NICOLA BASIN STRATEGIC PLAN
TECHNICAL DOCUMENT

PLANNING BRANCH AND THOMPSON-NICOLA REGION
MINISTRY OF ENVIRONMENT

MAY, 1983

The Nicola Basin Strategic Plan - Summary Document was approved by the Ministry Executive - July 1983.

PREFACE

The Nicola Basin Environmental Strategic Plan is the first example of this type of planning for the Ministry of Environment. The plan itself is approximately a 50 page document that accompanies this report and sets out the principal resource management policies and activities for the Ministry of Environment over the next 5 years.

This document provides a summary of the information and analyses that support the preparation of the plan. It contains an integrated information base of the Nicola basin at the strategic level and can be updated as new information becomes available during the implementation of the management measures recommended in the plan.

This technical document follows the planning process beginning with an outline of issues and a general description of the biophysical and socio-economic resources in the basin (Chapters 1 & 2). Chapter 3 summarizes the available information on current and potential supplies and demands for all environmental resources. The final chapter evaluates a number of resource management options, which will enable the Ministry to achieve its environmental objectives over the next 20 years. The plan itself sets out the priority actions to be undertaken by the Ministry over the next 5 years.

Discussion of the Ministry's strategic planning approach and principles is contained in a separate publication, entitled "Strategic Planning - Its Concepts and Application in the Ministry of Environment."

ACKNOWLEDGEMENTS

Most resource reports can generally be credited to a few individuals, however, the success of a strategic plan relies heavily on a mix of resource professionals from varied and diverse backgrounds. The development of the Nicola Basin Strategic Plan, from concept to implementation, was made possible by the efforts of many people within the Ministry of Environment from Victoria headquarters and the Kamloops Regional office. A special acknowledgement is extended to Jon O'Riordan, who pioneered much of the plan development and kept the participants on the right track. The Ministry of Agriculture contributed valuable information and Federal Department of Fisheries and Oceans provided essential data. In addition, the Nicola Valley Working Committee provided overall development direction. Grateful thanks are offered to the typing and technical service staff; without their patience and skill, the Nicola Basin Strategic Plan would still be in rough form.

The Planning Branch, Ministry of Environment, invites feedback from readers and welcomes any criticisms, comments and suggestions.

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CHAPTER 1 INTRODUCTION

The Nicola basin covers 7280 square kilometers in the south central interior of British Columbia (Figure 1.1, 1.2). The basin is mainly comprised of a rolling plateau dissected by a number of streams and dotted by numerous small lakes. This plateau country is fairly dry, though the western flanks of the basin include the Cascade Mountains that receive higher precipitation. The basin currently supports a population of 11,300 dependent mainly on ranching, mining and forestry. A growing service sector supports a thriving tourist and recreation industry.

The major environmental concern in the Nicola basin is the shortage of water during dry years to supply the 11,900 hectares (29,400 acres) of irrigated lands and maintain instream flows in late summer to support significant populations of anadromous and resident fisheries. These conflicts came to a head in the summer of 1977, with the result that the Federal Department of Fisheries and Oceans and the B.C. Ministry of Environment agreed to undertake an overall assessment of water resource potential for all uses in the basin. This assessment utilized the framework for a hydrologic model that had been developed by a private consulting firm (Bajard, 1980). In addition, the Federal Department of Fisheries and Oceans and the B.C. Ministry of Environment's Fish and Wildlife Branch initiated a three-year assessment of fisheries productivity and habitat requirements in the Nicola basin. The combination of these activities and others would contribute to improved water allocation decisions.

Water shortages are not the only environmental problem facing basin residents. On Christmas day, 1980, the Coldwater River flooded causing considerable damage in the upper and middle sections of the watershed. There is also a flooding potential around Nicola Lake and along the Nicola River downstream. Sport fish populations in the basins lakes are being heavily utilized by steadily growing numbers of anglers. Similarly, the basin's mule deer populations have been subjected to heavy hunting pressures. In addition, the water quality of some streams is deteriorating because of effluent discharges from Merritt and runoff from agricultural operations bordering these streams.

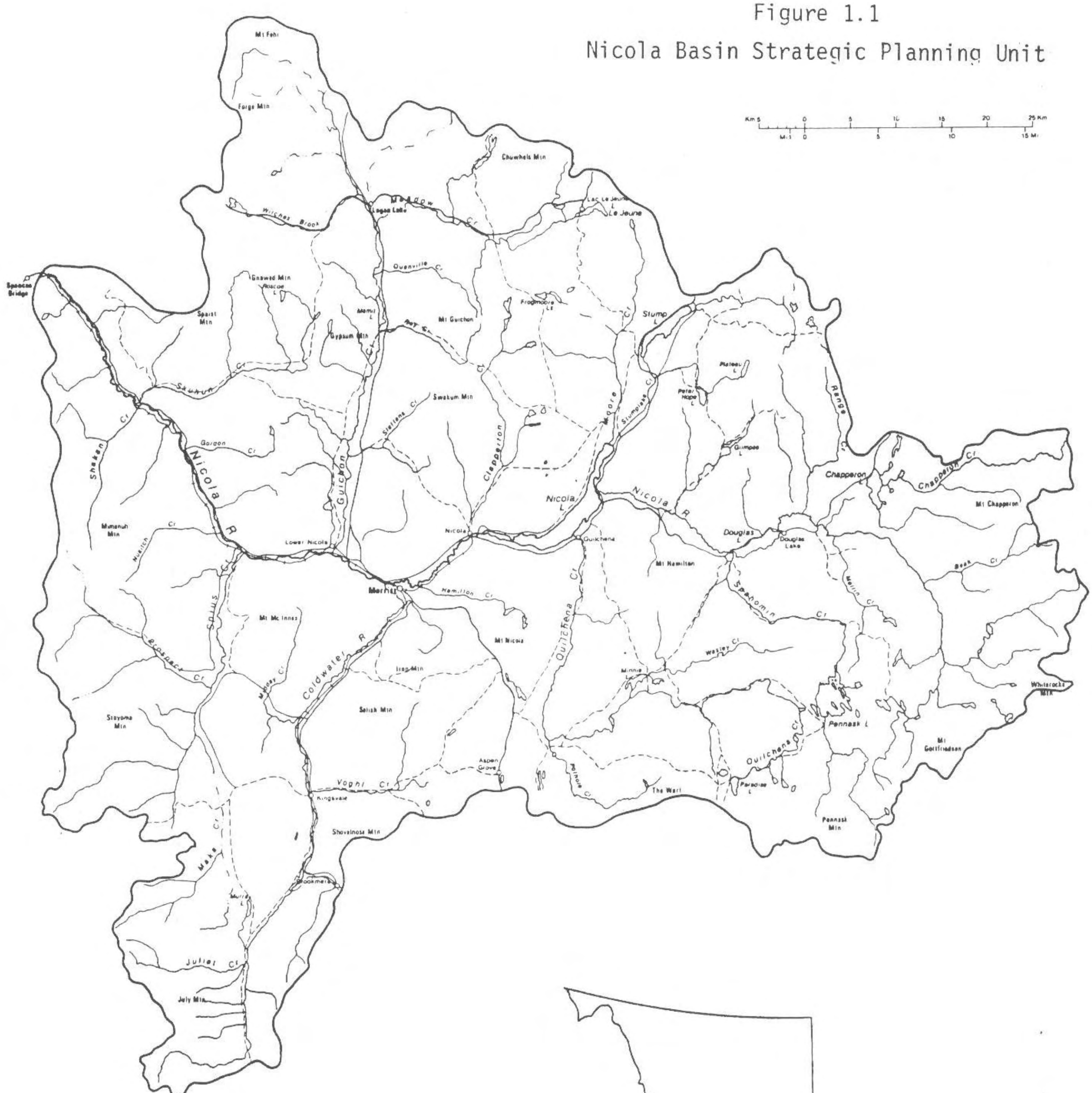
BACKGROUND TO ENVIRONMENTAL PLANNING

These environmental issues in the Nicola basin epitomize the type of resource management challenges that face the Ministry elsewhere in the Province, namely (1) demands for environmental resources are outstripping available supplies; (2) a need for internal integration of Ministry of Environmental activities and (3) the need to develop an improved information base for preparing long-range integrated water and land use plans with other Provincial and Federal agencies.

To meet this challenge, the Provincial Legislature passed the Environment Management Act, which provided the Ministry with the authority to prepare Environment Management plans. Over the past year, the Ministry has developed a planning process that will enable it to carry out this responsibility. Environmental planning is being carried out at two levels. The first level termed Strategic Planning involves the setting of resource management priorities and policies on a regional and sub-regional (watershed) basis such as the Nicola basin. The Province has been subdivided into approximately 40 units, (mainly river basins) for the development of strategic plans over the next few years (Figure 1.2). The second level is termed 'operational' and involves the implementations of priority management measures identified in the strategic plans to meet specified objectives for each environmental resource. Such operational activities have been undertaken by the Ministry in the absence of strategic planning, but they have not always integrated with other resource concerns within the Ministry as a whole. As strategic plans are developed for the major basins of the Province, a more integrated Ministry approach to the preparation of operational plans over the next five years will be developed.

Figure 1.1

Nicola Basin Strategic Planning Unit



As the first example of a strategic plan for the Ministry, the development of an environmental management approach for the Nicola had to overcome a number of problems. First, information on resource use and productivity has not been organized on a basin-wide basis and is not always available to set management priorities. This plan uses existing information only; however, data gaps critical for future management of resources are recognized and accounted for through priority management requirements. Second, a successful strategic plan must be based on well-defined resource management objectives and supporting policies for each of the major programmes in the Ministry's mandate. Such a set of objectives has been under development during the period of plan preparation, but is not yet in a form to provide adequate support to the strategic planning process. Third, a number of new approaches to environmental analysis had to be tried since existing methods were found to be inadequate. This problem was especially notable in the case of water quality management and the setting of water use priorities for surface waters in each tributary watershed.

MAJOR ISSUES AND CONCERNS

The most urgent resource management issue in the Nicola basin involves the allocation of water between consumptive and non-consumptive uses, more notably, for irrigation and fishery maintenance flows. Growth in demand for irrigated crops to support the ranching industry has reduced the instream flows in some tributaries below those required to maintain anadromous and some lake fisheries. On the longer term the completion of the Coquihalla Highway and the possible Hat Creek Thermal Power development to be located near Ashcroft could increase population growth and thus expand demands for environmental resources in the basin.

WATER QUANTITY

Much of the economic base in the Nicola basin is dependent upon an assured supply of water. Present levels of consumptive use in some smaller watersheds are already approaching the maximum amount of water available. Current or potential shortages may be offset by increased storage, or improved efficiency of existing storage. The main concerns are as follows:

- greatest demands for water in the low flow period (July-September) to support irrigation systems and instream flows for rearing and migrating anadromous fish
- inefficient irrigation practices result in higher than necessary withdrawals of water from streams
- limited water yields in some watersheds with high potential for agricultural development
- logging practices affect the runoff regime (sedimentation and flooding) in streams with high fisheries potential
- regulation of storages for irrigation and flood-control is not always compatible with resident sport fish management
- groundwater demand is increasing, but knowledge of supply is limited
- groundwater quality is affected by selected land uses, but limited data are available.

FLOODPLAIN MANAGEMENT

The Nicola River has some potential to flood downstream of Nicola Lake. The following issues have been identified:

- accelerated erosion of the river channel as a result of bank clearing, particularly on the Nicola River between Nicola Lake and Merritt

- channelization of the river corridor could affect stream ecology and fishery productivity
- residential development is occurring on floodplain.

FISHERIES MANAGEMENT

The Nicola basin contains valuable stocks of both anadromous fish (coho, pink and chinook salmon and steelhead) and resident sport fish (rainbow and brook trout and kokanee). There is a high existing and potential demand for both types of fisheries and considerable potential to enhance these fisheries. To realise this potential, the following issues must be addressed:

- lack of recruitment of anadromous stocks in many watersheds; spawners not returning
- lack of adequate resource maintenance flows during critical spawning and rearing periods in some watersheds
- increased water temperatures as a result of storage and low flows
- fluctuating lake levels due to irrigation withdrawals
- winter kills due to reservoir drawdown
- deteriorating water quality, particularly nutrient enrichment in certain watersheds and in Nicola Lake
- low levels of dissolved oxygen in smaller lakes in summer months
- poorly maintained irrigation ditch intakes and fish screens
- cleared or altered riparian habitats.

WILDLIFE

The Nicola basin supports a large diversity of both game and non-game wildlife species, some of which are restricted to the grassland and dry belt forest areas. Management of a range of habitats is necessary to maintain this diversity of wildlife. Specific concerns include:

- protection of rare and endangered species (e.g. Burrowing Owl)
- decrease in big-game wildlife populations due to continued loss of habitat as a result of logging and ranching activities
- declining hunter success rates (deer primarily)
- need to increase management of waterfowl habitat to meet a growing hunting demand.

WATER QUALITY

The required level of ambient water quality in the surface waters of the Nicola basin is dependent upon the ecological integrity of the tributary and on the desired uses of water. Because the major uses are for fisheries, recreation (in lakes), irrigation, and some domestic uses relatively high levels of water quality must be maintained. The major areas of concern are outlined below:

- increased nutrient loadings primarily from over-wintering cattle operations adjacent to surface water courses resulting in eutrophication of some lakes (and possibly streams)
- municipal effluent from Merritt Sewage Treatment Plant affecting water quality in Lower Nicola and Coldwater
- occurrence of heavy metals in Guichon Creek watershed
- sediment loads from forestry and agriculture affecting water quality for fisheries.

Figure 2.1
Physical Features

CHAPTER 2 DESCRIPTION OF THE NICOLA BASIN

BIOPHYSICAL OVERVIEW

The Nicola basin forms part of the Interior Plateau, with rolling hills interspersed with deep alluvial valleys (Figure 2.1). The dominant feature is the Nicola River system including Douglas and Nicola Lakes. The Nicola River rises near the eastern edge of the basin on the divide separating the Okanagan Lake drainage on the south and east and the Salmon River (Shuswap Lake) drainage on the north. It flows generally west some 193 kilometers to join the Thompson River at Spences Bridge.

A number of tributary watersheds, such as Coldwater, Spius and Quilchena flow through rugged forested lands with narrow valley bottoms supporting relatively unproductive agricultural lands except near river mouths. To the north lie Guichon, Clapperton and Moore-Stump Creeks, which drain the most productive agricultural areas of the basin.

PHYSIOGRAPHY

The plateau contains a great diversity of rocks: granitic rocks intrude through sedimentary and volcanic formations of Palaeozoic age. Flat-lying or gently dipping early Tertiary (Eocene) lavas obscure large areas of older rocks.

The basin was covered by Pleistocene ice, and a thick mantle of till material remains over large parts. Movement of the ice over the plateau produced drumlin-like forms oriented southeasterly and southerly. At the end of the Pleistocene ice age, meltwater channels were created forming a series of channels at successively lower levels as ice surfaces wasted. Such channels can be seen on valley walls in the Merritt area. The irregular melting of stagnant ice lobes in the larger valleys created numerous glacial lakes into which silt-laden streams discharged. Many of the existing lakes are remnants of these features.

CLIMATE

Since elevations vary from approximately 180 m to more than 2300 m, a broad range of climates occur. Low elevation areas on the lee side of the Coast Mountains are dry with hot summers and cool winters, whereas higher elevations are relatively wet and cool in all seasons.

Annual precipitation ranges between 25 and 30 cm below 900 m throughout the basin. At higher elevations annual precipitation increases to about 40 cm.

Snow depths increase greatly with elevation and have a significant influence on the potential supply of water in each of the basin's watersheds. Generally, the largest snowpacks and thus water yields occur in Spius and Coldwater Rivers, draining the Cascade Mountains, lesser snowpacks occur in the Upper Guichon and Nicola watersheds. Snow accumulations of more than 40 cm are rare at lower elevations.

Continental air tends to predominate on the Thompson Plateau, resulting in hot summers and cool winters. In the valleys, daytime temperatures of more than 16°C are common for five months of the year and period of hot weather with temperatures in excess of 32°C are frequent during July and August. Occasionally in winter, Arctic air enters the area bringing clear skies and cold temperatures, sometimes as low as -35°C.

The growing season in the Thompson Plateau and Mamit Lake vicinity, does not usually start until late April and continues until about mid-October, with the frost-free period ranging from 120-140 days annually. At the higher elevations, this period may total only 80 days annually.

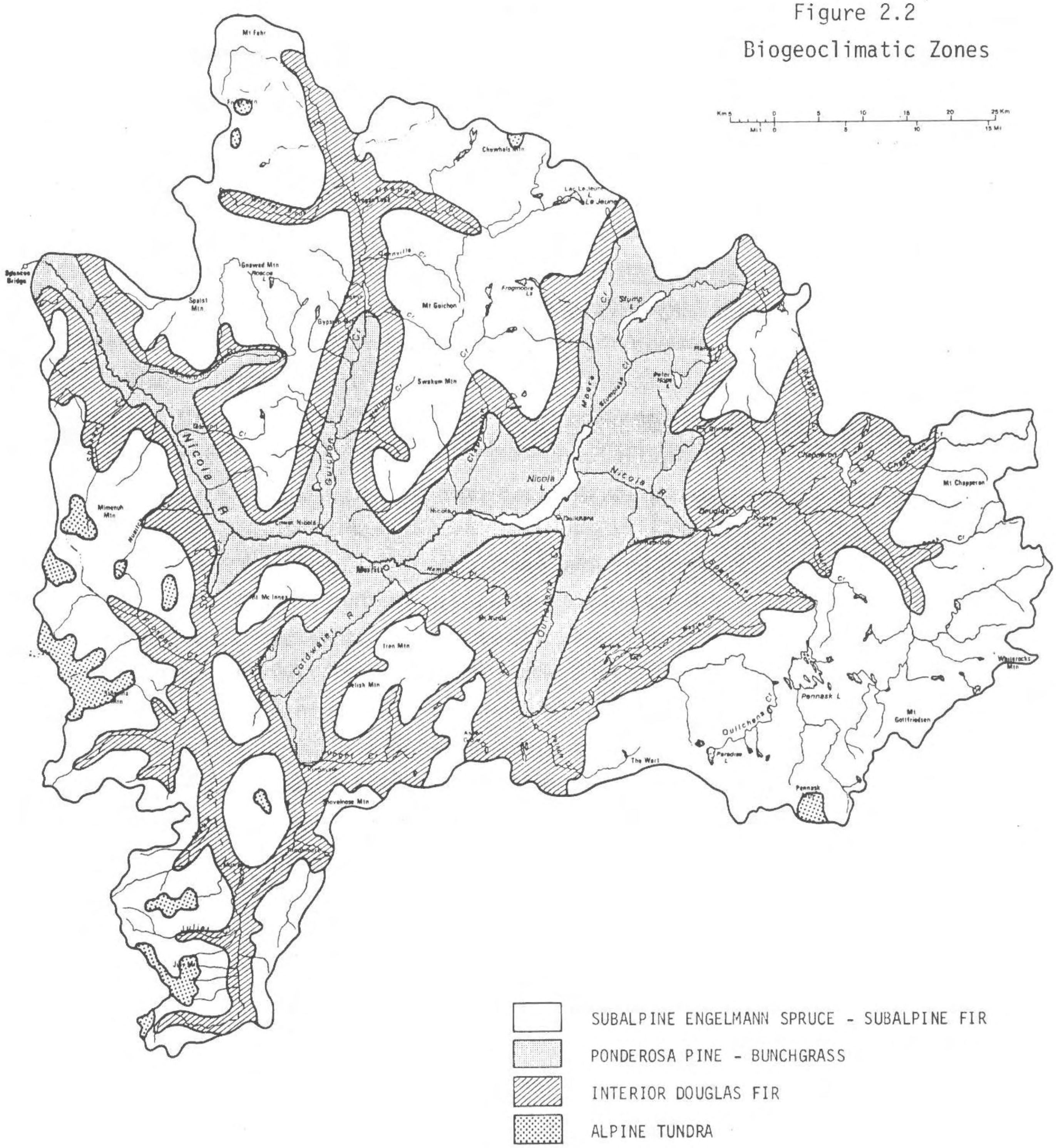
VEGETATION AND SOILS

The Nicola Planning Unit contains four biogeoclimatic zones (Krajina, 1969) (Figure 2.2). The Ponderosa Pine zone (19 percent of unit) occupies the valleys below 360 m and is dominated by an association of perennial bunchgrasses, though some areas have a mixture of grasses, shrubs and forbes. The Douglas Fir zone which lies between 360 and 1000 m (33 percent of unit) contains a gradation of vegetation over elevation from the bunchgrass/ Ponderosa pine to extensive stands of Douglas fir. Lodgepole pine regenerates as a sub-climax in the wake of forest fires. Above this zone is the Englemann Spruce-Sub-Alpine Fir zone (45 percent of unit) ranging from 1000 m to treeline around 1900 m, while above this open meadows occur in the Alpine zone (less than 3 percent).

The Unit's soils have developed from five major types of parent materials - moraine, colluvial, fluvial, lacustrine and organic. Morainal deposits are dominant in the area blanketing all moderate slopes above the valleys. The soils tend to be stoney and occasionally clayey proving very unproductive for agriculture. Colluvial materials are products of mass wastage and are thus found on the steeper slopes. These soils tend to be shallow and usually well-drained. Fluvial materials lie in all major valley bottoms and benchlands. Active floodplains are limited to the Nicola and Coldwater confluence, near Nicola and around Douglas Lake. However, significant deposits of fluvial material lie on old benches and terraces above the contemporary floodplains as a result of the most recent ice age.

Lacustrine soils occur in a few valleys where old glacial lakes have dried up. The main deposits can be found on terraces south and north-east of Merritt and in the Quilchena Creek Valley south of Nicola Lake. There are small localized pockets of organic soils near lakes and in hollows and depressions which provide important habitat for waterfowl.

Figure 2.2
Biogeoclimatic Zones



SOCIO-ECONOMIC OVERVIEW

The resource issues and concerns that are identified in the Nicola basin planning unit today have roots in the social and economic history of the area. Understanding how the Nicola basin has developed, as well as understanding the kinds of development that are possible, is necessary to make sound resource decisions.

ECONOMIC AND SOCIAL HISTORY

A fur trade between the Husdon's Bay Company post at Kamloops and the native peoples of the Nicola area flourished during the first half of the 19th century. This represented the first prolonged contact of the Okanagan, Stuwixemux (Nicola Athabaskans), and Nlakapamux (Thompson) peoples of the Nicola with white man.

The development of the Nicola area was profoundly affected by the discovery of gold on the Fraser River in 1858 and the successive gold rushes in the Cariboo, Finlay-Omineca and Klondike. Thousands of gold seekers poured into the Province, many of whom travelled through the Nicola area. However, the establishment of cattle ranches in the area in the 1860's to meet the miners' demands for fresh meat had a more significant effect on the Nicola. Treaties establishing a number of Indian Reservations were drawn up at this time. The native peoples and whites became closely linked both by blood and in their ranching activities.

The native bunchgrass and water have been the raw materials in cattle production while over time the limiting factors have included access to markets, availability of grazing lands and production of winterfeed. These limiting factors have been partially alleviated by road and rail transportation links, and irrigation.

ECONOMIC PROFILE

The economic profile of the Nicola basin planning unit conforms closely to that of the Thompson-Nicola region whose economy depends largely upon primary resource extraction and to a lesser extent upon primary processing, agriculture and services. As a result, the region is susceptible to fluctuations in world prices for raw materials and manufactured goods. This fluctuation influences demand and results in surges in population growth related to major developments. Resource development in the Nicola basin is dominated by the forest industry, followed by mining, agriculture and tourism.

FORESTRY

The forest industry utilizes Douglas Fir, Lodgepole Pine and Englemann Spruce. Forest productivity is generally moderate (Class 4 and 5) due to moisture deficiency and poor soils, though there are pockets of Class 3 sites on well to imperfectly drained tills on the north-facing slopes in the Coldwater and Quilchena watersheds.

The forest industry has experienced considerable growth in the past but stabilized in the early 1970's and is expected to decline gradually as resources diminish. The employment base of around 650 in logging and manufacturing of forest products can be expected to decrease accordingly over the next decade.

MINING

Mineral production and export are important components of the economic base of the Nicola basin employing about 9% of the labour force. Before its closure, the Craigmont Mine contributed significantly to the economy of Merritt employing about 400 workers. Despite the exhaustion of economic ore reserves in this locality, there is opportunity for mining expansion in the Highland Valley, located in the Guichon Creek watershed. Mining activity supports a dependent population of 1,650 and could expand as Bethlehem and Lornex Mines modernize and explore for new deposits of copper and molybdenum.

