   (i) conduct a habitat assessment of the mainstem Similkameen River and its major tributaries upstream of Enloe Dam in Washington and throughout the basin in British Columbia;
   (ii) conduct an inventory of the system's resident fish popuiations;
   (iii) estimate the quantity of spawning and rearing area available for steelhead trout and chinook salmon;
   [iv) estimate the system's potential steelhead trout and chinook salmon smolt production;
   (v) describe the hydrology and general water quality of the Similkameen River Basin as it is related to fish production.

2. Two field crews assessed approximately 400 km (250 mi.) of stream by making detailed biophysical inventories at 77 representative sites. A total of 43 km. (27 mi.) of stream habitat was inventoried, over 11% of the entire Similkameen River system. A minimum additional 160 km (98 mi.) of accessible stream,,in the headwaters of major tributaries and the smaller tribuatries, not vet assessed in-field, was estimated.

3. The Similkameen River system was estimated to contain approximately 961,000 m^2 (1 15,000 yd^2) of steelhead trout spawnable area. The present distribution of available spawning area in the Similkameen, Ashnola, Tularncen and Pasayten rivers was 55, 14, 30 and 1% respectively.

4. Steelhead trout spawner capacity for the entire system was predicted at 98,000 f ish. An approximate estimate of 54,000 fish would utilize the Similkameen River, 13,000 the Ashnola River, 30,000. the Tulameen River and only 1,000 the Pasayten River.

5. Chinook salmon spawnable area is estimated at 367,000 m^2 (439,000 yd^2) for the whole system. Nearly 55% is located in the Tulameen River with the remainder, 32, 1 1, and 1% present in the Similkameen, Ashnoln and Pasayten rivers, respectively.

6. The system is estimated to have a spring chinook spawner capacity of 55,000. Approximately 18,000 chinook would use the Similkameen River, 6,000 the .Ashnola River, 30,000 the Tulameen River and 600 the Pasayten River.

7 Potential steelhead trout rearing area in the Similkameen River system was estimated at about 1.8 million m^2 (2.2 million yd^2). Seventy-six percent is present in the Similkameen River, with 3, 18 and 3% present in the Ashnola, Tulameen and Pasayten rivers, respectively.

8. Estimated juvenile chinook salmon (age I+) rearing area was determined to he nearly 700,000 m^2 (837,000 yd^2) in the entire system. Contributions to this total from the Similkameen, Ashnola, Tulameen and Pasayten rivers was 7 1, 1, 24 and 4%, respectively.

9. For both steelhead trout and chinook salmon, rearing area was found to be a limiting factor to production at full seeding of the available spawning area.

IO. Smolt production estimates made for the Similkameen River system, and were found to be approximately 610,000 steelhead trout and between 1.6 and 4.8 million chinook salmon.

11. Similkameen River systern resident rainbow trout populations and standing crop were found to Se verv low when compared to other systems. In addition, the measured standing crop estimate resulting from fish sampling was usually less than that predicted by the Habitat Quality Index (HQI).

12. The rainbow trout in the Similkameen River system were found to be comparitively slow growing fish, requiring up to 4 years to reach 200 mm (8 in).

13. High standing crop estimates of suckers and mountain whitefish were found in the mainstem Similkamcen River below Similkameen Falls and lower reaches of the Tulameen River. Sculpin and lonqnose dace standing crop values were also high in most regions of the system.

14. Only rainbow trout anti longnose dace were found above Similkameen Falls Incidental species encountered, all in the Iower portions of the Similkameen system, were northern squawfish, kokanee and black crappie.

15. No major water quality, temperature or flow problems in the Similkameen system for either steelhead trout or chinook salmon were evident from the data available or the field survey.

16. A fish barrier, in the forrn of about 100 ft high falls, is present on the Tulameen River at about river mile 32.5. Other areas of difficult passage include the Similkameen Fails (a series of chutes) and the steep, boulder-v lower reaches of the Ashnola River.

17. From the Similkameen River habitat inventory and anadromous salmonid production estimates, it is evident that provision of passage at Enloe Dam Es justified on the basis that it would provide access to extensive anadromous salmonid rearing and spawning areas.

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