AGRICULTURE

The agricultural economy is based on extensive ranching for beef cattle, the Nicola Valley being one of the best known cattle ranching districts of British Columbia. It contains some very large scale operations such as the Douglas Lake Cattle Company. The cattle industry utilizes the upland forest areas and open grasslands for summer pasture with winter feed produced from alfalfa, oats and hay grown during the summer on the valley bottoms. The soils in the valley bottoms have an agricultural capability rating of Class 1 and 2, however, forage production is heavily dependent on irrigation. Greater production can be supported if irrigation water can be made economically available.

The shortage of irrigation water is not the only constraint to expansion however. Expected low economic returns due to the currently depressed state of the beef industry and the high cost of financing new capital investments will likely have a large influence on limiting expansion over the next few years. Once the industry returns to the upswing, expansion could occur through intensification of the livestock industry by the establishment of feedlots and ultimately, a processing plant in the region.

TOURISM

The Nicola basin is one of the more developed areas for tourism in the region due to its abundance of recreational opportunities, good accessibility and proximity to Kamloops. Merritt has good access to a large number of lakes with a past history of excellent fishing and boating, and open country well known for its wildlife. It is a relatively uncongested area with warm, dry summer weather which contributes to making tourism an important service industry.

There is good potential for future development of the tourist industry and construction of the Coquihalla Highway from Hope to Merritt will provide an impetus for this potential to be realized. The completion of the highway is forecast to channel almost two-thirds of the Fraser Canyon traffic through Merritt. The town is already well supplied with services and the service sector can be expected to grow to meet increased demands for road construction, vehicle maintenance and servicing and recreational activities.

POPULATION PROJECTIONS

The Nicola basin supports a total population of over 11,300 of whom live in Merritt (6,000) and Logan Lake (1,500). Almost half of the entire population of the Thompson-Nicola Region lives in Kamloops, the economic centre for the region for trade, services, administration and general manufacturing. Future growth of Kamloops will to some extent affect the growth in the Nicola basin.

Table 2.1 shows the present and projected future population of the Nicola basin. Based on a continuation of past growth rates and no major economic development, total population should increase by about 12% for a total of 12,700 by 1991.

The major factor which could influence future population growth is the level of mining development in the Highland Valley. If all known mine expansions proceed, 1,860 new jobs would be created with a resultant increase in total population in the basin of about 8,000. It is very unlikely that such a scenario would be realized although some expansion can be expected to take place after the current recession ends. Population growth would be slightly greater than over the past few years with the majority of the increase occurring in Logan Lake. Merritt will be affected to a lesser degree with services increasing to support the increased population and economic activity of the basin.

The Coquihalla Highway would also affect population levels in the Nicola, mainly as a result of employment and associated services which will be required during the construction period. The major impact of the highway will be the increased transient and tourist traffic. Any permanent population increases will be associated with the development of services to support the expanding tourist industry, the effect being relatively insignificant in terms of local population levels compared to that of mining.

From the viewpoint of the Ministry of Environment, this population growth will place increasing pressures on sport fishing and hunting, a further demand for irrigation water and greater needs to control the discharge of effluent from Merritt Sewage Treatment Plant. All these issues will be considered in the following Chapters.

TABLE 2.1

POPULATION PROJECTIONS FOR THE NICOLA BASIN

Scenario A: Without Major Economic Development

	1981	1986	1991	% Increase 1981-91
Merritt	5,993	6,236	6,438	7.4%
Logan Lake	1,527	1,805	2,142	4.0%
Rural Areas	3,809	3,965	4,121	8.2%
Nicola Basin	11,329	12,006	12,701	12.1%

Scenario B: With Proposed Mining Expansions

	1981	1986	1991
Merritt	5,993	8,165	8,791
Logan Lake	1,527	8,554	8,988
Rural Areas	3,809	4,506	4,801
Nicola Basin	11,329	21,225	22,580

CHAPTER 3 ANALYSIS OF RESOURCE SUPPLY AND DEMAND

WATER MANAGEMENT

The water resource forms the core of the Ministry's Environmental Management Programme for two reasons. First, all freshwaters of the Province are owned by the Crown with direct management responsibility vested in the Ministry of Environment under the Water Act. Thus, the Ministry is in a controlling position in any inter-agency planning process involving water and related resources. Second, three of the Ministry's six primary resource management programmes (surface and groundwater, fisheries and waste management) are all inter-related through the water resource medium.

Water management embodies surface water, groundwater, and floodplain management. The integration of these three components forms the basis for the water resource input to the strategic plan. Each component is considered separately in this Chapter in terms of supply/demand analysis, but the management options that are evaluated in the next Chapter provide for their integration.

PROGRAMME GOALS AND STRATEGIC PLANNING OBJECTIVES

The overall goal of the Water Management Programme is:

To manage the water resources of British Columbia so that its residents can safely enjoy to the fullest possible extent the economic and recreational benefits of good water quality in plentiful supply.

For planning purposes, a specific sequence of steps must be undertaken to organize information that accomplish this programme goal. These steps are set out as a number of planning objectives below. This Chapter assesses existing information on the first four objectives, while the remaining objectives are assessed in the following chapter.

Planning Objectives for Water Management

SUPPLY

1. Determine the present and potential supply of surface water in each major watershed of the strategic planning unit.
2. Determine the probable extent of flooding and areas of channel instability.
3. Determine the present and potential supply of groundwater available at certain selected sites.

DEMAND

4. Determine present and projected water use requirements both consumptive and non-consumptive in the strategic planning unit.

MANAGEMENT OPTIONS

5. Determine whether storage opportunites exist and approximate costs of development.
6. Determine if there are cost-efficient means for improving the efficiency with which existing licenced water is utilized.
7. Determine economic, environmental and social values for present and projected uses of water.
8. Set water management priorities for each major watershed to guide future allocation, inventory and control of water use.

SURFACE WATER

This section considers the yields of surface water by watershed in the Nicola basin and then compares this with current and projected consumptive (irrigated agriculture) and in-stream uses (anadromous fisheries) of water. The assumptions used in the collection and analysis of water supply and demand information are discussed below. The limitations in the existing data base for long-term resource management restrict the confidence for defining some supply-demand analyses in some watersheds.

Water supply information was obtained from hydrometric stations located throughout the basin (Figure 3.1) encompassing the years of 1961-79 (Appendix I). All missing data from this time period on specific watersheds were estimated using a multiple regression model based on long-term records for watersheds in the Okanagan basin (Appendix II).

The analysis of water supply information has to be carefully interpreted at the strategic level for two reasons. First, the broad scale can distort water distribution information. For example, water supplies have been estimated at the mouth of each watershed. In fact, yields will vary considerably between the headwaters and the mouth. Second, the monthly time scale can mask the occurrence of short-term peaks and low flows. For strategic planning purposes, a monthly water supply analysis on a watershed basis is considered broad enough to allow an extensive look at the entire basin, yet detailed enough to permit recommendations for water management improvements. More detailed supply analysis (weekly or daily) would be appropriate for operational planning.

Water demand information was provided from water licence records summed on a major watershed basis (Appendix III). Water use has been separated into consumptive (domestic, irrigation and industrial) and non-consumptive (fisheries, recreation, waste management). Demand data have been averaged by month to provide a generalized analysis for each watershed.

The major assumption of supply and demand data is the equivalence between 'licenced use' and actual use. Licenced use is the amount of water specified for storage and/or diversion. Many factors (soil types, slope, method of irrigation, efficiency of irrigation system) will influence actual water use and will result in the use of greater or lesser amounts than have

Figure 3.1
Hydrometric Stations in the Nicola Watershed

been licenced. Because actual use has not been monitored, it is not possible to indicate where and to what extent actual use differs from licenced use.

CURRENT AND POTENTIAL WATER SUPPLY

Water supplies in the Nicola basin vary significantly from watershed to watershed (Figure 3.2). The two major watersheds draining the eastern side of the Cascade Mountains, Spius Creek and Coldwater River, contribute over half of the annual runoff of the Nicola River system. The watersheds that drain the dry northern portions of the basin have limited yields. Generally, the mean annual runoff is characterized by low winter flows, high spring snow-melt freshet flows and summer recession to low late summer and early fall flows. Minor flow increases can occur during the late fall as a result of rainfall. The accuracy of flow estimates is considered to be good for all watersheds other than Quilchena, Moore-Stump and Clapperton, where monitored flow data are limited.

LAKE AND RESERVOIR STORAGE

Natural flows in all watersheds except Spius and Coldwater must be augmented in late summer to meet diversions and instream requirements. The Nicola basin contains 210 recognized lakes and depressions, approximately 70 of which are utilized, to varying degrees, for storage (Table 3.1).

The total volume of licenced storage in the Nicola basin is approximately 57 000 dam^3, the largest storage being Nicola Lake (surface area = 2500 hectares). Originally developed for a source of hydro-electric power, Nicola Lake now provides benefits directly by regulated flows for the consumptive and non-consumptive uses on the mainstem Nicola River.

Many small storages exist throughout the upper headwater areas of the Nicola watersheds. In terms of numbers of storages, the main developments are on the Upper Nicola, Guichon, Quilchena and Moore-Stump watersheds (see

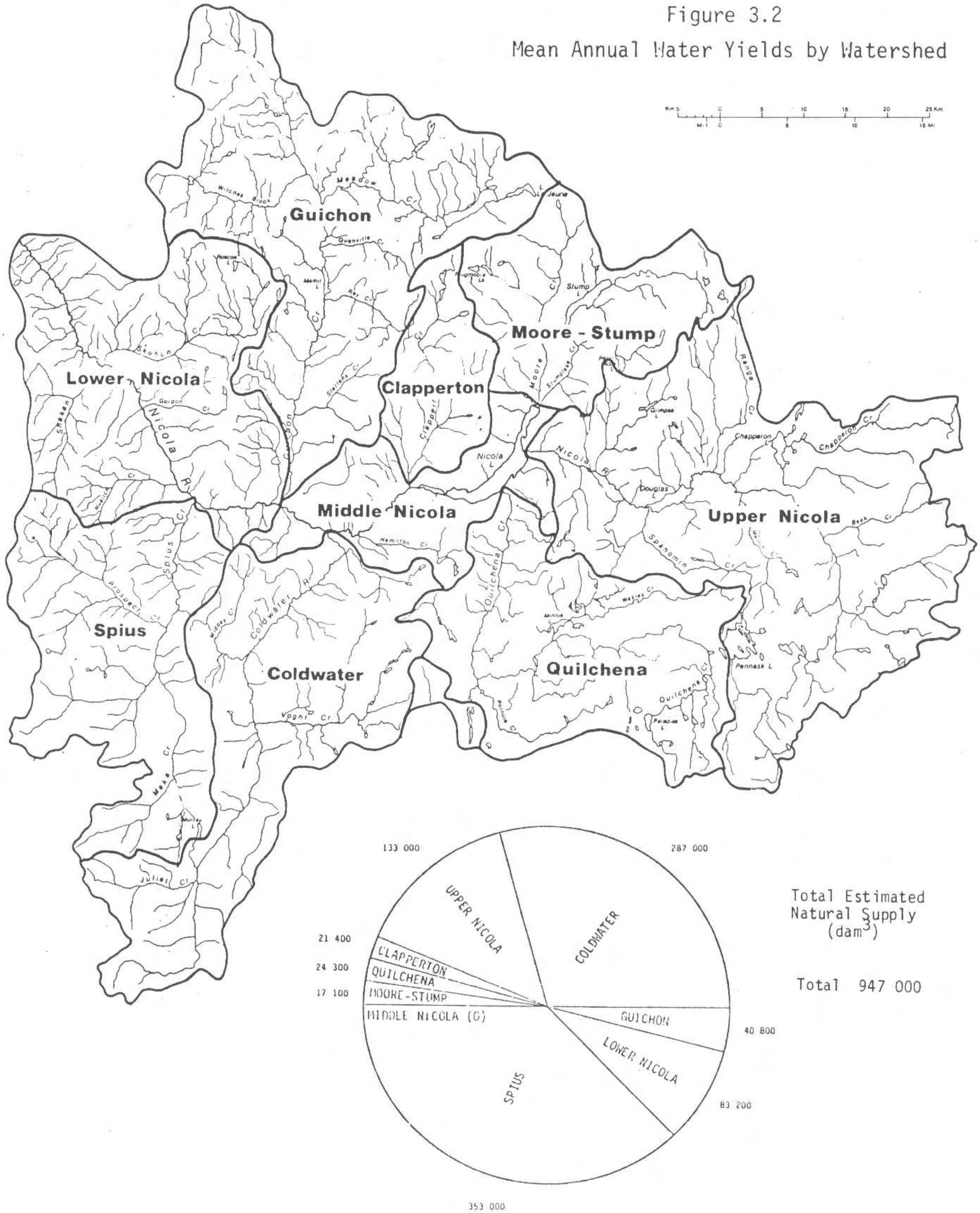


Figure 3.2
Mean Annual Water Yields by Watershed

TABLE 3.1

WATER STORAGE RIGHTS IN THE NICOLA BASIN

(units dam^3)

	Irrigation	Other Uses[1]	Totals[2]	Proportion of Total
UPPER NICOLA	12[3](10 498)[4]		10 498	19%
MIDDLE NICOLA	3(780)	1(24 701)	24 481	42%
LOWER NICOLA	3(716)			
QUILCHENA	13(5 005)	0	5 005	8%
MOORE-STUMP	15(5 458)	0	5 458	9%
CLAPPERTON	1(3 084)	0	3 084	5%
GUICHON	46(6 858)	5(943)	7 801	13%
COLDWATER	17(1 286)	1(10)	1 296	2%
SPIUS	2(74)	0	74	.1%
TOTAL	35 759	25 654	58 697	

[1]Other Uses - Domestic, Industrial

[2]Detailed outline of Storage Water Rights is included in Appendix III.

[3]Number of licences.

[4]Total licenced amount.

Appendix III). Although limited in size, these storages provide an important source of water to irrigated lands some of which are far removed from the main streams. Topographic constraints of upland plateaus and land developments around lakes limit the extent to which headwater storage can be increased (Appendix IV).

Many of these storages support other water-related uses, such as sport fishing, waterfowl hunting and general recreation. A number have resorts developed around their shorelines. Without integrated planning, these uses can be in conflict with storage regulation to supply irrigation systems downstream.

CURRENT AND POTENTIAL WATER DEMANDS

Water demands in the Nicola basin include two main types: (1) withdrawals or consumptive uses - such as irrigation or domestic use; and (2) in-stream or non-consumptive demands - such as fisheries or recreation.

CONSUMPTIVE WATER DEMANDS

Agriculture

Consumptive demands for the water resource are dominated by the agricultural industry, with approximately 71% of licenced consumptive use for irrigation. Approximately 11 900 ha (30 000 acres) are currently irrigated, mainly in the Upper Nicola, Middle Nicola, Guichon, Quilchena, Moore-Stump and Clapperton watersheds (Table 3.2). Most of these agricultural areas were established during the early part of the century. Development along Nicola River however, was accelerated during the 1950's, with an increase in water demand up until 1980, at which time the river was fully recorded. The main development emphasis during the last few years has been on more intensive management of existing agricultural lands rather than expansion of acreage. In general, agricultural water requirements are fully met (four years out of five), except in Clapperton and Moore-Stump watersheds.

TABLE 3.2
PRESENT AND POTENTIAL IRRIGABLE LANDS IN THE NICOLA BASIN

	Area (hectares)	Maximum Agricultural Lands[1]	Presently Irrigable Lands[2]	Additional Irrigable Lands Likely to be Developed in the Next 10 Years[3]
UPPER Nicola	159 126	11 030	2 495	1 100
MIDDLE NICOLA LOWER NICOLA	41 224	4 980[4]	1 660[4]	2 817[4]
QUILCHENA	82 552	7 320	734	minimal expansion
MOORE-STUMP	57 167	6 830	960	minimal expansion
CLAPPERTON	18 986	N/A	875	minimal expansion
GUICHON	129 020	7 030	2 235	N/A
COLDWATER	95 874	6 110	1 058	300
SPIUS	81 818	310	222	minimal expansion
TOTAL	665 767	43 610+	10 240	4 200+

[1] Maximum Potential - upper limit of total (present and potential land area that could support agricultural development; ALR land within 67 metres of 5 km of main watercourse. (Amounts estimated by Ministry of Agriculture and Food; Ministry of Environment.

[2] Present Irrigable Lands - lands currently under irrigation. Amount estimated by Y. Bahard and Ministry of Environment).

[3] Irrigable Lands to be - lands that could be irrigated given suitable econo ic and other factors. (Preliminary assessment conducted by Ministry of Environment to determine probability of and extent of agricultural development. Estimate subject to revision).

[4] Amount estimated by Ministr of Environment based on survey of individual ranchers who could potentially benefit by increased storage on Nicola Lake. (See Engineering Feasibility Study on Rebuilding Outlet of Nicola Lake, March, 1983, Water Management Branch, Ministry of Environment).

Potential agricultural demands are limited by a number of factors including: (1) water availability; (2) biophysical capability of the land to support agriculture; and (3) economic 'constraints'.

The overall biophysical capability for agricultural expansion in the Nicola basin is moderate to high. It is estimated that there are approximately 47 900 hectares of land available for irrigated agricultural development (Table 3.2). However, some of this land has topographic constraints that limit irrigation development. Given the economic factors facing the ranching industry and the growing power costs for pumping water, it is estimated that approximately 4200 additional hectares could be irrigated in the foreseeable future. Preliminary surveys indicate that the main expansion will occur in the Middle Nicola, Upper Nicola and Quilchena watersheds. If all the land were developed with an average use of 0.8 m per hectare the additional water demand would total 30,745 dam^3. This yield is available in these three watersheds, but costs, potential storage sites and biophysical limits will constrain demand. As a result, some ranchers may prefer to make better use of already licenced water to increase their forage production.

Industrial and Domestic

Domestic and industrial demands, although minor on the level of the entire Nicola basin play a significant role in some watersheds such as the Guichon (Table 3.3). Unlike irrigation demands, however, the domestic water use required for Merritt and the industrial water use for copper mining in the Guichon (Highland Valley) are accommodated primarily by groundwater rather than surface water.

Generally, there is not a conflict between industrial and domestic requirements and instream uses because most of these consumptive uses are supplied by groundwater and because quantities required are relatively small at present. In the future, the greatest increase will occur around Merritt and in Guichon Creek, should the mining industry expand. Increased

TABLE 3.3

MEAN ANNUAL WATER SUPPLY AND DEMAND - BY WATERSHED

NICOLA BASIN

(dam^3)

Watershed	Accuracy Of Flow Estimates	Supply		Demand				
		Total Estimated Natural Supply[1]	Mean Annual Flow	Licenced Diversions[2]		Licenced Storage[3]		Fishery Maintenance Flows
		(dam^3)	(m^3s^{-1})	Irrigation	Other	Irrigation	Other	(m^3s^{-1})
Upper Nicola	Good	133 000	3.92	9 650	105	10 500	0	.80
Middle Nicola	Good	83 200	2.28	13 200	85	680	22 850	1.70
Lower Nicola	Good			9 600	2 420	0	0	4.9
Quilchena	Fair	24 300	.752	590	0	5 000	0	NA
Moore-Stump	Poor	17 100	.482	1 925	0	5 460	0	NA
Clapperton	Poor	21 400	.564	2 900	0	3 080	0	.14
Guichon	Good	40 800	.990	6 810	2 820	7 800	940	.20
Coldwater	Good	287 000	8.81	6 960	4 140	1 290	10	1.42
Spius	Good	353 000	11.1	1 625	1 625	75	0	2.22
Total		947 000	28.8	53 260	11 195	34 625	23 800	11.40

[1] Average annual flow from historical records - Appendix I, Technical Document

[2] Licenced diversions for irrigation or other uses (industrial, domestic) - Source: Water Licence Records

[3] Licenced storage (Note on Middle Nicola the inclusion of Nicola Lake Dam) - Appendix III, Technical Document

[4] Flows required to maintain historical populatoins of fishery stocks

Note: 1 ac ft = 1.2335 dam^3

1 cfs = .02832 m^3s^{-1}

regulation of surface water supplies and development of groundwater supplies will play a major role if all water demands are to be met in Guichon watershed.

NON-CONSUMPTIVE WATER DEMANDS

Non-consumptive water demands in the Nicola basin are more difficult to determine as they are not licenced. Variations in the physical attributes of each tributary; stream beds, channel characteristics - depth and width, meander belt will influence the flows that are required to support fish populations, recreational requirements, or to maintain the ecological integrity of the tributary. These in-stream flows are a crucial component of any water resource study. For this reason, each tributary must be assessed individually.

Fisheries

Fishery maintenance flows represent the flow required to maintain the natural productive potential of each watershed. Maintenance flows for anadromous fisheries (pink, coho, chinook and steelhead) have been determined for most watersheds in the Nicola basin from field research (Table 3.3) (Hamilton and Kosakowski, 1982). These flows have been set so that they provide the necessary pools and ripples, bank cover and shelter to sustain the maximum fish populations given the current biological carrying capacity of the streams.

At present, recommended fishery maintenance flows are met in average runoff years in the Middle and Lower Nicola with current levels of storage on Nicola Lake. Without storage significant shortfalls would occur. In other watersheds, instream flows are generally deficient except in wet years and are one of the factors that have resulted in declines in anadromous fish populations.

Recreation

Minimum flow requirements have not been identified for recreation. However, it is generally felt that if instream flows to meet fishery requirements are maintained, these will meet many of the watershed-specific recreational requirements. Adequate lake levels and streamflows, bank and stream environments, shoreline conditions and aesthetics combine to create a successful fishing and camping experience for the recreationist.

Major recreation sites in the Nicola are confined to selected lakes and tributaries (Monck Park on Nicola Lake; Lac Le Jeune; and Pennask Lake). The Ministry of Lands, Parks and Housing is planning to include Kentucky and Alleyne Lake recreational areas in its future management programme. In addition to these sites, the Ministry of Forests has developed a large number of small recreational areas on lakes throughout the basin. Generally, there is not a conflict between recreation and water use, except for deteriorating water quality on Nicola Lake (See later section on Water Quality).

The future demand for recreational activities is expected to grow in the basin, primarily as a result of the Coquihalla Highway and potential expansion of the Logan Lake area. This growth will influence the demand for water based recreation (particularly fishing and swimming activities) and the need to protect water quality.

SUMMARY

An overview of water supply and demand in the Nicola basin indicates that there are varying degrees of resource conflicts between consumptive and non-consumptive uses. A broad annual analysis of water supply and demand (Table 3.3) indicates that while licenced irrigation demands are generally met most years fishery maintenance flows are not fully accommodated in most watersheds. While the basin overview provides an introduction to water supplies and demands, analysis must be conducted on a finer level of detail.

Chapter 4 provides this evaluation on a watershed basis, identifies specific water concerns now and in the future and discusses some management options for resolving them.

NICOLA RIVER FLOOD CONTROL

The possibility of flooding exists in the mainstem Nicola and Coldwater watersheds. The major floods in historical times occurred in 1894 and 1948, but only the latter flood was monitored in the Nicola River. During Christmas 1980, a record flood occurred on the Coldwater as the result of a sudden thaw and heavy rains, causing considerable bank erosion in the upper and middle sections of the stream. The Ministry of Environment, under its Emergency Measures Programme, subsequently constructed erosion control works along the Coldwater, effectively containing the stream. Although minor erosion along the Coldwater can be expected, the possibility of major erosion and channel instability as a result of high discharges has been greatly reduced by the construction of these control works.

NICOLA RIVER

In 1980, the Ministry of Environment surveyed the mainstem Nicola from Nicola Lake to its confluence with the Thompson River to determine the flooding and erosion potential of that system (McMullen, 1982). A river corridor was defined a zone of potential change in the streambed due to erosion, sedimentation and channel aggradation/degradation. This corridor was mapped based on an analysis of the change in channel configuration from the turn of the century to the present day. Channel boundaries depicted in the original district lot surveys of the mainstem Nicola undertaken between 1874 and 1915 were compared with the 1948 flood channel and the current channel mapped from detailed colour air photographs taken in June 1980.

Provided there continues to be regulation of flows from Nicola Lake it is anticipated that the river corridor identified by this survey represents the maximum extent over which changes in channel configuration can be expected to occur. Over time, there may be small scale refinements to this corridor based on more accurate topographical mapping and geotechnical bedrock information. In addition, major changes in flow discharge regimes in the Nicola due to new storage in the Coldwater or in Nicola Lake could alter the extent of the corridor.

POLICY

Generally, the Ministry of Environment will not approve permanent developments within the river corridor. This policy will reduce the need to construct bank protection measures, which are not only expensive, but will likely affect the fishery resource in the river. However, small scale erosion protection measures can be considered to protect farmland and existing settlements. Such works would have to be carefully designed in consultation with the fishery managers to minimize impacts on anadromous and resident fisheries.

The folio of maps that accompany this technical document contains a generalized outline of the Nicola River corridor. More mapping is provided in the detailed report of the survey and is available in the Regional Office of the Ministry of Environment in Kamloops.

GROUNDWATER

The purpose of this section is to assess the current information on groundwater resources in the Nicola basin, and to identify water producing areas. The available data consist of water well drillers' records, groundwater reports by government and groundwater consulting engineers and hydrogeologists and bedrock and surficial geology reports on file in the Groundwater Section of the Ministry of Environment.

GEOLOGY

BEDROCK GEOLOGY

Mapsheets of the bedrock geology for the Nicola (GSC Map No. 856A) and Ashcroft (GSC Map No. 1010A) areas show the Nicola River basin is underlain mostly by volcanic rocks mainly andesite and basalt of the Nicola and Kingsvale Groups, and by granitic rocks known as the Coast Intrusions. These rocks occur in zones that may be described as having roughly north to south trends. Also an area of sedimentary rocks, mostly argillite, possibly belonging to the Cache Creek Group, occurs in the east part of the basin to the east of Stump and Douglas Lakes. Further information on the bedrock geology of the area can be obtained from reports by Cockfield (1948); Duffell and McTaggart (1952).

SURFICIAL GEOLOGY

Surficial geology mapsheets for Merritt (GSC Map No. 1393A) and GSC Map No. 1392A) show unconsolidated deposits, primarily of glacial origin, cover much of the area (Fulton, 1975). These deposits comprise: (a) mainly till, commonly an unsorted mixture of clay, silt, sand and boulders with some sand and gravel occurring mostly in upland areas; (b) glacial lacustrine silt and sand deposits; (c) non-glacial fan deposits of sand and gravel; and (d) alluvial deposits of sand, gravel and silt.

Unconsolidated deposits are considered to be thin across much of the basin because of the numerous, and sometimes large, bedrock exposures mapped in upland areas. However, within the valleys surficial deposits may be very thick and are known to be about 1200 feet thick in parts of the Highland Valley (Klohn Leonoff, 1982). The glacial history of the region is quite complex in places and from work by Brown, Erdman and Associates (1980) it is known that deposits occur which are attributable to four periods of glaciation. These deposits consist of clay or silt, sand and gravel, and till, all of which may occur as layers of considerable areal extent and thickness or else as deposits of more local occurrence.

HYDROGEOLOGY

SOURCE, OCCURRENCE AND MOVEMENT OF GROUNDWATER

The sources from which groundwater supplies are known to be obtained are predominantly sand and gravel beds or lenses. However, groundwater supplies could also probably be obtained from granitic, volcanic and sedimentary rocks in the area.

Groundwater occurs in the void or open spaces in the unconsolidated deposits and in the bedrock. The main sources of groundwater occur in extensive, thick saturated sand and gravel beds. The capacity of the bedrock or unconsolidated deposits to act as reservoirs of groundwater depends upon porosity which is the percentage of the total volume of a rock type or materials such as sand and gravel occupied by open spaces. Porosity is commonly low in fractured bedrock so that relatively lower volumes of groundwater occur in bedrock compared to surficial deposits to a given depth. Consequently well yields are commonly lower from bedrock sources than from wells in the surficial deposits.

The movement of groundwater is controlled chiefly by topography and is modified by geology with flow being from areas of topographic highs to topographic lows. On a regional scale groundwater flow is from upland areas (areas of groundwater recharge) to lowland areas or river valleys (areas of groundwater discharge). It should also be mentioned that recharge to aquifers in the main valleys may occur by loss of water from tributary creeks into and through sand and gravel deposits lining creek beds.

GROUNDWATER DATA

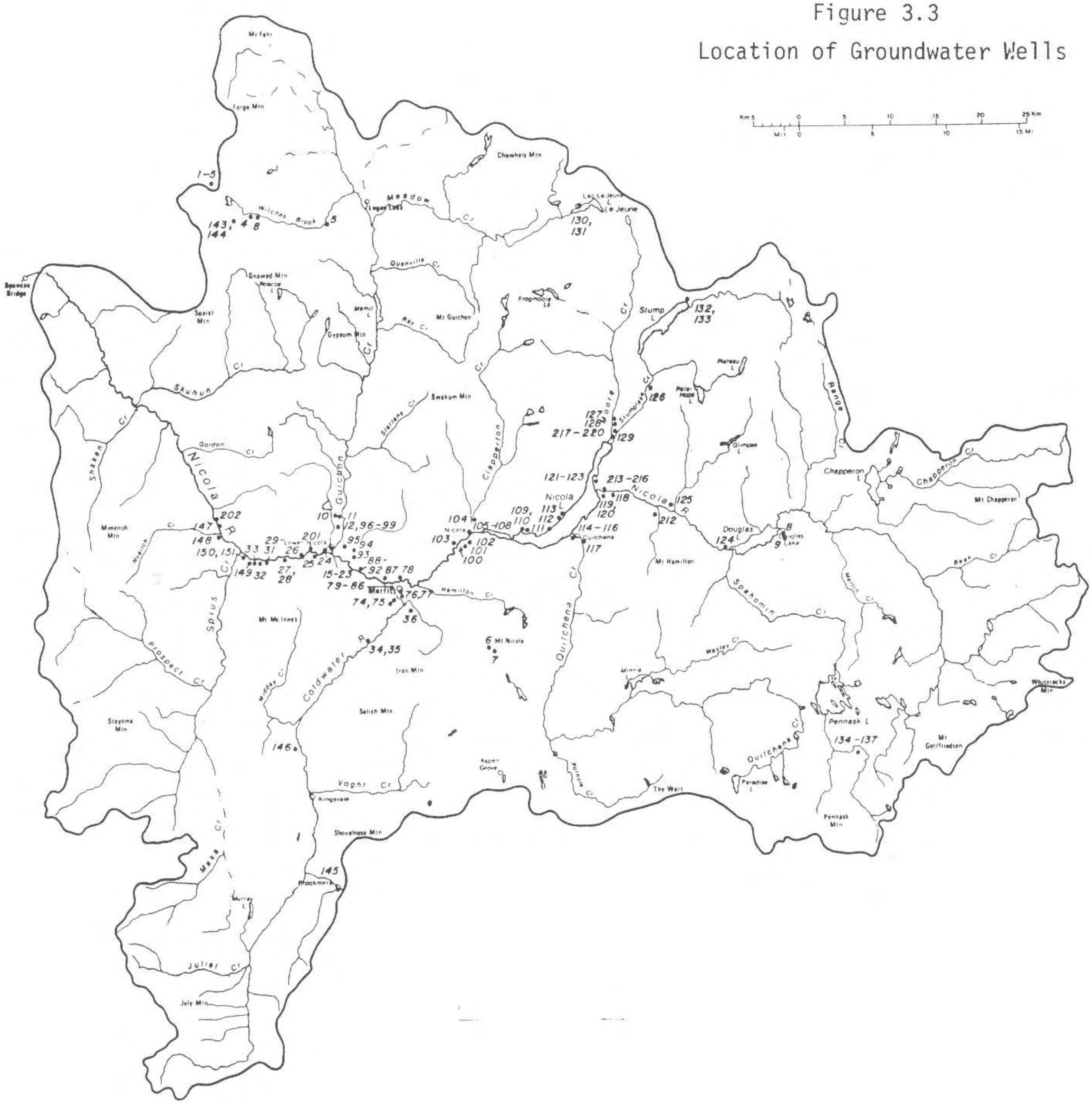
Only a limited number of records for water wells, about 180, are available on file in the Groundwater Section for the Nicola River basin and only one of these is for a well drilled into bedrock (Figure 3.3 and Appendix V). These records provide information mainly on well depth, water levels, well use, reported well yields, and a well log listing the materials encountered during drilling. There is very little pump test data available for calculating well yields or for aquifer evaluation, and some laboratory chemical analyses of groundwaters (Appendix VI) for well waters only in the Highland Valley, at Logan Lake and for one well at Stump Lake.

GROUNDWATER USE

From the available information groundwater resources in the basin are known to be developed to supply domestic, municipal, irrigation and industrial requirements. About one-third of the wells have been installed to meet domestic needs assumed to be about 0.25 L/s (litres per second) or 3 Igpm (Imperial gallons per minute). For about another one-third of the wells there is no reported use. Of these two groups of wells 30 produce 1 1/2 L/s (20 Igpm) or less and six others are reported to yield up to or over 7 1/2 L/s (100 Igpm). Yields for most of these wells are not available. As many of these wells only just penetrate an aquifer the use or reported yield may not be representative of potential well yields at many of these well sites.

Some wells have been installed at Merritt, Lower Nicola and Logan Lake to serve municipal water supply requirements and are considered to give a more reliable indication of groundwater supplies. Two of the Merritt wells yield over 75 L/s (over 1000 Igpm) and three others yield from 15 to 30 L/s (200 to 400 Igpm). The well at Lower Nicola yields 38 L/s (500 Igpm) and two wells for Logan Lake yield 15 and 60 L/s (200 and 800 Igpm).

Figure 3.3
Location of Groundwater Wells



Only one well is known to produce water for irrigation and its yield is estimated to be about 15 L/s (200 Igpm) based on a water supply need of 0.4 L/s (5 Igpm) per acre per day to irrigate 40 acres.

Groundwater resources are also developed for industrial use. The extraction of groundwater for this purpose occurs mainly in the Highland Valley for mill water supply for the two existing mines, Bethlehem Copper Corporation Ltd., Lornex Mining Corporation Ltd., and Highmont Operating Corporation Ltd. Exploration drilling has been conducted for a fourth mine, Valley Copper Ltd. Well yields are known to range from about 7 1/2 to 75 L/s (100 to 1,000 Igpm).

Exploratory drilling for groundwater supply was also conducted for Brenda Mines Ltd. in Pennask Valley near Pennask Lake. Results obtained from the exploratory program showed well yields ranged from close to 2 L/s (25 Igpm) to 23 L/s (355 Igpm). Test pumping of a groundwater supply for Craigmont Mine in Guichon Valley indicated a well yield of about 2 L/s (25 Igpm), a second test well was abandoned. A similar yield is reported for a well for a power sub-station about five miles upstream of Nicola Lake in the Nicola Valley.

From some estimates or calculations of well yields for various water supply requirements it is known that moderately high to high yield wells occur in river valleys at various locations distributed across the basin.

POTENTIAL DEVELOPMENT

Human settlement in the basin is unevenly distributed and is concentrated in the valleys of the major tributaries and the mainstem Nicola. Most wells are therefore located in the major valley bottoms and many occur in large groups. These groups and some individual wells are shown in Figure 3.3 with the well data presented in Appendix V. The distribution of and the type of data available permit little delineation of the extent and thickness of aquifers in the study area. Localities where wells produce over 100 Igpm are illustrated in Figure 3.4.

Some idea of the limitations in delineating the extent and thicknesses of aquifers can be seen from the shallow depths of many well records shown on the cross-section (Figures 3.5) drawn from Nicola to Canford. Only three moderately deep wells, deeper than about 60 metres (200 feet) occur along a rather steeply falling profile. The section does display the occurrence of confined aquifers, units A and C, water-bearing zones which occur below low permeable materials primarily till of units B and D, and of a shallow aquifer unit E which locally begins at ground surface and may be in hydraulic continuity with surface waters.

One aquifer unit C, 6 metres (20 feet) thick and encountered about 60 metres (200 feet) below ground level between two till units, may extend the full length of the cross-section, a distance of 30 kilometres (18 1/2 miles). This aquifer may be suited to meeting only domestic or livestock water supply requirements as indicated by two wells up to 0.75 L/s (10 Igpm).

An important aquifer unit A, capable of yielding water to wells at up to about 37 L/s (500 Igpm) underlies till unit B and is encountered at a depth of about 105 metres (325 feet) well number 22 (Figure 3.5). It is not known whether this deeper aquifer extends along the Nicola Valley or into the Guichon Valley. Test drilling should be conducted to determine continuity of this aquifer into either valley as the well within this aquifer occurs near the mouth of Guichon Valley.

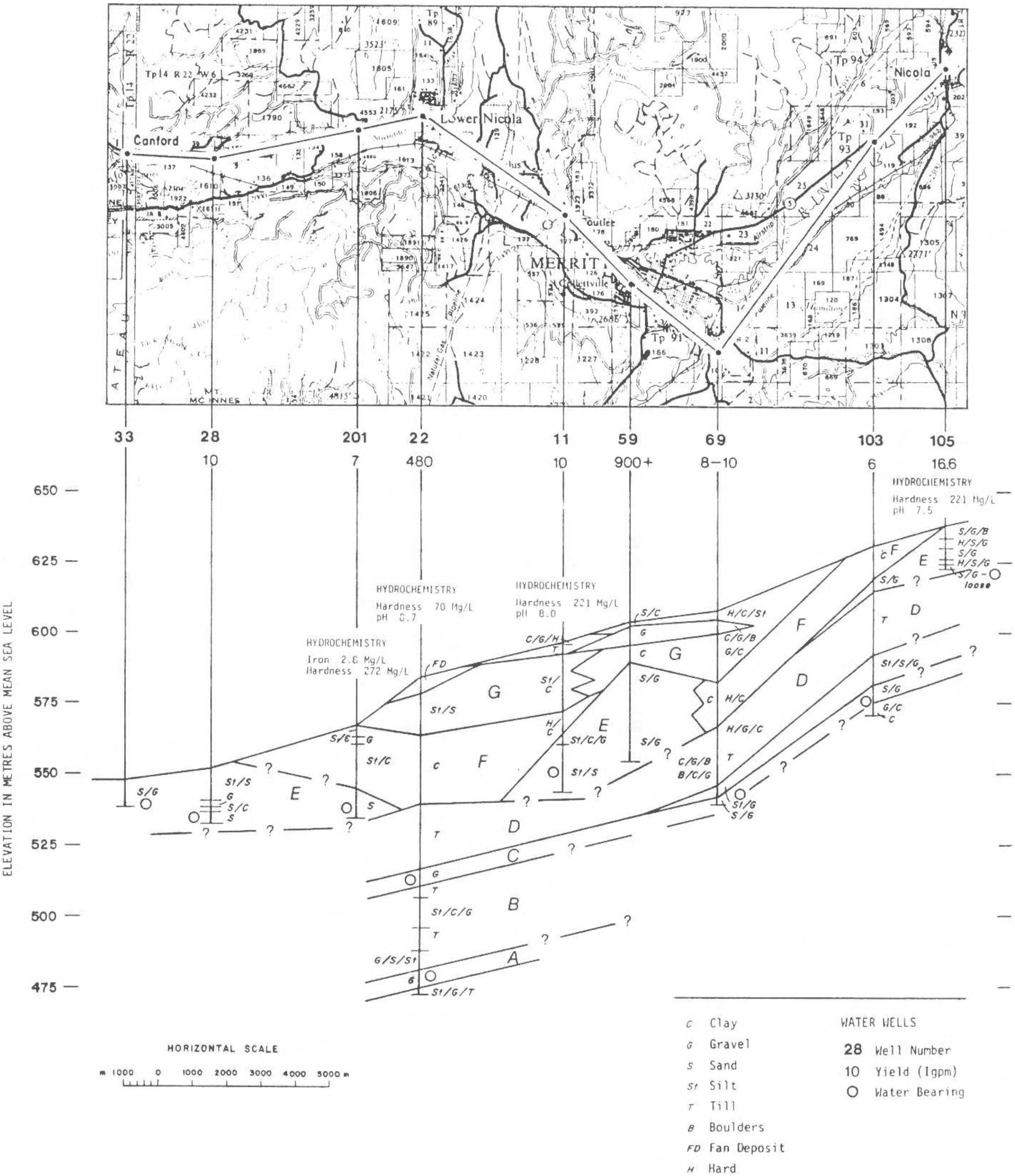
A third shallow but discontinuous aquifer unit E, commonly occurs at depths less than 16 metres (50 feet) below ground level near Nicola and Canford. Locally, as at Merritt, this aquifer may extend to depths of 50 metres (150 feet) or more where well yields of up to 75 L/s (1000 Igpm) may be obtained in the vicinity of the confluence of Lower Coldwater Creek with the Nicola River.

The only area where the occurrence and yield of groundwater is mapped, and quite well understood is in the Highland Valley. In this valley the

Figure 3.4
Potential Groundwater Producing Areas
(100 Igpm)

Figure 3.5

Geologic Cross Section of Groundwater Wells - Canford to Nicola



main developed aquifer averages about 30 metres (100 feet) thick occurring at a depth of about 75 metres (250 feet) and extends throughout much of the valley. Wells yielding over 38 L/s (500 Igpm) have been developed from this aquifer.

Elsewhere it is appropriate only to mention localities of present high well yields. There are four other such localities: Douglas Lake, Logan Lake, lower Moore Creek and Monck Park campsite near the centre on the north side of Nicola Lake.

GROUNDWATER QUALITY

Information on groundwater quality in the basin is extremely limited (Appendix VI). On most of the available drillers' reports for the basin, very little water chemistry information is supplied and some report only pH or that the water is hard. On some well records it is reported that wells were abandoned because of poor water quality. At present, there is simply not enough information to make any statement about groundwater quality in the Nicola basin.

The only wells for which detailed chemical analyses have been undertaken are the Ministry of Environment observation well at Stump Lake, the Logan Lake municipal supply wells, and the dewatering and mill supply wells of the two mining companies in the Highland Valley. From work by Brown, Erdman and Associates Ltd. (1980), the groundwater of the surficial aquifers of the Highland Valley can be classified as moderately hard calcium bicarbonate water with low total dissolved solids 320 mg/L (milligrams per litre). The groundwater contained within bedrock aquifers may exhibit similar characteristics. The Brown Erdman report concludes that the water is potable and suitable for domestic and industrial use. The groundwater samples from Logan Lake, total dissolved solids 416 mg/L and Stump Lake, total dissolved solids 250 mg/L, show that the water meets nearly all recommended standards for the Province of British Columbia (1969) for drinking water and industrial use except for two parameters: (1) the pH at the Stump Lake well is 9.3, which exceeds most recommended limits for drinking water and industrial use; and (2) the "total hardness" measured at Logan Lake is 208 mg/L, which is classified as "hard". The recommended upper limit for hardness in drinking water is 180 mg/L calcium carbonate. In conclusion, however, the limited number of adverse comments on groundwater quality that have been reported show no evidence of any widespread occurrence of unsuitable groundwater serious enough to restrict exploration for groundwater supplies for domestic and industrial use in any area of the Nicola watershed.

SUMMARY

In general, the movement of groundwater occurs from the upland areas towards the valley bottoms. The deep glacial sediments in the major valleys may contain several aquifers. Because of the limited amount of available data, the delineation of the depth and areal extent of the aquifers in the watershed is not possible except in the Highland Valley, and to some extent for the Nicola Valley.

There are seven known areas in which wells are capable of producing in excess of 7.5 L/s (100 Igpm): Highland Valley, Logan Lake, Douglas Lake, near Pennask Lake, Lower Moore Creek, at the confluence of Guichon Creek with the Nicola River and at the confluence of the Lower Coldwater River with the Nicola River. These areas may have the potential to support future demands for water supply from groundwater.

Commonly domestic and locally industrial uses can be met from groundwater sources. The quality of groundwater is probably good in much of the basin for domestic and some other uses, but more information on both quantity and quality will be required if the demand for groundwater increases significantly over the next few years.

FISHERIES

PROGRAMME GOALS AND STRATEGIC PLANNING OBJECTIVES

The overall goal of the fisheries program in the Ministry of Environment is:

> To produce maximum economic, cultural, recreational and scientific benefits to present and future generations of British Columbians by:
>
> i) maintaining all native and desirable introduced species of fish at optimum levels of distribution, abundance and health, and protecting or enhancing essential freshwater habitats, and
>
> ii) providing an equitable distribution of opportunities for a wide variety of socially acceptable uses of fish for all segments of society.

The overall goal of the fisheries programme in the Federal Department of Fisheries and Ocean is:

> To conserve fishery species and stocks and to ensure that the harvestable surplus will be used to generate optimum social and economic benefits for Canadians.

As a partial contribution to achieving this goal, a joint Federal - Provincial Salmonid Enhancement Program was initiated in 1979 to increase production of salmonids to historic levels or higher by the year 2000.

The Nicola basin contains valuable stocks of both anadromous and resident fish from which significant benefits are derived. There is a high existing and potential demand for both types of fisheries and considerable potential to enhance them. To realize this potential, the issues outlined in Chapter 1 have to be addressed.

Strategic planning for fisheries, through an analysis of the supply of fish and the demand for the use of the resource, will provide the information to determine management options which will enable the Federal and Provincial fishery goals to be achieved. The planning objectives are set out below.

Planning Objectives for Fisheries Management

SUPPLY

1. Determine present and potential supply of sport and anadromous fish species identified as a management priority in the basin.

2. Determine habitat requirements (water flows, water quality, ecological conditions) to support present and potential fishery populations.

DEMAND

3. Determine current demand for sport, commercial, native and other fishery uses over the planning period.

4. Determine projected demands on fishery habitat due to land use and in-stream influences on water flows, water quality and other ecological factors.

5. Determine the economic values of sport (tidal and fresh), commercial and other fish uses (native food).

MANAGEMENT OPTIONS

6. Determine the estimated costs of alternative management measures to enhance and protect existing stocks of anadromous and sport fisheries.

7. Establish management objectives and targets for each major fishery in lakes and streams consistent with Regional and Provincial fishery management policies.

JURISDICTIONAL FRAMEWORK

The administration, protection and development of freshwater fisheries, with the exception of anadromous salmon in freshwater, is the responsibility in this area of the Province of British Columbia. However, legislative responsibility was retained by the Federal Government, which passes legislation requested by the Province to regulate the use of the fisheries. Thus, the legislative base of the Provincial fisheries agency, the Fish and Wildlife Branch has always been Federal in nature. Both the B.C. Fishery Regulations and the Fisheries Act (Canada) are used by the Provincial agency to regulate and protect the resource.

Despite the federal responsibility for anadromous salmon, Provincial management strategies dealing with fisheries and water management will have a direct effect on this resource. Because the management of anadromous and resident fisheries requires different approaches the two fisheries are analysed separately.

ANADROMOUS FISHERIES

Below Kamloops Lake the Nicola basin is the largest of the major tributaries to the Thompson River that support anadromous fish. The Nicola River has historically been a major producer of steelhead trout, chinook, coho and pink salmon. However, present stock assessments indicate that spawner escapements are greatly depressed and may be as low as 10-30% of historic levels. This reduction can be attributed to two major factors; lack of recruitment due to increased harvest in the commercial sport fishery and habitat degradation as a result of low flows in some watersheds and high water temperatures.

The mainstem Nicola River serves as a major transportation corridor for anadromous fish to migrate into tributaries which support significant stocks of juvenile and adult salmonids. The importance of maintaining adequate flows and quality habitat in the mainstem Nicola River cannot be overstressed. However, increasing consumptive demands on water supplies have created conflicts between fisheries and agriculture which at present, limit the opportunities for habitat improvement and increased fish production. An integrated and proactive approach is required to resolve these conflicts before managers can embark on a programme to restore historic levels of production to the basin.

ASSESSMENT METHODS

Information on anadromous fisheries was provided from a joint Federal and Provincial biophysical assessment of fishery enhancement opportunities in the Nicola basin (Sebastian, 1982). This program was initiated in 1980 and two field seasons have been completed with funds provided from the Federal-Provincial Salmonid Enhancement Program. An additional year's field work has been proposed to complete the analysis. Consequently, it should be noted that estimates of carrying capacity and potential yields as outlined in the study are based upon incomplete data. Progressive analyses will refine the estimates of productivity potential and habitat requirements contained in this plan.

Specific fisheries information in the Coldwater River watershed was derived from a detailed study which examined the impact of the Coquihalla Highway from Hope to Merritt (Ministry of Highways, 1978).

CURRENT HABITAT CONDITIONS

Many factors must be considered when addressing habitat requirements for anadromous fisheries. These include surface flows, maintenance or enhanced flows for fisheries, water temperatures and water quality, gradients; flow character, and substrates, diversion designs and screening.

SURFACE FLOWS

In general, tributary surface flows in the Nicola basin are characterized by a late spring/early summer freshet (April-May-June) with decreasing flows throughout the late summer and early fall period. Occasionally, increases in surface flows occur during the winter period as a result of winter storms or thaws. Freeze-up in the December-January period generally stabilizes and moderates uneven flow regimes (information on surface flows is presented in Chapter 4).

During the summer of 1977, very low flows reduced spawning areas significantly and restricted fish migration, particularly in tributaries to the Nicola River. As a consequence, stocks the following year were significantly reduced. Low flows are not the only concern of fishery managers in the Nicola basin, for flooding can also cause considerable damage. The December 1980 floods in the Coldwater and Spius watersheds also had significant impact on anadromous fish populations. Impacts included accumulation of fines over the length of the tributary, extreme alteration of habitat from the transportation of spawning gravels and boulders, elimination of high flow refuge areas and channelization. Studies indicate there was a major impact on chinook egg-fry survival.

MAINTENANCE FLOWS

Adequate water supplies are critical to support the migration, spawning and rearing of all anadromous fisheries in the basin. Resource managers use the term 'maintenance flows' to define the flows of water required to maintain the natural productive potential of habitats throughout the system. Such flows have been defined after extensive analysis of various streams for the August-November spawning and rearing period and for the December-April incubation and overwintering period. Higher flows are required during the freshet (May-July) to clean the gravels in spawning areas. All flows provided in Table 3.4 represent initial estimates based on the two years of field study and may be refined following additional analyses.

TABLE 3.4

RECOMMENDED FISHERY RESOURCE MAINTENANCE FLOWS IN THE NICOLA BASIN

WATERSHED	ESTIMATED MINIMUM FLOW (cfs)[1]		COMMENTS
	Aug-Nov	Dec-Apr	
Upper Nicola (below Douglas Lake)	28[2]	*	Need to accommodate rainbow (steelhead) and chinook spawning and rearing, kokanee spawning, and provide a corridor for migration of fish to areas above Douglas Lake (coho, chinook, and kokanee).
Nicola R.			
N1 Thompson R. to Spius Cr.	200[1]	200[1]	Steelhead and chinook spawning and rearing, pink spawning.
N2 Spius Cr. to Coldwater R.	110[1]	110[1]	Chinook spawning and rearing, steelhead rearing.
N3 Coldwater R. to Nicola L.	60[1]	40[1]	Chinook spawning.
N4 Nicola L. to Douglas L.	28[2]	28[2]	Rainbow/steelhead rearing, chinook spawning and rearing.
Skahan	3	*	Need to provide corridor for steelhead fry access to mainstem Nicola. Steelhead spawning.
Skuhun	5	*	Need to accommodate steelhead fry and yearling rearing and provide access to mainstem Nicola. Steelhead spawning.
Nuaitch	5	*	Need to accommodate steelhead rearing and provide access to mainstem Nicola. Steelhead spawning.
Clapperton	5	*	With sustained minimum flow could support significant coho and steelhead production.
Quilchena	7	*	Need to accommodate rainbow rearing and kokanee spawning for Nicola Lake stocks, maintain corridor to Nicola Lake.
Guichon	7	7	Need to accommodate steelhead and coho spawning and rearing and provide access to mainstem Nicola.
Coldwater	50[1]	50[1]	Chinook, steelhead and coho spawning and rearing.
Spius	78[2]	78[2]	Chinook, steelhead and coho spawning and rearing.

[1] Minimum flows as measured at the gauge or stream's mouth - discharge required to maintain the present productic capability of the system - Aug-Nov -spawning and rearing period, Dec-Apr incubation and overwintering phases.
[2] Estimates based on 20% of mean annual flow and may be refined following additional analyses.
* Natural flow regimes between November and July meet suggested maintenance flows for mid-winter survival of fish, considering reduced metabolic activity and "living space" requirements.

Generally, water depth and velocity are the key parameters affecting the capacity of streams to support fish (Newcombe, 1981). Such flows are necessary to provide for the combination of pools, riffles and glides that are necessary to support the different life cycle requirements of chinook, coho, steelhead and pinks. Where specific stream surveys have been completed, seasonal flows are indicated (e.g. Middle Nicola). Where such assessments are not available, a general rule-of-thumb that approximately 20 percent of average annual flow is required to support fish production has been used (Hamilton and Kosakowski, 1982).

ENHANCED FISHERY FLOWS

In some watersheds, fishery production could be increased by providing higher flows than resource maintenance flows. These opportunities have not yet been quantified in the Nicola basin and would require further detailed fieldwork. Initial assessments, however, indicate that fry recruitment, rather than system carrying capacity is the major constraint on current production. Enhanced flows then would not be beneficial, unless there are fish to use the available habitat.

HABITAT FACTORS LIMITING PRODUCTION

The main factors limiting the productivity of habitats in the Nicola system are low flows, water diversions for irrigation and deteriorating water quality. In addition, some land-based activities such as logging and bank protection are affecting production in specific watersheds.

Maintenance Flows

Although maintenance flows for fisheries could be protected under the Water Act, in the past they have not been guaranteed except in a few cases where the fishery managers have applied for a water licence. They could be enforced under the Federal Fisheries Act. It is now standard practice to protect fishery maintenance flows in some watersheds, by including 'fish clauses' in conditions for granting irrigation water licences. For example, in the mainstem Nicola, some irrigators can divert water only when river flows are above maintenance flows required for fisheries. In smaller watersheds, fishery flows are only met incidentally in average or wet years. Storages such as Nicola Lake provide maintenance flows in average runoff conditions on the mainstem Nicola. The largely unregulated flows on the Coldwater and Spius systems do not meet fishery flow requirements during the late summer months. The greatest shortages occur on Guichon, Clapperton and to a lesser extent Quilchena Creeks and on the Upper Nicola above Nicola Lake.

Irrigation diversion systems can also affect fishery production as fish can be trapped in unscreened irrigation intake pipes or stranded in ditches and fields.

A further concern is the rip-rapping of stream channels to prevent erosion and flooding. Such channelization will affect the velocity of water, gravel quality and remove riparian vegetation that is essential for streambank stabilization, shade, temperature control and a source of food. This issue is most pronounced in the Middle Nicola, which is an active meandering river, but which requires its current riparian vegetation to protect its fish production. Any control structures and regulation of water flows must consider the impact on anadromous fish habitat.

Another impact from regulated flows includes increased water temperatures as surface waters become stationary and controlled. In the Nicola River maximum water temperatures occur in the late summer as flows decrease and water is released from the Nicola Lake (Hamilton and Kosakowski, 1982). Limitations to salmonid production and growth rate as a result of high water temperatures are most likely to occur in the reach between Merritt and Nicola Lake. The influence of the relatively cooler waters in the Coldwater and Spius tributaries ameliorate water temperatures in the lower reaches of the Nicola River.

Water Quality

It is difficult to say whether water quality is having a direct impact on fisheries productivity anywhere in the Nicola system at present. The ambient water quality in a number of streams is discussed in a later section in this report, but as there are no quantified objectives for various water quality parameters with respect to fisheries, it is not possible to establish whether present water quality is having a detrimental affect on the resource.

The main concerns to fishery managers are the high nutrient loadings to the Coldwater and Nicola Rivers due to the Merritt Sewage Treatment Plant and from cattle overwintering operations that border a number of streams tributary to Nicola Lake and Middle Nicola. This enrichment can cause algal growth on spawning gravels and in extreme cases lead to oxygen depletion in lakes and streams.

Siltation impacts on spawning and rearing capabilities. Land-based activities such as logging and road development increase silt loadings to some streams, notably Spius and Coldwater. Silt boils in the Nicola River are a source of fine sediments which restrict spawning and rearing production. These boils may be a result of seepage from excessive irrigation on the adjacent benchland. Consequently, this portion of the river is only lightly utilized by fish even though there is considerable potential to increase production if the siltation problem could be lessened.

Another concern is runoff containing heavy metals from mining operations in Guichon Creek. As will be shown in the section on water quality, concentrations of a few metals appear to be approaching levels which may be damaging to fisheries, but no conclusive statements can be made without further monitoring.

CURRENT AND POTENTIAL PRODUCTION

STEELHEAD

The Nicola basin currently supports an adult steelhead population of 6360[1] which represents approximately 13% of total anadromous production (Table 3.5). The majority of these fish (77 percent) are in the Lower Nicola, the remainder in Spius, Coldwater and Guichon Creeks. There is potential to increase the adult population in the Nicola basin to close to 24,000 - almost four times the current levels. Lower Nicola could provide the greatest numerical expansion in production (7000 fish), but low flows, poor water quality and recruitment limit the full utilization of potential habitat.

After the mainstem Nicola, Spius and the Coldwater rivers are the most important for potential steelhead production (Table 3.5), contributing a combined 30% of potential production. Good habitat availability in the upper reaches of Spius Creek and its two major tributaries (Maka and Prospect) as well as the lower portions of Coldwater provide suitable conditions for extensive rearing of steelhead fry and fish production. Maintaining adequate flows and good water quality is essential if current populations are to be maintained and the productive potential realized in the Coldwater River. Guichon Creek is the other tributary that has an important potential for steelhead production, but this would require improved flow controls in the lower reaches and the maintenance of good water quality. The smaller tributaries in the Lower Nicola Watershed, Nuaitch, Shakan and Skuhun have a more moderate potential for steelhead fry and yearling production to the mainstem Nicola River. At present, irrigation diversions limit the full use of the capacity in these tributaries.

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[1] All population figures refer to adult production before harvest.

TABLE 3.5

CURRENT AND OPTIMUM PRODUCTION OF STEELHEAD IN THE NICOLA BASIN

STREAM/SECTION	RELATIVE FISHERIES VALUE	CURRENT FISH POPULATION					SUGGESTED FISHERIES MAINTENANCE FLOWS		HABITAT REQUIREMENT[4]	OPTIMUM FISH POPULATION[1]					PRESENT[7] FACTORS LIMITING FISH PRODUCTION	COMMENTS
		SMOLTS[5]	ESCAPEMENT[6]	ADULTS[6] HARVESTED	TOTAL ADULT PRODUCTION	C/E RATIO	m^3/s (cfs)	GAUGE LOCATION		SMOLTS[2]	ESCAPEMENT[3]	HARVEST[3]	TOTAL ADULT PRODUCTION	C/E RATIO		
Lower N1-N2 Nicola	H	41,000	1200	3700	4900	3:1	5.66 (200) 3.12 (110)	08LG006 08LG007	Rearing	100,000	3000	9000	12,000	3:1	R	The major production area in the watershed.
Middle N3 Nicola	L-nil	0	0	0	0	-	1.70 (60)	Above Coldwater	For Chinook and Coho	-	-	-	-	-	Q(T)	Heavy siltation. Low gradient.
Upper N4-N5 Nicola	L-M	0	0	0	0	-	0.80 (28)	08LG049	Rearing	13,000	400	1200	1600	3:1	R(Lf)	Upstream of natural spawning migration.
Coldwater	H	2200	65	200	265	3:1	1.42 (50)	08LG010	Rearing	40,000	1200	3600	4800	3:1	R,Lf(F)	Could benefit from flow control & headwater storag
Spius System	H	6800	200	600	800	3:1	2.22 (78)	08LG008	Rearing	25,000	750	2250	3000	3:1	R	The only "natural" production area remaining.
Guichon	M	1800	54	162	216	3:1	0.20 (7)	08LG004	Migration Spawning Rearing	12,000	360	1080	1440	3:1	Ud,Lf,R	Needs screening and improved flow control.
Skuhun	M	375	11	34	45	3:1	0.14 (5)	Mouth	Migration Rearing	4000	120	360	480	3:1	Ud,R(S)	Could benefit from flow control.
Skahan	M	0					0.09 (3)	Mouth	Outmigration (FryRearing)	0	-	-	420	3:1	Lf,S	A major fry production area for Nicola.
Nuaitch	M	800	25	75	100	3:1	0.14 (5)	Mouth	Rearing Migration	800	25	75	100	3:1	Ud	Major fry & yearling prod. area for Nicola.
Clapperton	M	300	9	27	36	3:1	0.14 (5)	Mouth	Outmigration (Spawning)	1600	50	150	200	3:1	Ud,Lf,R	Needs screening and improved flow control.
Total		53,275	1564	4798	6362					196,400	5905	17,715	23,620			

Figures in this table are discussed in: "Nicola Fisheries Assessment; Interim enhancement opportunities and recommendations based on 1980 and 1981 invest-gations, March, 1982".

Opportunities and priorities for steelhead enhancement are provided in this report.

1. Based on habitat area at fisheries maintenance flows.
2. Both direct and indirect smolt yield based on estimates of habitat "carrying capacity".
3. Derived from smolt production, 12% natural ocean survival and a 3:1 catch to escapement (C/E) ratio.
4. Relative to fisheries maintenance flows during low water period: rearing is generally more critical as most streams experience natural freshets during the spawning period (exceptions are Guichon and possibly Clapperton as a result of flow regulation and large diversions). "Migration" in most cases refers to fry and parr (presmoff) outmigrations which can occur throughout the year.
5. Based on 1980 and 1981 standing crop estimates.
6. Based on 12% natural ocean survival rate from smolt stage and a 3:1 C/E ratio.
7. Key: R = recruitment (relative to numbers of adult spawners)
   Lf = low flows
   Ud = unscreened irrigation diversions
   Q = questionable water quality (refers to silt)
   T = high temperatures in summer
   F = subject to flood impacts (partly due to channelizatic
   S = lack of spawning areas

COHO

Current production is limited to the three major tributaries - Nicola, Coldwater and Spius (Figure 3.6) - which support a total of approximately 4000 adults (Table 3.6). This total represents around 14% of total anadromous production in the basin. Assuming a catch to escapement ratio of 3:1, some 3000 coho would be harvested in the commercial and recreational fishery with an annual commercial value of around $54,900.

Population levels could be tripled to about 13,650 adults if various enhancement measures were undertaken. Potential areas for increasing coho production include Coldwater, Maka, Guichon Creeks, and Nicola River - mainstem and upper reaches. Fry stocking in conjunction with required fishery flows in all watersheds would be required to realize this potential. In Guichon Creek, screening of irrigation intakes would also be a priority protection measure.

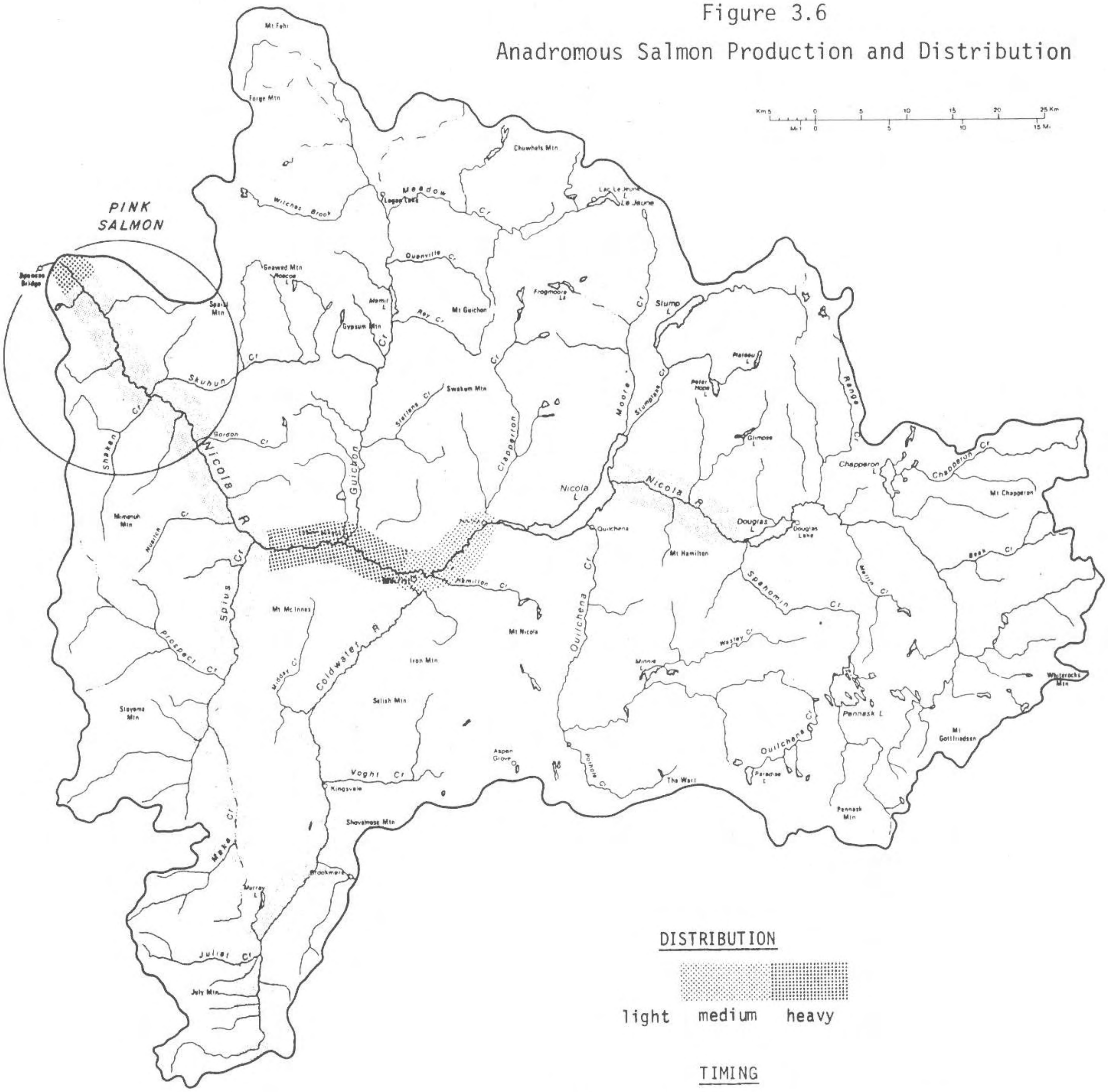
CHINOOK

Current population estimates for chinook salmon total approximately 22,150 adults. Assuming a catch to escapement ratio of 4.5 to 1, the harvest would be about 18,125 representing an annual value of $529,276. Chinook represent approximately 75% of the total anadromous production in the Nicola basin. Major producing areas include the Nicola River, and portions of the Coldwater River and Spius Creek.

Potential production or total carrying capacity is defined by total spawning area or by late summer rearing area in the Nicola River. With recommended maintenance flows of 110 cfs during August-November there is adequate habitat to support a total (catch and escapement) adult population of 28,000. In addition to the mainstem production, the Coldwater and Spius Rivers have an estimated potential to support 6000 and 3000 adults, respectively.

Figure 3.6

Anadromous Salmon Production and Distribution



TIMING

	ARRIVAL	START	PEAK	END
CHINOOK	July	early Aug.	end Aug.	mid-Sept.
COHO	Sept.	end Sept.	late Oct.	early Nov.
PINK	Sept.	late Sept.	early Oct.	late Oct.

TABLE 3.6

CURRENT AND OPTIMUM SALMON PRODUCTION AND ANNUAL VALUE IN NICOLA BASIN

		CURRENT PRODUCTION					OPTIMUM PRODUCTION				
SYSTEM	SPECIES	ESCAPEMENT	CATCH	TOTAL	C/E RATIO	VALUE ($1982)	ESCAPEMENT	CATCH	TOTAL	OPTIMUM C/E RATIO	VALUE ($1982)
Nicola R.	chinook	3320	14,940	18,260	4.5:1	436,194	7000	21,000	28,000	3:1	613,231
	coho	325	975	1300	3:1	17,833	950	1900	2850	2:1	34,748
	pink	708	1983	2691	2.8:1	11,389	708	1983	2691	2.8:1	11,389
						465,416					642,515
Coldwater R.	chinook	572	2574	3146	4.5:1	75,163	1500	4500	6000	3:1	131,406
	coho	445	1335	1780	3:1	24,404	3000	6000	9000	2:1	109,733
						99,567					241,139
Spius Cr.	chinook	136	612	745	4.5:1	17,919	750	2250	3000		65,681
	coho	231	693	924	3:1	12,681	600	1200	1800		21,948
						30,600					87,629
Total	chinook	4028	18,126	22,151		529,276	9250	27,750	37,000		810,318
	coho	1001	3003	4004		54,918	4550	9100	13,650		166,429
	pink	708	1983	2691		11,389	708	1983	2691		11,389
System Total		5737	23,112	28,846		595,583	14,508	38,833	53,341		971,283

Sources: Federal Fisheries and Oceans

Notes: Technical Document provides details of the calculatoin of production value figures and detailed description of catch and annual value for commercial, sport tidal, sport fresh, native food and U.S. commercial sport fishing. Employment estimates provided. Appendix VII.

[1]The "optimum" production estimates are based on fishery maintenance flows outlined in the Nicola Strategic Plan (Table 1). Higher levels of productivity might be obtained if "enhanced" flows were available.

The difference between optimum and potential fish production are described:

Optimum - level of fish production that could be achieved given current habitat conditions and guaranteed fishery resource maintenance flows. Stocking may be required in some tributaries.

Potential - level of fish production which could be achieved with enhancement techniques, such as increasing flows beyond maintenance flows and increasing the habitat available for spawning and rearing.

Thus, total chinook potential for the Nicola basin is estimated at 37,000 adults (27,750 catch, 9250 escapement) valued at $810,300 in 1982 dollars. This represents almost a doubling over current production rates.

PINK SALMON

Current production of pink salmon totals around 2700 adults all of which are found in the Nicola River itself but is increasing in each 2 year cycle. The commercial value of the harvest is also low at present (about $11,000 per year). Given the steady increase in pink salmon populations, no specific enhancement measures are being considered at this time.

SUMMARY

The Nicola system currently supports approximately 55% of its potential production of anadromous fish. As one of the major tributaries to the Thompson River, it is important that some of this potential be realized over the next few years as part of the overall goal of increasing commercial and sportfish production in the Fraser River System.

The key to increasing anadromous fish populations in the Nicola basin lies in water management habitat protection and fry stocking in selected tributaries. Chapter 4 will outline the management options associated with water supplies, water quality and fisheries enhancement required to realize this potential.

RESIDENT FISHERIES

The Nicola basin is one of the major angling centres in the Province. Anglers are attracted to the area by an abundance of annually stocked, productive lakes where access is good, facilities are available and there are good opportunities for catching fish. Unusual variety is available as anglers can fish trophy lakes, wilderness waters or popular resort areas all within close proximity to each other. There are few other areas in the province which can provide the level and diversity of angling opportunity in close proximity to major population centers as is found in the Nicola basin and the Thompson-Nicola region.

CURRENT AND POTENTIAL PRODUCTION

An estimated 143 lakes in the Nicola planning unit (17% of the regional total) contain fish or are thought to be capable of sustaining fish populations. The majority are relatively small with the exception of Nicola, Douglas and Stump Lakes. The Nicola basin is designated as second priority for fisheries management after the Thompson-Bonaparte since the lakes in the basin are generally very productive, easily accessible and already heavily used.

Lakes with the capacity to support sport fisheries have been separated into three classifications which have been developed from criteria relating to physical characteristics and types of angling opportunities provided. The three classifications are as follows:

a) Developed Environment - middle to low elevation lakes characterized by high productivity, easy access and substantial cottage or other shoreline development (e.g. Nicola, Stump, Lac le Jeune, Corbett, Surrey, Sussex).
b) Natural Environment - middle to low elevation with little or no lake shore development, fair to good access on secondary or forest roads and aesthetic surroundings (e.g. Courtney, Kane, Lundbom, Marquart).
c) Wilderness - remote in setting with difficult access, generally low productivity and very aesthetic surroundings (e.g. Pennask, Reservoir, Face, Paska).

CURRENT FISH PRODUCTION

The lakes in the Nicola support a number of different fish species but salmonids are the most desirable in terms of satisfying angler demand.

Three resident species - rainbow trout, kokanee and brook trout (a char) - dominate recreational catch comprising about 70%, 10% and 7% of total catch respectively. Other resident species in the unit - whitefish, burbot and Dolly Varden - are relatively insignificant in terms of angling effort, presently comprising about 10% of the total recreational catch.

Table 3.7 provides fish production information by lake type and shows there are currently around 312 to 352 thousand game fish available for harvest in the Nicola basin. These are distributed among less than half of the total number of lakes in all categories due to production constraints and/or lack of stocking. The greatest production (43% of the total) comes from lakes in the developed environment category even though these are the fewest in number.

Although the lakes in the Nicola are generally very productive, few are capable of being self-supporting. Sixty-five percent of developed environment lakes rely on stocking to sustain more than ninety percent of their production. Stocking accounts for a lesser but still substantial proportion of production from natural environment and wilderness lakes.

Factors Limiting Fish Production

The main factors which currently or potentially limit the production of sportfish in the planning unit are listed below:

a) Water Resource Competition

A basic issue in the Nicola basin is one of competition for a finite water supply which must be allocated among various legitimate uses. In relatively dry years, the amount of water extracted from the rivers and streams for irrigation, together with low seasonal flows, leaves insufficient quantities for fish spawning and rearing. Withdrawals can affect lake levels to the extent that fish production is adversely impacted. This is currently a problem on at least seven

TABLE 3.7

CURRENT AND POTENTIAL RESIDENT FISH PRODUCTION IN THE NICOLA BASIN[1]

Lake Classification	Natural Production		Stocked		Total Current Production		Potential Production		% Increase Over Present Production
	Lakes	Fish	Lakes	Fish	Lakes	Fish	Lakes	Fish	Fish
Developed	11	3,400	7	140,000	18	143,400	22	420,000	193%
Natural	14	19,500	19	84,600	33	104,100	66	210,000	102%
Wilderness	11	53,800	7	32,600	18	86,400	55	120,000	39%
TOTAL	36	76,700	33	257,200	69	333,900	143	750,000	125%

[1] Average figures

Source: Fish and Wildlife Branch, Regional Office.

lakes in the unit. In addition, unscreened diversions draw juvenile fish out of streams to be left dying on irrigated fields or in dry irrigation ditches.

b) Biological Competition

Some lakes in the Nicola are heavily populated with coarse fish which currently have little or no recreational or commercial value. These fish affect the more valuable species and their habitat through competition for feed or by predation which is a serious problem on about eight lakes in the unit.

c) Oxygen Deprivation

Winterkill or summerkill are problems in about 15 lakes with shallow depth due to either natural causes or to water withdrawals. The result is that potentially self-sustaining lakes require annual stocking with game fish.

d) Habitat Deterioration

The removal of vegetation and/or soil cover by forestry, mining and agriculture causes radical changes in the timing, extent and quality of natural runoff which can have serious impacts on aquatic resources. All three of these resource activities are prominent in various areas of the Nicola and potentially limit the productive capability of the lakes and streams. Degradation of instream habitat through channelization of the river corridor for flood control purposes could also be detrimental, especially in the mainstem Nicola and Coldwater rivers.

e) Over-Fishing

Over-fishing can limit the capability of fish populations to sustain themselves over the long term. Although this is not a biophysical constraint, the amount of angling effort has definite implications for natural fish production, especially over the long term.

POTENTIAL FISH PRODUCTION

By removing constraints on all lakes where management measures have been identified, an increase in fish production of about 125 percent over current levels could be realized. Table 3.7 shows that potential production of harvestable game fish in the Nicola to be around 750 thousand with the developed environment lakes accounting for 56 percent of this total.

Although such enhancement opportunities exist, the appropriate level of management will be dependent on the demand for angling in the basin and the relative priority of the Nicola within the Thompson-Nicola region for sport fish management.

CURRENT AND POTENTIAL DEMAND

The Nicola basin presently supports 217,000 angler-days annually which is 25% of regional effort (second highest after the Thompson-Bonaparte with 31%). This relatively high level of use can be attributed to the Nicola's proximity to Kamloops, the economic centre for the region, good access and of course, the attraction to the many lakes in the area.

Table 3.8 provides angling and harvest information by the three lake types outlined earlier and shows that over half of total angling activity takes place on developed environment lakes. In addition to the diversity provided by the various lake types, Island and Blue lakes are currently designated for trophy fisheries and have a 2 fish/day limit imposed in order to allow for the growth of fish to a larger than average size.

The average success rate in the Nicola basin is 1.1 to 1.3 fish per angler-day. This particular rate applies to rainbow trout angling which constitutes the majority of activity. Depending on the species, different success rates represent equivalent levels of quality. A success rate of 3 fish per angler-day for kokanee is roughly equivalent to 1.1 to 1.3 fish per angler-day for rainbow as is a catch of 2 to 3 brook trout per day. Future reference to success rate will apply to rainbow trout and will imply the respective rates for the other major sport fish noted above.

Other factors also affect quality such as the size and quality of fish caught as well as the less tangible values associated with numbers of competing anglers and aesthetics of the setting. The goal of the Fishery Programme in the Ministry to provide a diversity of angling experiences is particularly relevant in this respect.

Due to high lake productivity in most of the Nicola unit, current harvest rates can be sustained on most lakes with the exception of about fourteen which are being fished at or near capacity (Appendix VII). It is questionable, however, whether anglers are satisfied with the current success rate. Over the past ten years, there has been a shift in activity away from the Thompson-Nicola region to the Cariboo region which historically has supported a relatively low level of angling activity but has provided higher success rates, presently estimated at 2.2 fish per angler-day.

Factors Influencing Future Angling Activity

Besides the effects that a general increase in provincial and regional population will have on angling effort, there are specific developments that are expected to increase the future level of angling activity in the Nicola basin. The main ones are outlined below.

TABLE 3.8

ANGLING ACTIVITY IN THE NICOLA BASIN

Lake Classification	Current Angler-days	% of Total	Future Angling Projections* (angler-days) 1985	1990	2000
Developed	110,100	51%	149,100	187,400	263,900
Natural	63,550	29%	84,800	106,500	150,000
Wilderness	43,550	20%	58,500	73,500	103,500
TOTAL	217,200	100%	292,400	367,400	517,400

Source: Fish and Wildlife Branch, Regional Office, Kamloops; Planning Branch.

* Assuming future division of activity among lake types will remain the same as at present.

a) Improved Access

The most dramatic effect on angler activity in the area will likely be due to the development of the Coquihalla Highway. The new route is forecast to channel almost two-thirds of the Fraser Canyon traffic through Merritt, greatly improving accessibility of the region's fishery resource to Lower Mainland residents.

b) Mineral Development

Mining activity in the Highland Valley, situated in the Guichon watershed of the Nicola basin, is expected to increase with the expansion of Bethleham and Lornex mines. Although the timing is uncertain at present and low copper prices are dampening expansion plans, some regional population growth can be expected as a result of economic developments in this area.

c) Recreational Congestion in Adjoining Regions

Increasing use of recreational facilities in the Okanagan is leading to congestion in that region, particularly in the summer months. Overflow into the Nicola is expected to add to future angling demand.

The effect that the above factors will have on the future amount of angling activity has been quantified into angler-day projections for the Nicola planning unit. These projections were made assuming the future quality of angling will be comparable to that currently enjoyed. Whether or not this assumption holds largely depends on fisheries management measures affecting the level and distribution of fish production in the region.

Table 3.8 gives a range of projections for future angling activity in the Nicola basin. It is anticipated that the Nicola will support approximately the same proportion of regional angling activity in the future as it does currently with Lower Mainland residents contributing a slightly larger population. Total angling effort could more than double to over 500,000 days by the end of the century if the fishery could support this level of demand.

The amount of effort and type of angling that actually occurs in the Nicola in the future will depend a good deal on the following factors:

a) Supply of Fish

The availability of fish production in the Nicola to support angling activity will depend on the extent to which constraints to production (outlined earlier) can be removed.

b) Access Within the Nicola

Much of the Nicola drainage is subject to Crown land leases for grazing purposes. When the Ministry of Forests renews grazing leases, the Ministry of Environment must be able to ensure public access to lakes where benefits may be realized from angling. Where good angling opportunities exist on lakes situated on private and leased lands, negotiations with the owner are needed to gain public access through their property.

Difficult access to wilderness lakes also limits the amount of use. This situation, however, cannot be considered totally negative since the limited access in itself maintains the quality of angling.

c) Overfishing

As fishing effort increases in an area the quality of angling is potentially reduced in two ways: a) through the over-harvest of resident fish populations and b) through greater pressure on relatively inaccessible lakes that currently offer a good wilderness experience. Such trends serve to reduce the overall quality and diversity of angling in the basin, thereby leading to a lower level of use and a lower value per angler-day than would otherwise occur.

SUMMARY

Demand for fish as derived by the angling effort is currently being met by the supply of game fish over the entire basin at an average success rate of 1.1 to 1.3 fish per angler-day. As angling activity increases, the maximum rates that could be sustained with the current level of production are in the range of 0.8 to 1.0 and 0.6 to 0.7 fish per day for the years 1990 and 2000 respectively. This decrease in quality would mean that benefits from recreational angling would be lost due to a smaller than potential increase in activity and a lower value per angler-day.

The capability exists in the Nicola to increase fish production substantially and maintain the current success rate of 1.1 fish per day, for the demand of some 510,000 days.

Given the close inter-relationship between supply and demand, management options available to the Ministry must be related to maintaining certain quality criteria for the sport fishery in order to ensure a continued high level of use. These include access to a variety of angling experiences, satisfactory success rates and sustained biological integrity of the fishery itself. Management options discussed later will therefore include both managing production and regulating demands such that these quality criteria can be met over the time horizon of the plan.

WATER QUALITY

INTRODUCTION

Maintaining good water quality is an essential component of the management of surface and groundwater supplies. The quality of water must be compatible with the uses that individuals and society require. Increasing water use in the Nicola basin, from residential, industrial and agricultural sectors has resulted in changes to water quality. These changes are the result of intermittent and continuous discharges from point and non-point sources. Major concerns include the Sewage Treatment Plant at Merritt and overwintering cattle along stream courses, both of which contribute significant nutrient loadings to surface waters. Other water quality concerns are a result of runoff from disturbed areas around mining developments in Guichon Creek and logging operations in Coldwater and Spius Creeks.

Anticipated increases in resource development and the associated waste products will further affect water quality. Additional pollutants from point and non-point sources and the growing demands of water make it necessary to establish parameter levels that will ensure good water quality in the Nicola basin.

PROGRAMME GOALS AND STRATEGIC PLANNING OBJECTIVES

PROGRAMME GOALS

The management of water quality is a component of the Ministry's Water Management Programme. The goal of water management is:

> To allocate, manage and protect the water resources of the Province to obtain the highest and best use of the resource and to derive optimum benefits for all people of the province for the foreseeable future.

A number of programme objectives support this goal. The objective that addresses water quality is:

To preserve the quality of surface water and groundwater resources for both consumptive and non-consumptive purposes.

Legislative authority for water management and water quality is provided by the Environment Management Act, Waste Management Act, Fisheries Act and Water Act.

STRATEGIC PLANNING OBJECTIVES

The development of the water quality input is guided by a number of strategic planning objectives. These objectives will identify the opportunities available to improve or maintain standards of water quality.

SUPPLY

1. Determine present and projected waste loadings to major water systems. Identify major sources of pollutants affecting surface waters.

2. Determine present ambient water quality and ecological status of major water systems and note trends or changes in specific parameters.

3. Determine the consequences of projected waste loadings on the ambient water quality and ecological status of water systems.

DEMAND

4. Determine priority uses in each major water system.

5. Determine acceptable ambient water quality objectives for major uses of water (e.g. fisheries, agriculture, recreation, aesthetics) in each major water system. Indicate where parameters are close to or are exceeding the objective levels established.

6. Determine social, economic and environmental costs and benefits of meeting desired ambient water quality objectives.

MANAGEMENT OPPORTUNITIES

7. Assess the benefits and costs of waste management measures designed to achieve ambient water quality objectives for designated in-stream and consumptive uses of water.

PRESENT AND PROJECTED WASTE DISCHARGES IN THE NICOLA BASIN

One of the sources of pollutants in the Nicola basin is waste discharges. These have potential to impact upon water quality to varying degrees. There are two types of waste discharges to the Nicola basin; point and non-point source discharges. Point sources discharge directly or indirectly to water (Figure 3.7). These discharges are regulated by effluent permits administered under the Waste Management Act e.g. Merritt Sewage Treatment Plant. Non-point source discharges include pollutants from various background or widespread sources. Refuse site and mine-mill tailings impoundments can contribute to general groundwater contamination via infiltration. This infiltration, however, is taken account of during the Permit processing stage and all precautions are taken into the design of the facility to minimize such effects. The discharge of refuse or tailings is covered by a permit. Non-pont source discharges include domestic tile field systems and cattle or farming operations. These pollutants are not regulated by the Waste Management Act since their widespread nature does not allow effective and precise control. However, other management measures can be implemented to control these discharges.

PRESENT WASTE LOADINGS

Point Sources Discharging Directly to Water

The Merritt Sewage Treatment Plant is the only current direct discharge to water (Coldwater River). At present, monitoring has indicated that permit conditions are exceeded on a yearly average basis (Table 3.)

Figure 3.7

Permitted Waste Discharge Sites

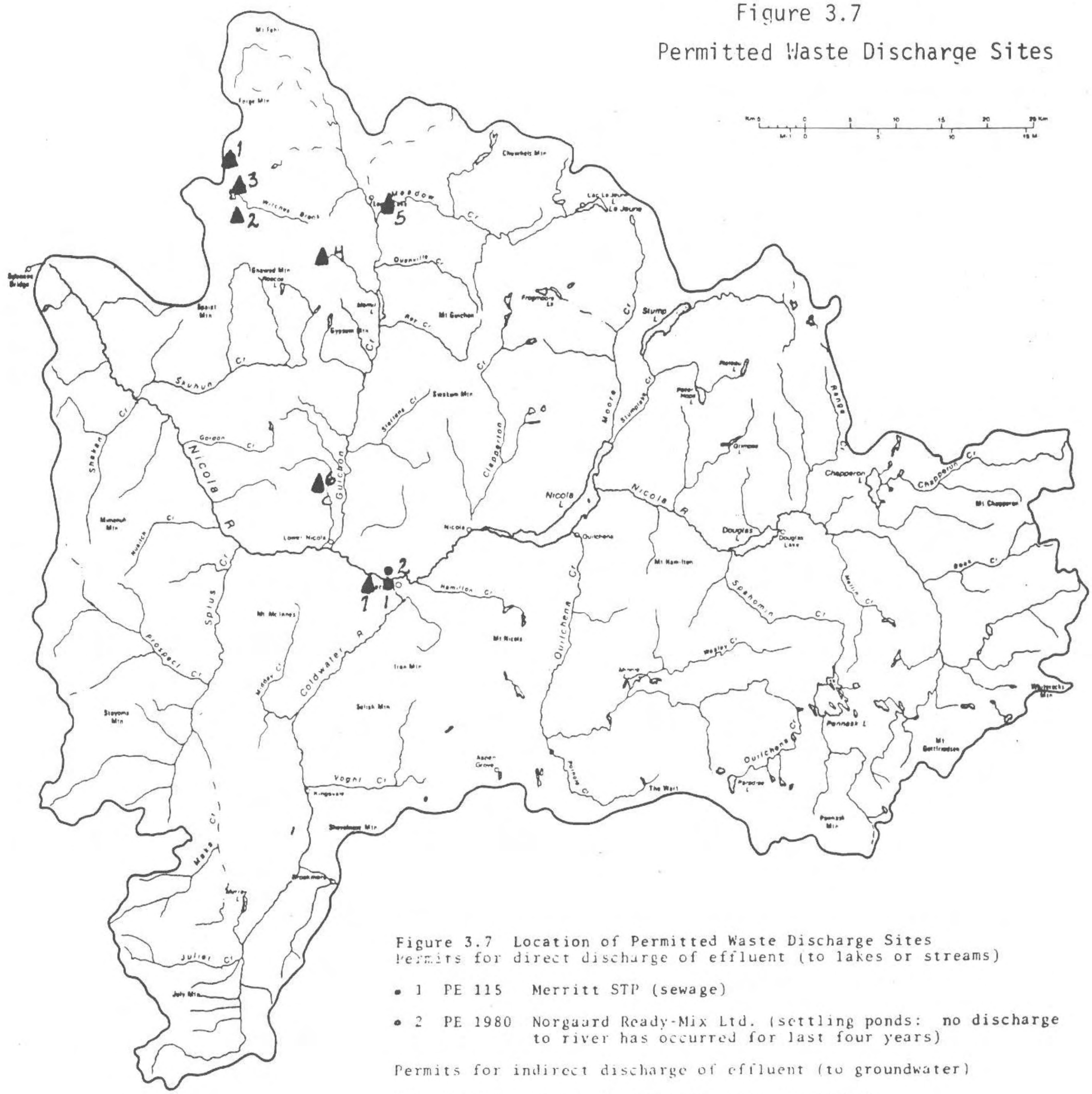


Figure 3.7 Location of Permitted Waste Discharge Sites

Permits for direct discharge of effluent (to lakes or streams)

- • 1 PE 115 Merritt STP (sewage)
- • 2 PE 1980 Norgaard Ready-Mix Ltd. (settling ponds: no discharge to river has occurred for last four years)

Permits for indirect discharge of effluent (to groundwater)

- ▲ 1 PE 376 Lornex Mining Corp. Ltd. (tailings)
- ▲ 2 PE 367 Lornex Mining Corp. Ltd. (sewage lagoon and spray irrigation)
- ▲ 3 PE 428 Bethlehem Copper Corp. Ltd. (tailings)
- ▲ 4 PE 1190 Highmont Mining Corp. (tailings)
- ▲ 5 PE 433 Logan Lake Sewage Treatment Plant (sewage lagoons)
- ▲ 6 PE 1388 Craigmont Mines Ltd. (tailings)
- ▲ 7 PE 4783 Steffens, Dr. R.J. (tile field)

TABLE 3.
MERRITT SEWAGE TREATMENT PLANT - COMPARISON OF PERMIT CONDITIONS AND EFFLUENT MONITORING*

	Permit (maximum)	Actual Levels (ave./year)
Flow	2900 m^3/d	2717 m^3/d
Biological Oxygen Demand	15 mg/L	30 mg/L
Total Suspended Solids	10 mg/L	64 mg/L
Total Phosphorus	1.0 mg/L	2.2 mg/L

* Monitoring Data are data for 1979-82 for B.O.D., S.S., and Total P. flow data are from 1982. The figure of 2717 m^3/day includes infiltration during spring runoff in May and June. In these months the outflow consequently increases to a volume of 3070 m^3 of diluted effluent. Average flow without infiltration (May and June) is 2616 m^3 day.

The BOD_5 and total suspended solids values of 15 and 10 mg/L respectively were placed in the Permit at the insistence of the city of Merritt despite advice from WMB that such quality from the treatment plant was very unlikely. Quality requirements (Pollution Control Objectives, 1975) for fresh water discharge when dilution ratios are 320:1 to <200:1 are BOD/SS = 30/40 mg/L which puts the actual discharge closer to WMB guideline requirements. Consequently, comparisons of actual performance against the Permit requirement may not be entirely valid.

Although the effluent is dechlorinated and approximately 80-90% of phosphorus is removed (though the addition of alum and ferric chloride), the discharge is having an effect on the water quality of the Nicola and Coldwater Rivers. Upstream measurements along both the Nicola and Coldwater Rivers have indicated that nutrients, suspended sediments and coliforms are significantly lower than those measured downstream of the Sewage Treatment Plant and river confluence during low flow periods (Table 3.).

MEASUREMENTS OF SELECTED PARAMETERS AT STATIONS
ABOVE AND BELOW THE MERRITT STP (1980/81 DATA)

Parameter	Upstream Measurements		Downstream Measurements
	Coldwater (Stn. 500)	Nicola (Stn. 115)	Nicola (Stn. 534)
Total Phosphorus	0.013 mg/L	0.041 mg/L	0.051 mg/L
Total Nitrogen	0.13 mg/L	0.44 mg/L	0.49 mg/L
Suspended Solids (non-filterable residue)	7.9 mg/L	9 mg/L	13.6 mg/L
Fecal Coliforms	16 MPN	21 MPN	1146 MPN

The effect on the Nicola River includes loss of aesthetics for <1 km downstream of the confluence of the two rivers from algae growth and possible damage to fisheries spawning grounds, again the result of increased algae growth. The use of the Nicola River for drinking water is marginal at any point including upstream of the Coldwater River. Below the confluence there is no doubt the water quality is inadequate for drinking purposes (see Ecological Status of Major Watersheds for further discussion).

Because of continued pressure from Federal Department of Fisheries and Oceans and the public upon Waste Management to in some way remove the discharge from the river, or upgrade the effluent quality such that there was no discernable effect on the river, the city and its' consultant looked into options of both land disposal and plant upgrading (for consistent high quality effluent). The land options were for infiltration/spray irrigation disposal. These proved to be extremely expensive and financially out of reach for Merritt. The plant upgrading needed for consistent high quality effluent for direct discharge was inturn expensive. In light of the recent economic situation and the unlikelihood of Ministry of Municipal Affairs grants, acceptance of the proposal was deemed to be somewhat improbable. The alternative suggestion was to take advantage of the capabilities of the existing plant which is able to produce good acceptable effluent for a process known as rapid infiltration most of the time. Some physical changes in the plant were needed to give consistent effluent around the clock, the main installation being flow equalization. Flow variations are the prime cause of effluent quality variations. The city is currently, with their consultant, looking at this disposal method and if successful will remove the discharge from the river and be a viable process for disposal for many years in to the future.

Point Sources Discharging Indirectly to Water

The Norgaard Ready Mix or gravel washing plant discharges indirectly to the Nicola River. Although Norgaard Ready Mix has a permit for direct discharge, there has been no direct discharge from the settling basins for four years. Consequently, there is little or no impact on the environment from this operation.

Appendix IX summarises the remaining point sources of wastes in the Nicola basin that are discharged to the ground and eventually seep into watercourses. Generally, these discharges do not cause any problems for surface water quality, because discharge amounts are small. They may affect groundwater quality, but monitoring of groundwater is not adequate to analyse this.

Non-Point Discharges

Resource activities associated with agriculture, forestry and lake shore developments result in non-point source pollutants that have some important impacts on water quality in the Nicola basin. From a management viewpoint these sources are a problem because their impacts are difficult to measure, the non-point sources are often widespread with variable discharges, there are few cost-effective control measures available and the

Ministry does not have a clear mandate to enforce controls in some instances.

There are four main sources of non-point discharges in the Nicola basin:

i) farming activities from summer range cattle grazing and winter feedlot on lower valley confined areas; and
ii) domestic septic tank tile fields and related surface runoff from storm sewers or ditches;
iii) industrial activity from logging operations, (mining open pit area and waste rock piles), sawmill yards and miscellaneous industrial storage yards;
iv) natural contaminants.

Agricultural

Agricultural activities, particularly the over-wintering of cattle near or in streams, produce the major source of pollutants in the Nicola basin. Over 25,000 head of cattle graze on Crown range under forestry grazing permits during the summer months. In addition, cattle graze on private lands, mainly located in the valleys. During the winter, all these cattle are fed along the stream banks resulting in large nutrient loadings during winter thaws and the spring freshet. The major cattle feeding areas have been mapped (Figure 3.8), but the site specific impacts of these operations on ambient water quality have not yet been determined. These would depend on the size of the operation, soil type, terrain and proximity to watercourses (including irrigation ditches). Impacts from nutrient enrichment include increased algal growth and high levels of N and P instream as well as increase of rates of eutrophication in lakes. Increases in fecal coliforms would reduce drinking water quality, particularly during spring run-off.

Disturbance of river banks by cattle also causes siltation of rivers. Over-irrigation and the effect on groundwater percolation along the Middle

Nicola River is suspected of contributing to 'silt boils' and increased levels of suspended sediments. These sediments would reduce spawning gravels available for anadromous fish. The use of fertilizers also introduces contaminants into surface waters, including nitrogen and phosphorus, which contribute to the overall problem of nutrient enrichment in agricultural areas.

Major areas of concern with respect to the impacts of agricultural activites on water quality are the upper and middle Nicola Basins. Several major concentrations of cattle in the Douglas Lake and Chapperon Lake areas and a series of smaller concentrations along the middle Nicola (and lower Nicola above Spius Creek) are main cattle wintering concerns (Figure 3.8). Sizable numbers of cattle are also wintered along inlet streams immediately upstream of Nicola and Stump Lakes, with possible effects on these lakes as well as those mentioned above.

Industrial

Industrial activities in the Nicola Basin are confined to two main types, logging and mining. Logging has occurred mainly in the Coldwater and Spius watersheds. Although no studies have been done in the upper Coldwater to determine the effects of logging, high sediment loads in the Coldwater have been recorded during spring runoff (over 700 000 kg/day) (Table 17, Appendix X). The sediment may have the greatest impact on spawning gravels as the interstitial spaces are filled with silt.

Copper mining developments are concentrated in the upper reaches of Guichon Watershed. (Craigmont mines at Merritt were recently closed.) The impacts from mine development include exposed waste rock piles, milling reagents from tailings ponds and nitrate leaching from mining operations. There is some recent evidence that heavy metals levels are increasing (and water quality deteriorating) in the Highland Valley area as a result of mining activities such as Bethlehem mines. Seepage from waste dumps and/or disturbance due to stream diversion in new tailings pond areas are likely causes of contamination. A program of further study is planned by the Waste Management Branch to do the further sampling necessary to provide more conclusive data.

Domestic

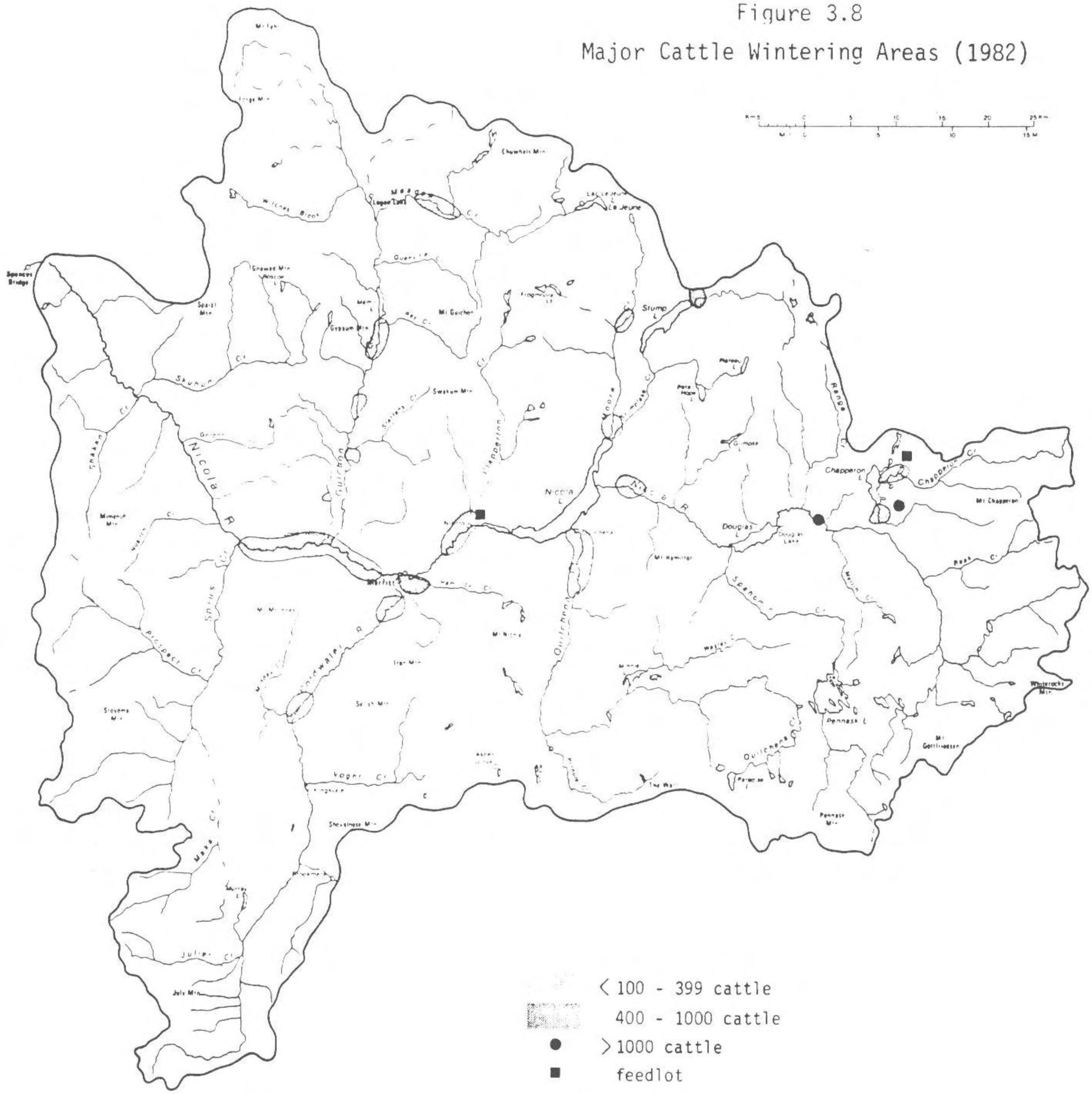
The city of Merritt and the village of Logan Lake have about 7,500 people on domestic sewer connections and about 4,000 people or 1,500 houses on individual septic tank systems. These tank systems eventually seep into the Nicola River and may impact upon water quality through the addition of nutrients. Coliform levels in Merritt's sewage discharge are high, causing substantial increases in coliform numbers downstream from the discharges from the Merritt Sewage Treatment Plant.

Storm sewer runoff, particularly during freshet, contributes a significant quantity of contaminants including nutrients, oil and grease and sediments.

Natural Contaminants

There are relatively few widespread sources of natural contaminants in the Nicola Planning Unit; however, mineralization and siltation can create problems for water quality. The Guichon watershed possibly has high background levels of selected heavy metal concentrations; however, due to land use disruptions (mining) in the headwaters, it is difficult to determine definitive background levels. Streams previously considered unaffected for "background" purposes are now considered possibly contaminated. The Coldwater and Spius watersheds have typically V-shaped valleys and as a result, high siltation occurs during the freshet period. The impact on receiving waters includes loss of fish habitat and decline in drinking water standards.

Figure 3.8
Major Cattle Wintering Areas (1982)



< 100 - 399 cattle
400 - 1000 cattle
● > 1000 cattle
■ feedlot

Data: from aerial surveys Feb.8, 1982

PROJECTED WASTE LOADINGS

Future development projects in the Nicola basin are expected to be limited in number and in scope. Agricultural operations are expected to increase minimally as most lands capable of supporting irrigation are already under production. Cattle herds are expected to remain about the same size, although if present overwintering practices continue, further nutrient enrichment will accelerate water quality degradation in lakes and possibly some streams. The impact will affect drinking water standards, fishery productivity and aesthetics.

The further development of copper (and molybdenum) in the Highland Valley could deposit greater amounts of the metals in the Guichon Watershed. The project will involve tailings ponds (indirect discharge to water), exposed waste rockpiles and possibly cause some underground leaching of contaminants.

It is estimated that exposed waste rockpiles will be considerably larger than existing operations. Although pollution control permits are issued for tailings ponds and other direct or indirect discharges, waste rockpiles are not licenced. It is felt that most of the metal contamination in Guichon Creek comes from these exposures and will be exacerbated with further development. The combination of low flows and increased metal concentrations will exceed the (interim) ambient objectives for drinking water and fisheries. The impact on these uses may include a decline in fishery productivity and poor quality drinking water.

Expansion in the Merritt area is expected to be limited. The extension of the Coquihalla Highway may increase tourism, but the impact on residential growth is anticipated to be low. Land use activities associated with the construction of the Coquihalla Highway could cause excessive siltation harmful to fish spawning and mating. The updating of the Merritt Sewage Treatment Plant is expected to handle about 9200 m^3/day or a 60% increase in residential growth. While current levels of sewage are now within the permit levels for flow, other permit levels (B.O.D., suspended solids, and phosphorus) are exceeded during peak flow periods. It is likely that permit levels for these parmaters will continue to be high, even with the increase in the volume the plant is able to handle. The discharge may be having a substantial impact on spawning grounds for fisheries, aesthetics and standards of drinking water. Any further increase in residential development, albeit small, will exacerbate this trend. Increased storm sewer runoff will also contribute more nutrient, grease, oils and sediment contaminants as quantities increase.

Further pollution control permits are expected to be issued on an infrequent basis. Landfill sites and waste disposal areas may be required. The impact on the environment is expected to be limited.

Potential sites for the management of special wastes include the Nicola basin. The magnitude and impact of this project is subject to more detailed studies, although the Nicola Basin Strategic Plan will contribute information regarding final site selection.

PRESENT AMBIENT WATER QUALITY OF MAJOR WATER SYSTEMS

Over the past five years, the Ministry has undertaken a special programme of monitoring water quality in the mainstem Nicola, Lower Coldwater, Guichon Creek and Nicola Lake (Figure 3.9). This section summarizes the results of this programme in terms of the selected parameters shown on Table 3.9 for sampling undertaken in 1978-79 and 1980-81. Relatively good data are available for the Nicola and Coldwater Rivers as a result of these studies, while Guichon Creek and Nicola Lake were also studied in some detail. Data for other watersheds such as Moore-Stump and Quilchena are limited. Very little information has been collected on Spius, Coldwater and Clapperton Creeks. A more detailed evaluation of water quality in each watershed with summaries of water quality data is presented in Appendix X.

TABLE 3.9

SUMMARY OF KEY WATER QUALITY PARAMETERS MEASURED IN THE NICOLA BASIN

CHARACTERISTICS	PARAMETERS	IMPACTS
Physical	suspended sediment Temperature	- changes may have acute and sub-lethal effects on both resident and anadromous salmonids; aquatic biota
Chemical	Nutrients - Phosphorus - Nitrogen	- advance entrophication indirectly may affect fish populations and community structure; algal growth
	Metals e.g.- Copper - Molybdenum	- lethal and sub-lethal toxic effects on fish - some metals detrimental to grazing animals through irrigated crops
Biological	Coliforms - Fecal - Total	- water contaminated by inadequately disinfected sewage or animal wastes
	Chlorophyll 'a' Algal species composition	- determines trophic status; entrophication decline in aesthetics of water bodies; large masses of algae can cause plugging of water intakes. - affect drinking water suitability (taste, odour) - affect fish habitat

NICOLA RIVER

Nutrients

During the freshet, nutrient loads increase from the Upper Nicola watershed downstream to below the confluence with Coldwater River mainly due to cattle operations and the Merritt STP which discharges to the Coldwater. Below Coldwater phosphorus loadings decrease significantly due to the high dilution flows in Coldwater, and Spius. Nitrogen loadings (organic and ammonia forms) remained high (e.g. about 400-800 kg/day, in 1980/81 for organic nitrogen), throughout the Upper and Middle Nicola, with a small improvement in the Lower Nicola. A similar pattern was apparent in the non-freshet period with highest concentrations in the Middle Nicola (Tables 3 and 4, Appendix X).

In terms of algal growth, the Upper and Middle Nicola are generally N-limiting during freshet and with the removal of phosphorus at the Merritt STP, the N:P ratio increased downstream of the confluence with the Coldwater. In low flow periods, N remained limiting above the Coldwater and P limited algal growth below the Coldwater. However, there appeared to be sufficient nutrients in the system at all times to permit algae to flourish.

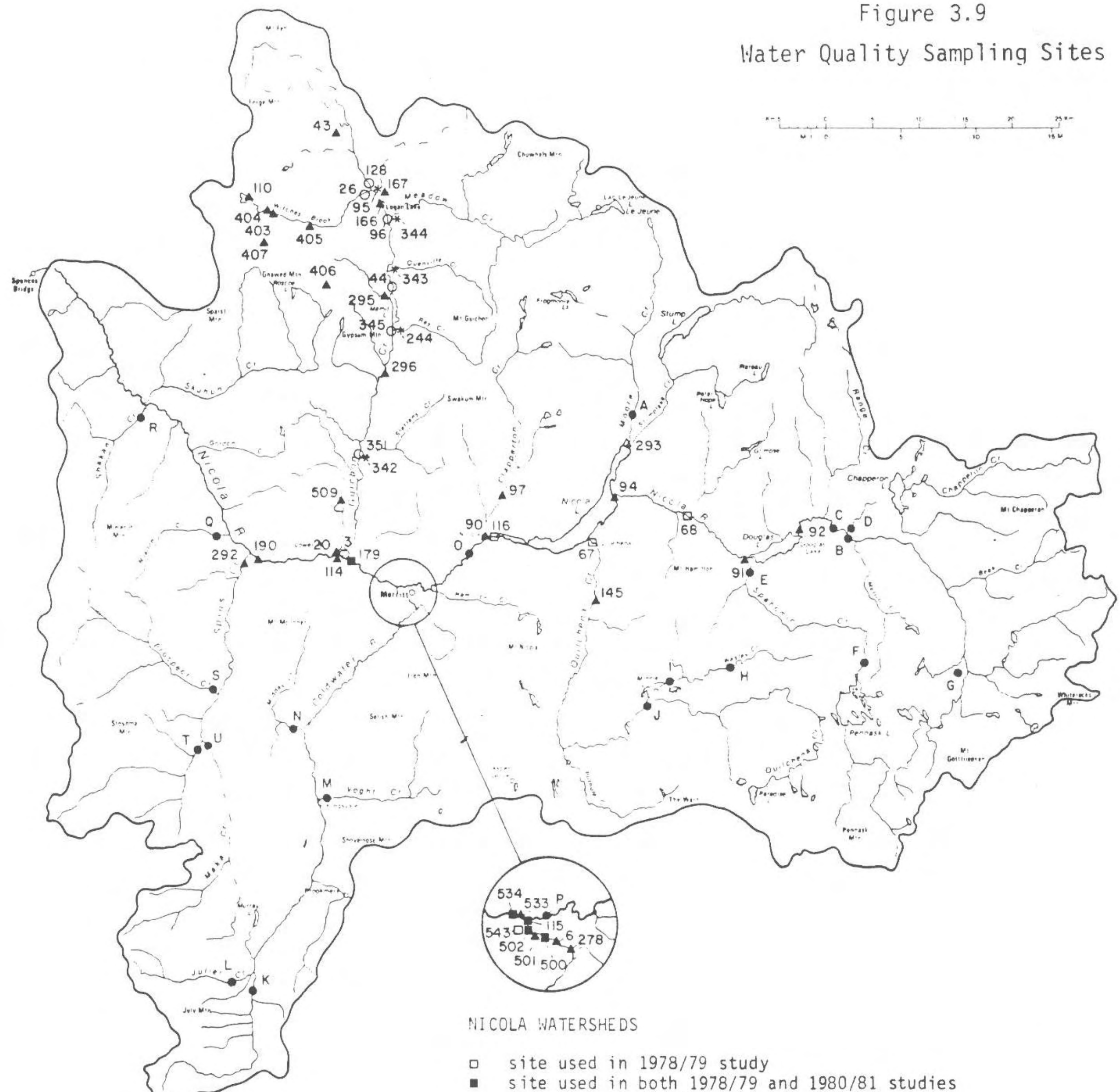
Suspended Sediments (Non Filterable Residue)

The Middle Nicola contains a large concentration of suspended sediments (8-25 mg/L) in the Nicola basin due to bank erosion, silt 'boils' and seepage from open irrigation ditches both in freshet and non-freshet. The Upper Nicola has low concentrations of suspended sediment except during the peak runoff period.

Coliforms

The level of both total and fecal coliforms is relatively high throughout the Nicola River compared with its tributaries. The STP effluent at

Figure 3.9
Water Quality Sampling Sites



NICOLA WATERSHEDS

- □ site used in 1978/79 study
- ■ site used in both 1978/79 and 1980/81 studies
- △ site used in 1980/81 study
- ▲ other sites (established after 1965)

GUICHON WATERSHED

- ○ major site used in Guichon study (1979/80)
- * additional site used in Guichon study (1979/80) (very little data gathered)
- ▲ other sites (established after 1965)

PROPOSED SITES

- ● sites proposed 1982

Merritt causes extremely high levels in the lower Coldwater (10,000-70,000 MPN in 1980/81). Levels continue to be high (200-300 MPN in 1980/81 in the middle Nicola below the Coldwater confluence (Tables 14 and 15, Appendix X).

MOORE CREEK

Nutrients

In both freshet and non-freshet periods, nutrient concentrations in Moore Creek are similar to the Nicola and Quilchena watersheds. However, because of lower flows, the nutrient loadings to Nicola Lake are considerably less, with the exception of ammonia nitrogen at low flows.

Coliforms

Limited data available indicate high levels of coliforms present, particularly during non-freshet (Table 21, Appendix X).

QUILCHENA CREEK

Nutrients

Quilchena Creek contributes significant nutrient loads to Nicola Lake largely due to intensive cattle operations in the valley. Loading rates for phosphorus are especially high relative to flows as the concentration for total phosphorus is 0.141 mg/L during freshet compared to less than 0.070 mg/ in the upper Nicola (Tables 1, 3, 18, Apendix X). Indeed, loading in freshet is almost as great as for the Upper Nicola, even though the Quilchena generally experiences lower flows. Nitrogen concentrations were a little higher than in the Nicola, but total loadings were lower.

Suspended Sediments (Non-Filterable Residue)

Quilchena Creek contributes a large suspended sediment load (40,000 kg/day) to the Nicola River (eight times the existing load) during the freshet period. However, this trend is reversed during the low-flow period when sediment loads are much lower than in the Nicola River (Tables 13, 20, Appendix X).

Although data are sparse, indications are that Quilchena Creek contains high levels of coliforms (100-500 MPN) (Table 21).

NICOLA LAKE

Nicola Lake is fed by the Upper Nicola, Moore-Stump and Quilchena Creeks. Consequently, nutrient loadings from these creeks affect the water quality of the lake itself, which supports an important sport fishery and water-contact recreation activities.

The limnology of the lake was studied in 1978 as part of the basin-wide analysis of water quality. A summary of the study conclusions follows:

1) Nicola Lake is tending towards a eutrophic state, with annual blooms of blue-green algae that detract from the aesthetic appearance of the lake for recreation.

2) The eutrophic state of Nicola Lake is probably a result of nutrient loadings from cattle operations in the tributary watersheds. The data supporting this premise are based on aerial surveys of cattle feeding areas and experience from other watersheds in the Province.

3) It is possible that the trophic state of Nicola Lake has not changed appreciably over the years. In 1960, Northcote _et al_. (1964), while studying fish movements commented ... "Heavy blooms of blue-green

algae result in relatively low Secchi disc readings (1.5-4m) throughout the summer."

In 1931, D.S. Rawson (1934) undertook a preliminary survey of Nicola Lake. Although chemical data were not obtained, plankton species and density were observed. He noted that: "On July 8, the blue-green algae, Anabaena, Coelosphaerium and Aphanizomenon were present as a dense bloom and extended down to a depth of two or three metres. On August 20 the blue-greens were again predominant and extended down to 10 metres."

In 1978 dense blooms of blue-green algae were noted and sampled. In addition Secchi disc readings (light penetration depth) in 1978 ranged from 1.25 - 4.3 m., very similar to Northcote's data.

Based on the data and observations of both Northcote and Rawson, the trophic condition in both 1931 and 1960 appears to have been very similar to the condition in 1978. The extent of the similarity cannot be defined due to a lack of chemical data.

4) Since agricultural nutrient impacts on the lake could be of a similar magnitude to previous decades, some other factor may be limiting growth beyond that experienced. This appears to be due to the lake's relatively high flushing rate, in which case, the present trophic state of the lake may not deteriorate unless the water residence time is increased.

COLDWATER RIVER

Nutrients

Even with the removal of some phosphorus from the Merritt STP, phosphorus concentrations below the discharge point are increased by 50-100 percent during freshet, from 0.016 mg/L above to 0.31 mg/L below in 1980/81

(Table 2, Appendix X). This compares with 1500-3000 percent before tertiary treatment was implemented. The tertiary treatment process (addition of alum to secondary treated sewage) has had no impact on N-concentrations in the lower Coldwater. In the low-flow periods, the discharge has a much greater impact on water quality, increasing total phosphorus concentration from 0.013 mg/L above to 0.360 mg/L below, dissolved phosphorus from 0.005 mg/L to 0.004 mg/L and total nitrogen concentrations from 0.13 mg/L to 2.43 mg/L (Table 6, Appendix X).

After upgrading the Merritt STP, an essentially N-limited system was reversed to a P-limited system. But, like the Nicola, there are sufficient concentrations of both nutrients below the STP to support algal growth.

Suspended Sediments

The Merritt STP increased concentrations of suspended sediments in the lower Coldwater. In both sampling years (1979/80 and 1980/81), the sediment load in the Coldwater was similar to that in the Nicola during non-freshet. The Coldwater has very high concentrations (e.g. 176 mg/ in 1978/79) during freshet, however (Tables 12, 13, 16, 17 in Appendix X). No monitoring has been undertaken in the Upper Coldwater to determine the impacts of logging on water quality.

Coliforms

During the freshet, both total and fecal coliform counts are quite high below the STP due to agricultural activity and the influence of the Merritt STP (see above discussion on Merritt STP).

GUICHON CREEK

Guichon Creek had 11 water quality monitoring stations throughout the mainstem of the Creek, so there is a relatively complete picture of water quality during the few years of monitoring.

Nutrients

During freshet, total phosphorus concentrations were high in the upper parts of the watershed above Witches Brook (100 mg/L), but decrease in the central part above Mamit Lake then increase downstream to the mouth (Table 22, Appendix X). Because of relatively low flows, however, total nutrient loadings to the Nicola are smaller than other streams. Nitrogen concentrations follow a similar pattern, with the highest concentrations at Mamit Lake and near the mouth. There is strong evidence that these high concentrations are the result of cattle overwintering on the stream banks, since after a thaw in February, 1980, very high loadings were recorded.

Suspended Sediments (Non-Filterable Residue)

Limited sampling during freshet prevented any detailed analysis. Suspended sediment concentrations are generally low during the low flow period, the exception being during the February thaw when extremely high loadings and concentration were found.

Coliforms

Only small numbers of total and fecal coliforms were found along Guichon Creek during freshet although higher levels were recorded at selected sites (Tables 37 and 38, Appendix X). Increase in total coliforms may be related to cattle as accumulated wastes are washed into streams.

While coliforms remain low throughout the year, mean total and fecal coliforms were higher during summer (non-freshet) than at other times, except for the anomalous freshet flow on February 28, 1980.

Metals

A limited number of samples for metals were analyzed in Guichon Creek. Thus, conclusions made in this section are preliminary due to sparse data.

Most metals (total and dissolved) were below detectable limits: arsenic, cadmium, mercury, nickel, vanadium and zinc.

Metals that were recorded above detectable limits occurred during high snowmelt and runoff and include: aluminum, chromium, copper, lead, manganese, molybdenum, zinc and iron (see Appendix VIX for detailed description of recorded levels. Table 3.11 (Water Quality Criteria and Metals Parameters Applied to Guichon Creek Sub-basin) compares Guichon Creek metals levels to existing national and provincial guidelines for water qualtiy.

WATER QUALITY OBJECTIVES

The ultimate goal of the Ministry of Environment is to maintain water quality of the Province's streams and lakes at or better than levels required to support the designated uses of these waters. The process of setting and maintaining water quality objectives requires good information on ambient conditions and the capability of surface water systems to assimilate wastes. However, as this is a new approach in the Ministry's Water Management Programme, it has not yet been fully developed. The Ministry's present objective continues to emphasize control of discharges from all point sources through a permitting system based largely on the impact of individual discharges upon the receiving environment to meet Provincial waste discharge objectives.

At this time, ambient water quality objectives for specific uses of the surface waters in the Province, such as irrigation, fisheries, recreation and aesthetic appearance have not been formulated. Water quality standards for drinking water have been established by the Ministry of Health. Because specific objectives are not available, water quality criteria cited in the literature from a number of countries have been used as a check-list. Clearly, any conclusion regarding the adequacy of water quality in the tributary watersheds to support various designated uses must be treated with caution until the Ministry has developed its own Provincial objectives, and until adequate stream-specific monitoring has been undertaken.

Table 3.10 summarizes water quality objectives for a range of parameters, most of which are heavy metals, for irrigation and livestock drinking uses of surface waters. The same quantified relationships are not available for uses such as fisheries and recreation with respect to parameters such as suspended solids and nutrients, which are more of a potential problem in the Nicola basin. In the case of fisheries, there is not a sufficient understanding of the direct and indirect effects of nutrients and sedimentation on fishery productivity. This must be considered on a site-specific basis. Furthermore, there are complex intra-relationships between such factors as substrate, light and temperature and nutrient concentrations and the impact on fishery resources.

Given these general difficulties, an attempt has been made to compare the current quality of water in the major watersheds of the Nicola with what criteria are available from the literature (Table 3.11). In the strategic plan itself, priority water uses for each tributary basin will be designated based on economic, ecological and social values. At this time, however, each watershed will be considered for all potential uses - drinking, fisheries and irrigation. A summary of the current levels of water quality in each watershed compared with interim ambient objectives is presented on Table 3.12.

Water Quality Objectives for Potential Water Uses

The main waste management measures required to improve or maintain ambient water quality in the various watersheds such that it is compatable with designated uses will be discussed in the next chapter.

TABLE 3.10

WATER QUALITY PARAMETERS AND CRITERIA USED TO SET INTERIM WATER QUALITY OBJECTIVES FOR THE NICOLA BASIN

Designation	Criteria	Parameters						
		pH Range	Non-filterable Residue	Total Coliforms	Fecal Coliforms	Ammonia Nitrogen	Nitrate + Nitrite Nitrogen	Total Phosphorus *
Agriculture	Max. permissible limit for irrigation	4.8-9.0[1] 4.5-9.0[2]			100/100 ml[1]			
	Max. for livestock drinking						20.0 mg/l[1]	
Fisheries	Limits for fisheries[3] with: - max. protection	no change from natural						
	- high protection	6.0-9.0	<25 mg/L (good fisheries)					
	- moderate protection	5.0-9.3	25-80 mg/L (good or moderate)					
	- little protection	4.5-10.0	80-400 mg/L (not good when present)					
	Range for productive fisheries	6.5-8.5				Un-ionized - <0.02 mg/l[7] (freshwater aquatic life)		
Drinking Water	Recommended objective	6.5-8.5[4,5]		no coliforms[2,6] per 100 mL	no coliforms[2] <10/100 ml[1,6] (95% of samp./ 30 days)	<0.01 mg/L[1,5,6]	<.001 mg/L[4]	
	Max. permissible limit	6.0-9.0[1]		<10/100 ml[2,6] (90% of samp./ 30 days) <100/100 ml[1,4]	<100/100 ml[2]	0.05 mg/L[4,5,6]	10.0[2]	<0.065 mg/L (Total Inorg. phosphate as P)[6] <0.100 mg/L (Total phosphate as P)
Recreation	Objective for direct contact recreation	6.5-8.3[4]		<100 median MPN[4]	<20 median MPN[4]			
	Max. limit for direct contact recreation	6-9[4]		500 MPN[4]	200 median MPN[4,5]		20.0 mg/l[1]	

[1] Guidelines and Criteria for Water Quality Management in Ontario, Ministry of the Environment, Toronto, Ontario. 1973.
[2] Dept. of National Health and Welfare, Canada. 1979.
[3] All data for pH and non-filterable residue for fisheries is taken from Inland Waters Branch Bulletin 67, 1972[4].
[4] Guidelines for Water Quality, Objectives and Standards Technical Bulletin No. 67, Inland Waters Branch, Dept. of the Environment, Ottawa, Canada. 1978.
[5] Recommended Water Quality Standards. Dept. of Health Services and Hospital Insurance. Province of B.C. Victoria, B.C. 1978.
[6] Canadian Drinking Water Standards and Objectives 1968. Dept. of Nat. Health and Welfare, Ottawa, Canada. 1969.
[7] Quality Criteria for Water. Rept. #US-EPA 440/g-76-023. U.S. Environmental Protection Agency, Washington, D.C.

NOTE: Criteria for nitrate nitrogen and nitrite nitrogen are not given as no data were available for the Nicola Basin for comparison. No criteria are given for specific conductance, carbon or other phosphorus and nitrogen parameters. Chemical industrial effluent criteria are the only criteria available for Kjeldahl nitrogen. Refinery effluent criteria are the only criteria available for total residue.

TABLE 3.11

WATER QUALITY CRITERIA APPLIED TO THE NICOLA BASIN

Designation	Criteria	Parameters						
		pH Range	Non-filterable Residue	Total Coliforms	Fecal Coliforms	Ammonia Nitrogen	Nitrate + Nitrite Nitrogen	Total Phosphorus
Fisheries	- Upper Nicola	acceptable for all uses	below most stringent limits	exceeds most stringent limits[2,6] but within other limits[1,4]	meets recreat-ion objective	slightly exceeds recreation objective	well below limits	well below limits except one date (sudden thaw)
	- Middle Nicola	acceptable but often has pH 8.4-9.0	below most stringent limits except one site (179) at freshet	exceeds drinking water limits at 534 and slightly at 179	exceeds drinking water and irrigation limits at 534 and slightly at 179	well within permissible limits except 1 date	well below limits	slightly exceeds .065 mg/l fre-quently in 1978/79 below .065 in 1980/81 except 1 site (115) at freshet
	- Lower Nicola	acceptable; occ. pH 8.4-9.0	well below most stringent limits (limited freshet data)	exceeds drinking water limits in freshet 1978/79 (no data 1980/81)	within limits	within limits	well below limits	well below limits
	- Guichon Cr.	acceptable; often pH 8.4-9.0	well below most stringent limits	freshet: usu-ally <100/100 non-freshet: exceeds 100/100 at most sites	freshet: within limits non-freshet: exceeds 100/100 at 3 of 7 sites	no data	well below limits	variable; above 0.065 mg/l at 3 sites but above 0.100 mg/l at only 1 site

[1] Guidelines and Criteria for Water Quality Management in Ontario, Ministry of the Environment, Toronto, Ontario. 1973.
[2] Dept. of National Health and Welfare, Canada. 1979.
Guidelines for Water Quality, Objectives and Standards Technical Bulletin No. 67, Inland Waters Branch, Dept. of the Environment, Ottawa, Canada. 1972.
[6] Canadian Drinking Water Standards and Objectives 1968. Dept. of Nat. Health and Welfare, Ottawa, Canada. 1969.

NOTE: Criteria for nitrate nitrogen and nitrite nitrogen are not given as no data was available for the Nicola Basin for comparison. No criteria are given for specific conductance, carbon or other phosphorus and nitrogen parameters. Chemical industrial effluent criteria are the only standards available for Kjeldahl nitrogen. Refinery effluent criteria are only available for total residue.

Designation	Criteria	Parameters						
		pH Range	Non-filterable Residue	Total Coliforms	Fecal Coliforms	Ammonia Nitrogen	Nitrate + Nitrite Nitrogen	Total Phosphorus
Tributaries	Irrigation Use Only - Quilchena	acceptable for all uses	low flow: <25 mg/L freshet: 99 mg/L	limits exceeded for irrigation & drinking H_2O at mouth of basin	low flow: acceptable freshet: slightly exceeds limit	well within permissible limits for drinking and irrigation	well below limits	non-freshet: acceptable freshet: above limit (.141 mg/L)
	- Moore-Stump	acceptable for all uses	well below most stringent limits except on 1 date which has 30 mg/L	exceeds all limits in samples at basin mouth	exceeds all limits in samples at basin mouth	exceeds objective but within permissible limits	well below limits	within limits
	- Clapperton	acceptable for all uses	within most stringent limits	well below limits	well below limits	well below limits	well below limits	well below limits
	- Coldwater	acceptable for all uses	low flow: <25 mg/L freshet: 150-200 mg/L	within limits except below STP (site 502), where limits are greatly exceeded	within limits except below STP (site 502), where limits are greatly exceeded	meets recreation objective above STP, exceeds permissible limits below STP	well below limits	freshet: within limits low flow: exceeds limits in 1978/79 but not 1980/81
	- Spius	NO DATA ON SPIUS CREEK						

NOTE: Criteria for nitrate nitrogen and nitrite nitrogen are not given as no data was available for the Nicola Basin for comparison. No criteria are given for specific conductance, carbon or other phosphorus and nitrogen parameters. Chemical industrial effluent criteria are the only standards available for Kjeldahl nitrogen. Refinery effluent criteria are only available for total residue.

[1] Criteria for fisheries use for these parameters are not available. Objectives are considered for irrigation and drinking water use only.

Designation	Criteria	Parameters (mg/L)													
Guichon Creek		Aluminum	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Molybdenum	Nickel	Vanadium	Zinc	Total Diss. Solids
Agriculture	Recommended objective for irrigation	1.0[3]	<1.0[3]	0.005[3]	0.10[1]	<2.0[3]	5.0[3]	5.0[3]	0.20[3]		0.005[1]	0.20[3]	0.10[1]	2	
	Max. permissible limit for irrigation a) acidic soils/ continuous use on all soils	<5.0[1]	0.10[1], 10.0[3]	0.010[1]	0.1[1]	0.20[1]	5.0[1]	5.0[1]	0.20[1]		0.010[1]	0.20[1]	0.10[1]	2.0[1]	500[3]
	b) fine textured alkaline soils	20.0[1]	2.0[1]	0.050[1]	1.0[1]	5.0[1]	20.0[1]	10.0[1]	10.0[1]		0.010[1]	2.0[1]	1.0[1]	10.0[1]	500[3]
	Max. for livestock drinking	5[1]	0.2[1]	0.010[3], 0.05[1]	0.05[3]	0.5[1]		0.05[3]		.003[4]	0.01[5]		0.1[1]	25[1]	2500[3]
Fisheries	Guidelines for protection of freshwater aquatic biota	.100[6] (tentative)	0.05[4]	0.0002[4] (toxicity varies with species exposure time)	0.04[4], 0.05[6]	0.005[7]	0.300[7] 1.0[8]	0.03[1]		0.0001[4]		0.025[7]		0.030[7] (acutely toxic to fish, dep. on hardness temp. O_2 etc.)	
Drinking Water	Recommended objective		not detectable[3] 0.005[2]	0.001[2]	0.0002[2]	<1.0[2]	<0.05[2]	0.001[2]	<0.01[2]	0.0002[2]				<5.0[2]	
	Max. permissible limit		0.050[2]	0.005[2]	0.05[2]	1.0[2]	0.3[2]	0.05[2]	0.05[2]	0.001[2]				5.0[2]	

1 Environmental Studies Board, 1973, EPA, R 3. 73.003 (U.S.).
2 Dept. of National Health and Welfare, Canada, 1979.
3 Ministry of the Environment, Ontario, 1974.
4 Environment Canada, 1974.
5 Hart, 1974, Aust. Water Res. Council, Tech. Paper 7.
6 International Joint Commission, 1977.
7 Great Lakes Water Quality Board, 1976.
8 Environmental Protection Agency, 1976. EPA, R 440/9.76.023. (U.S.).

NOTE: Limits are less than or equal to values given unless indicated as being less than the value (e.g. <20).

Designation	Criteria	Parameters (mg/L)													
Guichon Creek		Aluminum	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Molybdenum	Nickel	Vanadium	Zinc	Total Diss. Solids
Recreation	Objective for direct contact recreation														
	Max. limit for direct contact recreation		0.05[4]	0.01[4]	0.1[4]					0.001[4]					
Guichon Creek		exceeds fish-eries limits on Witches Br. and down-stream (very limited data)	well below limits when detec-table	not de-tectable	not de-tectable except 1 date (very limited data)	often exceeds fish-eries limit, well within other limits	often exceeds fish-eries, drinking H_2O limits very high on 1 date of thaw (Feb., 1980)	well within limits; occ. ex-ceeds rec. obj for drinking water	often exceeds dr. water limits; not usually above 0.2 mg/l	not detec-table	exceeds limits on Witches Br. and occ. at site directly below on Guichon Cr.	not detec-table	well below limits when detec-table	well below limits when detec-table	

[4] Environment Canada, 1974.

NOTE: Limits are less than or equal to values given unless indicated as being less than the value (e.g. <20).

TABLE 3.12

AMBIENT WATER QUALITY IN NICOLA WATERSHEDS FOR DESIGNATED USES

WATERSHED	PROPOSED USE DESIGNATION(S)	CURRENT WATER QUALITY
Upper Nicola	Fisheries and Irrigation	meets all criteria except coliform levels for drinking water
Mainstem Nicola	Fisheries and Irrigation	does not meet suspended sediment criteria for fisheries (Middle Nicola) does not meet temperature criteria for fisheries (Middle Nicola) does not meet fecal coliform for livestock or human drinking water
Quilchena	Irrigation	meets all criteria except coliform levels
Moore-Stump	Irrigation	meets all criteria except coliform levels
Clapperton	Irrigation	meets all criteria
Coldwater	Fisheries	meets all criteria except coliforms: some toxicity problems below STP
Spius	Fisheries	no ambient water quality data
Guichon	Irrigation and Fisheries	exceeds fishery use criteria for aluminum, copper, molybdenum and iron exceeds drinking water use for coliforms, manganese and iron

AIR QUALITY

The focus of the Ministry's air management programme is to minimize harmful effects of air quality on plants and animals and 2) to ensure that good quality air is compatible with public health and well being. Management of the airshed requires that discharge permits are met and that ambient air quality is maintained. Air quality management is generally restricted to either settlement areas or industrial zones. In the Nicola basin, wood teepee burners and particulate matter have resulted in very minor changes to the air environment in the Merritt area. There is a potential concern, that air emissions from the proposed Hat Creek Thermal Generating Plant may affect air quality in the basin under certain weather conditions.

The scope of the air quality input for the plan is to present information on air emissions in the basin and note trends or changes in measured parameters, to identify those emission parameters that are close to or exceed emission permits, and to recommend priority areas for management. Recommendations will include regulation via emission permits and if appropriate the setting of air quality objectives.

PRESENT WASTE LOADINGS TO THE ATMOSPHERE

Air Permits within the Nicola basin are as follows:

Pa-	Name	Main Operation	Disch. Char.
2412	Ardew Wood Products Ltd.	wood waste burner	wood particulate
2410	Aspen Planners Ltd.	wood waste burner	wood particulate
1945	Balco Industries Ltd.	wood waste burner	wood particulate
2446	Bethlehem Copper Corp. Ltd.	copper concentrator	particulate & SO_2
2494	Craigmont Mines Ltd.	copper concentrator	particulate

Pa-	Name	Main Operation	Disch. Char.
5924	Dekalb Mining Corp.	copper concentrator	particulate
5667	Highmont Mining Corp.	copper/molybdenum concentrator	particulate
1557	Lornex Mining Corp.	copper/molybdenum concentrator	particulate
3240	Westcoast Transmission Co. Ltd.	natural gas compressor station	products of combustion of natural gas
2414	Weyerhauser Canada Ltd.	wood waste burner	wood particulate

AIR EMISSIONS MONITORING

Air emissions monitoring in the Nicola Valley consists of monitoring one sample site (no. 0605040) at the Merritt Town Hall from 1971 to the present.

Means for the parameters measured at the Merritt sampling site are presented in Appendix X for the years 1974-1981. Monthly means for a) Particulate: Total Dust. Tot, b) Particulate: Total S. Part TL, and c) sulfation index are given in graphic form as well (Figure 3.10). The trends indicated in the data for the years of record are summarized in Table 3.13. From this table, it appears that values for most parameters have remained constant from 1974-1981. Part: sol dust. sol is the only parameter showing a sizable increase, with values ranging from .155 to .258 $mg/dm^2/d$ in 1975 to 1978 increasing to .431 to .770 in 1979 to 1981. Sodium S. Part TL and Part: total S. Part TL decreased slightly to 1981.

SUMMARY

There are no significant trends apparent in the data to indicate deteriorating air conditions at the Merritt station. It is recommended that the monitoring station be maintained at Merritt to provide background data as a check should the Hat Creek Thermal Plant be developed.

TABLE 3.13

TRENDS IN AIR EMISSIONS DATA

(from Merritt Town Hall: station #0605040)

PARAMETER*	RANGE OF VALUES max(yr)/min(yr)		TRENDS (FROM MEANS FOR 1974-1981)
Part: tot. Dust. tot	4.33 (76)	2.36 (75)	- fairly constant (no signif. trend)
Part: tot S. Part. TL (ug/m^3)	103.63 (74)	61.19 (81)	- slight decrease from 1974-81
(mg)	280.25 (76)	142.0 (81)	- no signif. trend (constant)
Part: sol Dust: sol	.770 (79)	.155 (76)	- values .155 to .258 1975-78 (increase) .431 to .770 1979-81
Part: ins Dust: insl	4.19 (76)	1.75 (81)	- constant
Sol. ash Dust. sol	.807 (76)	.107 (74)	- variable, poss. slight increase
Insl ash Dust. insl	2.99 (76)	1.37 (81)	- constant (very slight decrease)
Part: com Part: tot	1.01 (79)	.704 (78)	- constant (records only 1978-81)
Sulfate S. Part. TL	2.87 (78)	1.79 (80)	- constant (records only 1978-81)
Sulfate Dust. sol	.111 (79)	.044 (78)	- very slight increase (records only 1978-81)
Arsenic S. Part TL	one value only		- .05 (77)
Sodium S. Part TL	.78 (77)	.5 (81)	- slight decrease (records only 1977-81)
Sodium Dust. sol	.035 (79)	.003 (77)	- constant (records only 1977-81)
Chloride S. Part. TL	.61 (79)	.5 (77)	- constant (records only 1977-81)
Chloride Dust. sol	.006 (77)	.064 (79)	- constant (records only 1977-81)
Sul. Inde	.107 (75)	.02 (81)	- decreasing (records 1975-81)

* Records for 1977 only for S. Part TL for arsenic, copper, zinc, cadmium, and mercury so these parameters were not included in the above table.

WILDLIFE MANAGEMENT

Wildlife management has benefitted from the most advanced approach to resource planning within the Ministry. A draft wildlife management plan has been prepared for the Thompson-Nicola Region. Because the habitat base is not directly controlled by the Ministry under existing legislation, the Ministry has had to negotiate land use allocations with the Ministries of Forests and Lands, Parks and Housing. Thus, wildlife management must be undertaken in the context of land use plans developed by these agencies. This makes it all the more important to develop specific wildlife management targets with which to negotiate the required land base with the controlling Provincial Ministries.

The Nicola basin is considered provincially significant in terms of the abundance and diversity of wildlife species that exist in the predominantly dry land habitats of the basin. At present, approximately 297 species of wildlife find suitable habitat (see Appendix XI). Of these the burrowing owl is on the Provincial endangered species list, while the yellow badger is on the threatened species list. The feringinous hawk, a bird from the Prairie badlands is also known to have nested in the area.

Much of the original habitats of these species have been affected by agricultural, urban and industrial developments. While the greatest loss has been to the non-game species, to some extent the Ministry has been able to protect and enhance some habitats for game species such as mule deer, moose and grouse via logging and grazing plans developed by the Ministry of Forests. Although habitats have been dramatically altered in the Nicola, there remains opportunities to protect the rich diversity of species through an understanding of the various wildlife communities, how they change over time, and how they respond to land use activities. Unfortunately, there is very little information on wildife community dynamics both within the Nicola, and within the Province. The systematic organization of existing information associated with the development of this strategic plan, however, should help identify the priority, aspects of wildlife management that deserve attention in the short run.

WILDLIFE PROGRAMME GOALS AND STRATEGIC PLANNING OBJECTIVES

The Ministry's Wildlife Programme Goals provide an overall framework within which strategic plans can be prepared. These goals are:

To maintain the diversity and viability of species representative of the major biophysical zones of land capability and biological limits of each species, and

To insure that wildlife is available in sufficient abundance to meet the social, recreational, ecological and economic needs of society.

The information required to achieve these goals is associated with the Programme's strategic planning objectives.

Planning Objectives for Wildlife Management

SUPPLY

1. Determine present and potential distribution, and abundance of priority wildlife species and their habitat.

2. Determine habitat requirements (vegetative requirements, ecological condition, seasonal extent) to support present and potential wildlife populations.

DEMAND

3. Determine current demand for sport, and other wildlife uses over the planning period including the rare and endangered, and threatened species.

4. Determine projected demands on wildlife habitat due to land uses (habitat quality, extent and other ecological factors).

MANAGEMENT OPPORTUNITIES

5. Determine the estimated costs of undertaking wildlife management measures to meet anticipated demands and needs.

6. Establish management objectives (targets) for each major wildlife species consistent with Regional and Provincial wildlife management policies.

CURRENT AND POTENTIAL PRODUCTION OF GAME AND NON-GAME SPECIES

The Nicola basin contains a high proportion of the Thompson-Nicola Region's grassland and dry-belt forest which supports a rich variety of game and non-game species. This population diversity includes mule deer, moose, elk, grouse and waterfowl, as well as dryland non-game species such as the pileated woodpecker, pygmy nuthatches and the now rare and endangered burrowing owl.

In the context of the region as a whole, the overall wildlife capability in the Nicola is low to moderate with relatively few opportunities for improvement. Few species have any particular regional importance with the possible exception of ducks and Canada geese. The benefits derived through the use of the resource are felt to be generally lower in the Nicola than elsewhere in the region for both consumptive and non-consumptive uses, especially in terms of level and quality of hunting activity.

NON-GAME SPECIES

There is very little information on the populations of non-game species in the Nicola basin. Most of the Ministy's management focus in on game species and because the Nicola is a low priority in this regard, the

Ministry has expanded most of its resources in other parts of the Region. However, a wildlife habitat analysis is being undertaken at present in the Dewdrop and north of Kamloops Lake and this will provide more information on the interrelationships between wildlife and their habitat requirements in grassland ecosystems. Some of this research might be extrapolated to the Nicola basin.

GAME SPECIES

Mule Deer

The key ranges for mule deer in the Nicola basin are concentrated in two biogeoclimatic zones: (1) the Ponderosa Pine - blue bunch wheatgrass zone, and (2) the interior Douglas Fir zone (See Figure 2.2). These zones cover approximately 45 percent of the basin (3,200 km^2), mainly along the river valleys and lower slopes of the plateau. Much of this area is no longer able to support mule deer because of the change of vegetative cover due to agriculture, grazing and forestry activities (see Land Status Map). The critical period for the mule deer populations is the wintertime, when the animals require both food and shelter to protect them from cold and predation. A number of critical over-wintering habitats have been identified (Figure 3.10) and these must be protected in order to sustain current populations in the colder winters. Generally, these can contain a mixture of old growth forests for shelter and open grasslands and shrub communities for food supply.

Currently mule deer populations in the Nicola basin number around 3000 or approximately 10% of the regional population (Table 3.14). The population peaked in the mid-1950's when it was estimated to be over 5,000 due to a succession of mild winters. Colder winters in both the late 50's and mid 1960's have reduced populations significantly, but they have recently increased to present levels. The continued removal of habitats due to forestry and grazing reduces the capacity of remaining populations to survive cold winters. Without the continued interaction between the

Figure 3.10
Critical Habitats for Mule Deer

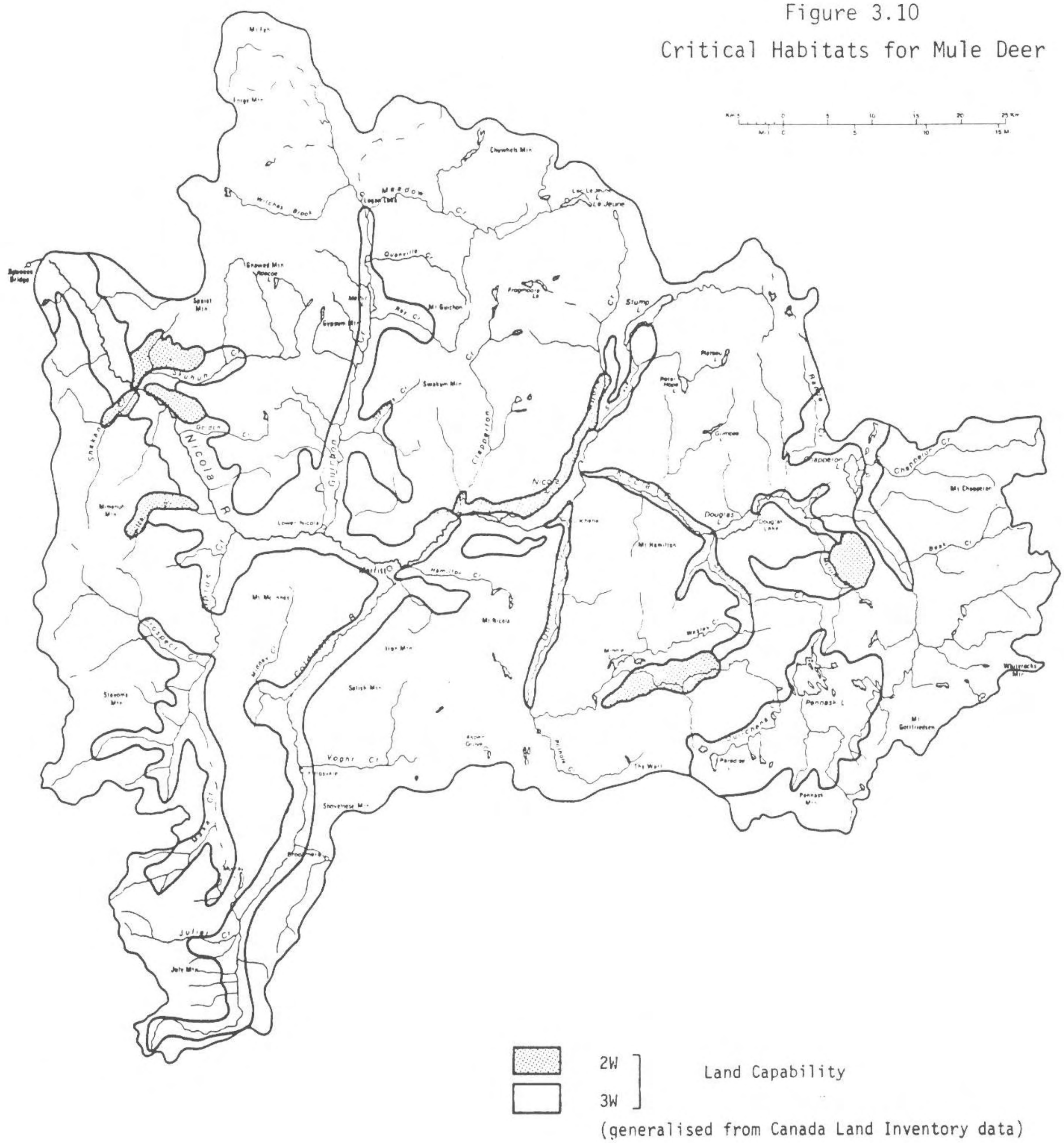


TABLE 3.14

CURRENT AND POTENTIAL MULE DEER POPULATIONS IN THE NICOLA BASIN

Management Unit	Current	Potential
3-12	200	250
3-13	580	1160
3-18	830	2050
3-19	1040	1500
3-20	310	390
Total	2960	5300

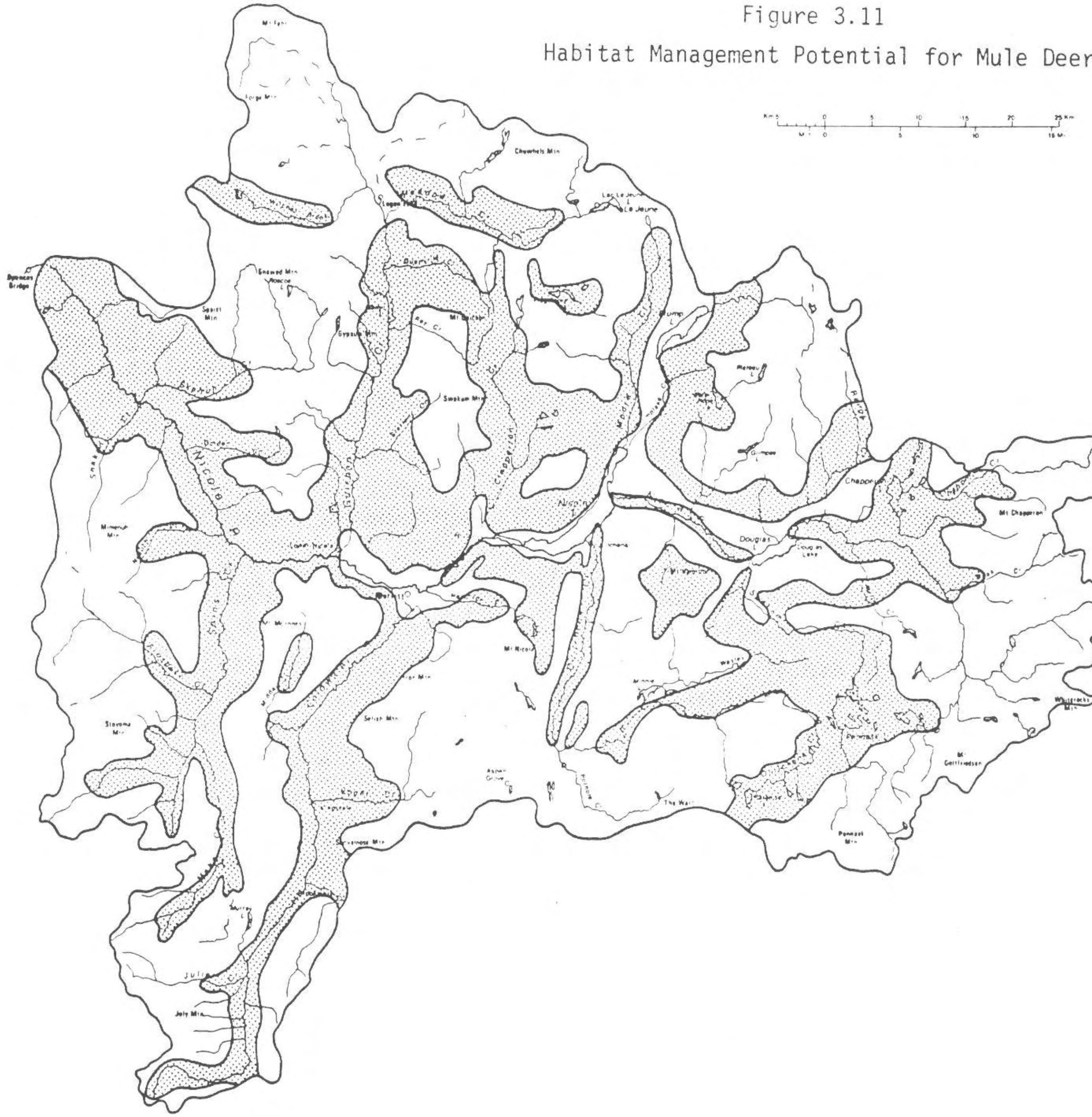
Source: Fish and Wildlife Branch, Kamloops Office.

Ministries of Environment and Forests in logging and grazing plans, it is possible that current populations could be cut in half, if key shelter and shrub communities were removed.

Deer population vary between 15-40% above and below the average depending upon the quantity and quality of forage available each winter. Legal hunting removes about 15-20%, while about 15% die from malnutrition or natural predation. Illegal hunting has had the greatest impact on deer production. It is estimated that about 20% of the population is affected by out of season harvests.

There remains a considerable opportunity to increase mule deer populations in the Nicola through manipulation of vegetative cover in the Class 2 and 3 habitats (see Figure 3.11). The most suitable habitats for enhancement are located in selected grassland and forest environments where a suitable mix of both grassland and tree cover is available. Management measures include selective burning to increase productivity and the development of biological control techniques to reduce the need to clear cut forests as the result of insect infestations. It is estimated that given reasonsble

Figure 3.11
Habitat Management Potential for Mule Deer



management opportunities (i.e. habitat enhancement from selective logging) the current muledeer populations could be increased by about 2300 animals.

This figure does not represent the full potential deer population, which could be much higher given the inherent biophysical capability of the land in the Nicola. It represents a reasonable compromise in the part of the Ministry to estimate a population that could be supported given the continued pressures for land clearing, fire controls, logging and grazing. However, site-specific land use management plans will have to be prepared with other Provincial agencies to ensure that this potential can be protected in the future.

PRESENT AND FUTURE DEMAND FOR MULE DEER

CURRENT HUNTING ACTIVITY

Table 3.15 summarizes hunting activity in the Nicola for the years 1976 to 1980 in terms of number of hunters, hunter-days and harvest of deer. Comparable data are shown for the Thompson-Nicola region to provide a picture of the Nicola basin in a regional perspective.

In 1980, approximately 2400 hunters spent an average of seven days hunting deer in the Nicola for a total of 16,800 hunter days of activity. The amount of effort has increased between 1976 and 1980 by about 40%, due to an overall increase in the number of hunters in the area. The average number of days that each hunter spends hunting has changed very little from year to year. The number of active hunters in any particular year depends a great deal on the severity of winter weather and snowfall during the hunting season and the concentration of deer on their winter ranges.

Deer harvests totalled 473 animals in 1980. There has been a steady increase in harvest over the 1976-1980 time period despite the fluctuations in number of hunter-days.

TABLE 3.15

MULE DEER HUNTING IN THE NICOLA BASIN (1976-1980)

	1976	1977	1978	1979	1980
Hunters					
Nicola Planning Unit	1682	1384	1945	2281	2416
Thompson-Nicola Region	15,289	10,809	14,196	15,414	16,775
Hunter-Days					
Nicola Planning Unit	11,083	8428	12,467	16,018	16,803
Thompson-Nicola Region	100,607	65,601	91,053	107,993	116,910
% in Nicola	11.0%	12.8%	13.7%	14.8%	14.4%
Hunter-Days Per Hunter					
Nicola Planning Unit and Nicola Region	6.6	6.1	6.4	7.0	7.0
Harvest					
Nicola Planning Unit	170	220	313	458	473
Thompson-Nicola Region	2486	2471	3537	3798	5146
% in Nicola	7%	9%	9%	12%	9%
Success Rate-(Days/Deer)					
Nicola Planning Unit	65.2	38.3	39.8	35.0	35.5
Thompson-Nicola Region	40.5	26.5	25.7	28.4	22.7

Source: Fish and Wildlife Branch, Kamloops Office.

In 1980, the average success rate in the Nicola for deer hunting was 35.5 hunter-days per deer killed, but this statistic varies considerably from year to year depending on the severity of winters and population survival. The average rate is somewhat lower than the average for the Thompson-Nicola Region as a whole. It is considered to be around the threshold below which hunters will move elsewhere, or simply forego the opportunity to hunt.

Success rates should be considered as only one indicator of the quality of deer hunting to the average hunter. The value cannot be totally expressed by the simple measure of number of animals killed since other factors relating to the hunting experience such as the aesthetics of the surroundings also have value to the hunter. Nevertheless, the chance of harvesting a deer seems to be quite a significant motivation for participation in hunting so the harvest success rate can be considered a fairly good measure of overall quality of the hunt.

Hunting Regulations

Hunting activity and the quality of the hunt is directly related to regulations which control the length, timing, and location of the hunting season. In the Nicola, bucks can be hunted at any time from September 22 to December 13 with a bag limit of one deer (either mule or whitetail). Although this is a long season, serious hunting is concentrated at the end of October and into November. The season for antlerless deer, on the other hand, is only two weeks, from November 7 to November 22 for most parts of the basin and is closed altogether in management unit 3-13 which covers the Coldwater and Spius watersheds. Clearly, this length of season would limit the total harvest of deer. The timing of the season is set according to deer migration and behaviour and can be used to tailor the quality of the hunt for the hunter as well as a control on population levels.

The harvest rate of deer through recreational hunting in the Nicola is currently around 17% of the total population. This rate is sustainable in the long run. The regulations are currently structured such that hunting activity and the resultant harvest does not have any adverse effect on deer populations but provides the hunter with the maximum opportunity in view of the fluctuations in populations.

FACTORS INFLUENCING FUTURE ACTIVITY

A number of factors will influence the future level of participation in deer hunting in the Nicola.

a) Deer Populations - The results of various hunter preference surveys have indicated that it is important for hunters to feel they have a good chance of bagging game. The level and distribution of deer populations will determine what the chance is of being successful in killing an animal. Factors influencing deer populations were discussed in the previous section.

b) Improved Access to the Area - The completion of the Coquihalla Highway will greatly improve accessibility of the region's wildlife resource to Lower Mainland residents. The extent to which this may increase hunting effort will depend on transportation costs and opportunities in other parts of the Thompson-Nicola region. It does appear that an increase in the harvest potential through animal population management would be snapped up by both region and out of region residents.

c) Hunting Regulations in Other Regions - Hunting regulations which limit the opportunity for hunting or adversely affect the quality of the hunt in an area, could result in hunters shifting their activity to other regions. Since there are currently no limited entry hunts in the Nicola area, or the whole Thompson-Nicola region, and there is a long hunting season, the area could potentially receive hunters who are excluded from hunting in other regions for one reason or another.

FUTURE DEER HUNTING IN THE NICOLA PLANNING UNIT

Projections of deer hunter-days in the Thompson-Nicola region were made based on estimated population growth, past hunting activity and consideration of the effects the above factors may have on hunting effort in the region. The methodology and calculations for these projections are outlined in the demand section of the regional wildlife plan for the Thompson-Nicola.

Based on the proportion of regional hunting effort which the Nicola currently supports, deer hunting activity in the basin could increase by about 51% to a total of 20,800 hunter-days by 1991, about 13.3% of total Regional effort. Obviously, projections become more uncertain the farther they are in the future, but if demand continues to grow at the same rate beyond 1991, there could be 26,100 hunter-days in the Nicola by the year 2001, providing the quality of deer hunting in the area is maintained in the future.

Demand for Non-Consumptive Use Wildlife

Very little information is available on the non-consumptive use of wildlife which includes such activities as the visual sighting and photography of deer by the general public, on a trip taken solely for that purpose, or during more generalized recreational activities. Despite the lack of data on actual amount of time spent in such activities, the values associated with this form of recreation are recognized as being substantial.

A survey of non-consumptive wildlife use was undertaken in 1974 to provide information on several aspects of non-consumptive use in the Kamloops region (Selbee, 1974). The results indicated that at least six out of every ten people in Kamloops had some interest in non-consumptive wildlife use, be it viewing, photographing or painting, or through the presence of wildlife providing greater enjoyment on trips whose main purpose was some other recreational activity. Deer was selected as the species most enjoyed by non-consumptive users.

It appears there is increasing emphasis being placed on the value of wildlife to the non-hunting community. As this aspect of recreation is growing, with an associated increase in values, there is a need to identify trends related to non-consumptive wildlife use in order to determine what level of wildlife management is justified to meet such demands. It seems likely that the potential benefits from non-consumptive use would serve to justify some expansion of resource management efforts.

Given a potential to increase animal populations by approximately 50 percent through habitat management, there does appear to be a limit on the total hunting effort that could be sustained at the current success rates. The options for the future will thus depend upon a combination of habitat management and hunting regulation. This mix will be discussed in the next Chapter.

WATERFOWL

The wetland habitats in the Nicola support a variety of staging and nesting areas for approximately thirty species of ducks (Table 3.16). Although the populations appear to be abundant, various land use practices are affecting the productivity of waterfowl habitats. This section outlines existing information on populations, hunting demands and management issues.

POPULATION

Approximately 30 000 birds are found in the Nicola basin, the most abundant species being mallard, Lesser Scaup, Barrow's golden-Eye, Bufflehead and Ringneck duck (Table 3.16). Little quantitative information is available on the trends in populations of these waterfowl species, but it is assumed that some will be decreasing while others (such as mallards) may be increasing.

In the past, the apparent abundance of small water bodies with waterfowl habitats did not warrant intensive management or protection. Agricultural practices have removed the riparian vegetation around some of these lakes making it necessary to protect wetlands from further encroachment. The main concerns are: 1) competing use of water between irrigation and waterfowl production areas, 2) drainage of small potholes and waterbodies for agricultural expansion, 3) destruction of nesting sites for cavity dwellers by logging and other land based activities, and 4) removal of nesting cover due to grazing.

Protection of waterfowl habitat is complicated. Firstly, waterfowl are migratory and thus under jurisdiction of the Federal Government (Environment Canada). Secondly, the Ministry of Environment does not have direct control of the land base and thus riparian habitats. Thirdly, most of the management funds are provided by Ducks Unlimited, a private organization which receives its money from hunters mainly in the United States.

TABLE 3.16

WATERFOWL SPECIES BREEDING IN THE NICOLA BASIN

Geese	Dabblers (Common)	Divers (Common)
Canada Goose	Mallard	Redhead
	Pintail	Ring-necked duck
	Green-winged teal	Lesser scaup
	Blue-winged teal	Barrow's Goldeneye
	Cinnamon teal	Bufflehead
	American widgeon	Ruddy duck
	Northern shovelor	
	Rare	**Common**
	Gadwall	White-winged scoter
	Wood duck	Hooded merganser
		Common merganser

Additional Transient Waterfowl in the Nicola basin.

Geese and Swans	Dabblers	Divers
Snow goose	Europian widgeon	Canvasback
White-fronted goose		Greater scaup
Whistling swan		Common goldeneye
		Oldsquaw
		Harlequin duck
		Surf scoter
		Red-breasted merganser

The important lakes supporting waterfowl production in the Nicola basin are listed in Table 3.17. These lakes in conjunction with the small, high quality wetlands scattered throughout the Nicola basin provide the habitat base for the majority of the waterfowl population.

DEMAND

There is a high recreational demand for waterfowl (both consumptive and non-consumptive) in the Nicola basin. Unlike most other wildlife species, waterfowl viewing is easily accessible and therefore activity enjoyed by Regional residents. There is no quantified information on this demand, but it is accepted by most managers in the Region that there is a high appreciation of the resource.

In contrast, the number of duck hunters has steadily decreased over the past few years (Table 3.18). This decline may be attributed to changing preferences or disatisfication with the availability of ducks. Table 3.18 shows this decline over the years 1976-80. It also indicates that most of the hunting activity is concentrated in the northern part of the basin in MU 19 and 20, because of its close proximity to Kamloops.

It is assumed that if waterfowl populations were to increase, there is a strong demand for duck hunting in the Nicola. Given the population trends in Kamloops and the completion of the Coquihalla Highway, the number of hunting days is forecast to increase to around 12,000 days to 1987 and by a similar amount by the mid 1990's. This 1987 demand would require a sustained annual harvest of around 7000-7500 birds.

In summary, the Nicola basin is considered regionally significant in terms of both waterbird production and associated recreational activity. There is not sufficient information on populations to understand trends, but it is apparent that hunting success is declining and there are continued loss to the remaining habitat base due to conflicting land use activities. However, the demand (both non-consumptive and consumptive) appears to be strong provided the resource itself is protected and managed. Some options for future management are discussed in the next Chapter.

TABLE 3.17

MAJOR WATERFOWL HABITATS IN NICOLA BASIN

Chapperon Lake
Nicola Lake and Guichon Flats
Mamit Lake
Douglas Lake
Minnie Lake, Stoney Lake and potholes
Index and Pikehead Lakes
Shumway, Napier and Trapp Lakes
Stump Lake

NOTE: Small but productive wetlands occur throughout the Nicola basin in addition to the lakes noted above.

TABLE 3.18

DUCK HUNTING IN THE NICOLA BASIN

Number of Hunters

MU	1976	1977	1978	1979	1980
3-12	236	155	201	166	133
3-13	175	89	150	73	47
3-18	195	177	205	195	134
3-19	459	241	340	326	297
3-20	506	308	306	307	247
	1571	970	1202	1067	858
% of Thompson-Okanagan Region	47%	40%	40%	45%	35%

Harvest

MU	1976	1977	1978	1979	1980
3-12	2074	1194	1136	571	588
3-13	1478	434	1177	306	92
3-18	1090	969	1321	582	499
3-19	3351	1546	2106	2106	1747
3-20	3805	2869	1957	2721	1548
	11,798	7012	7697	6286	4474
% of Thompson-Okanagan Region	46%	37%	40%	39%	32%

Harvest/Hunter

MU	1976	1977	1978	1979	1980
3-12	8.8	7.7	5.7	3.4	4.4
3-13	8.4	4.9	7.8	4.2	2.0
3-18	5.6	5.5	6.4	3.0	3.7
3-19	7.3	6.4	6.2	6.5	5.9
3-20	7.5	9.3	6.4	8.9	6.3
Thompson-Okanagan Region	7.5	7.2	6.4	5.9	5.2

CHAPTER 4 MANAGEMENT OPTIONS

In the preceding Chapter, the present use and possible future demands for a range of environmental resources in the Nicola basin were analyzed, together with the capability of environmental systems at their present level of management to meet these demands. A number of areas where demands exceed supplies were highlighted.

The purpose of this Chapter is to evaluate a wide array of possible management options that might be undertaken to balance supply with demands over the next 20 years. The approach taken in developing the options to be evaluated is to set out as specifically as possible the resource management objectives for each environmental resource sector, namely water supplies, water quality, fisheries, wildlife and air quality. Then, based on the analysis of supply and demand summarized in the preceding Chapter, it should be possible to see whether these objectives are being met now and in the future, and what management measures are required to permit their achievement over the next 20 years. Where possible, management measures will be evaluated using economic, social and environmental criteria. Where this information is not available and the measures appear worth evaluating in more detail, the studies necessary to obtain this information will be identified as part of the Ministry's management programme at the operational level.

Uncertainty regarding what will happen in the Nicola over the next 20 years and the effectiveness of various management measures is obviously a key issue in strategic plan development. The best way to handle this factor is to provide as much flexibility as possible on plan development. However, there are certain minimum levels of environmental quality below which the Ministry will not compromise. These will be identified in the plan as sign-posts which establish the framework for future resource management.

The management objectives and the measures required to achieve them will be analysed for each environmental programme. Inter-relationships between resource sectors (e.g. water and fisheries management) will be identified and analysed. This Chapter contains the technical analysis of management options. The plan itself will provide an integrated statement of Ministry management objectives and measures required and how to achieve them over the next 5 years. This management strategy thus becomes the Ministry's operational blueprint for the Nicola basin.

WATER MANAGEMENT

WATER AND RELATED RESOURCE MANAGEMENT OBJECTIVES

Environmental management objectives set out specific targets for resource management and are supported by performance criteria so that achievement can be monitored. They therefore differ from the strategic planning objectives discussed in the previous Chapter. These were procedural objectives designed to guide the overall planning process. The following water and related resource management objectives have been established for the Nicola basin to guide future resource management.

WATER MANAGEMENT OBJECTIVES[1]

1. To meet licensed water supplies for domestic and industrial uses from surface sources at all times.

2. To meet licensed water demands for irrigation from major sources at least four years out of five and ideally fourteen years out of fifteen.

[1] These objectives are not guarantees for licenced users. They are targets that the Ministry would like to achieve in its management of the bsins water resources.

3. To provide fishery resources maintenance flows to support targetted populations of anadromous and resident sport fish in designated streams under average flow conditions (1 to 2 years) in unregulated streams and 14 in 15 years in regulated streams.[3]

WATERSHED ANALYSIS

Because the objectives for water quantity, water quality and anadromous fisheries are so closely inter-connected, management options for these resources will be considered simultaneously. This analysis will be undertaken for each watershed. In the overall strategic plan, management objectives that are in conflict in or between tributaries may have to be traded off to develop an integrated management strategy for the basin as a whole. Details of supply and demand statistics (both consumptive and non-consumptive) by month of each watershed are listed in Tables in Appendix XI.

UPPER NICOLA

The Upper Nicola watershed is generally characterized by rolling grasslands in the lower elevations surrounded by high elevation plateaus (Figure 4.1). There are numerous small lakes scattered throughout the watershed, though it does contain three major lakes - Douglas, Chapperon and Pennask. The economy in the watershed is based mainly on ranching and forestry plus a small amount of recreational development. The Douglas Lake Indian Reserve is located between Douglas and Nicola Lakes. The watershed displays a typical hydrograph with a sharp, peaked runoff in May and June and low flows by September (Figure 4.2).

Current Resource Management Situation

1. Licenced irrigation demands for some 2500 hectares are met in all years through currently developed storages (10 497 dam^3) and licenced diversons (9650 dam^3).

2. Estimated maintenance flows to support anadromous and resident sport fisheries of 28 cfs (.792 m^3 s^{-1}) are met only in wet years in the late summer and early fall. Critical shortages occur below Douglas Lake and in the reaches of the Upper Nicola and Spahomin Creeks.

Future Resource Potential

1. The watershed has an annual surplus yield of between 24 000 dam^3 and 48 000 dam^3 in a 1:20 and 1 in 5 year droughts respectively. This could support instream and consumptive uses if storage sites are available.

2. The maximum extension of irrigated area in the watershed is approximately 11 000 hectares.

3. The production potential for anadromous fisheries assuming water flows and

3. The watershed supports small populations of juvenile chinook and steelhead, mainly in the reach below Douglas Lake.

4. Kokanee and rainbow trout that spawn and rear in the Upper Nicola provide an estimated 30,000 angler days to the Nicola Lake fishery. This reach is critical to the entire sport fishery.

5. Ambient water quality in the Upper Nicola meets objectives set for irrigation use and for fisheries with the possible exception of nutrient concentrations. Water quality enrichment has increased algal growth which may limit spawning potential and diversity of food.

quality criteria are met, is estimated at 1600 steelhead (before harvest). Increased production of coho and chinook would occur also, although this has not been quantitatively defined.

4. The production potential for resident sport fisheries could provide an additional 44,000 angling days in the Nicola Lake fishery, provided instream flows were met.

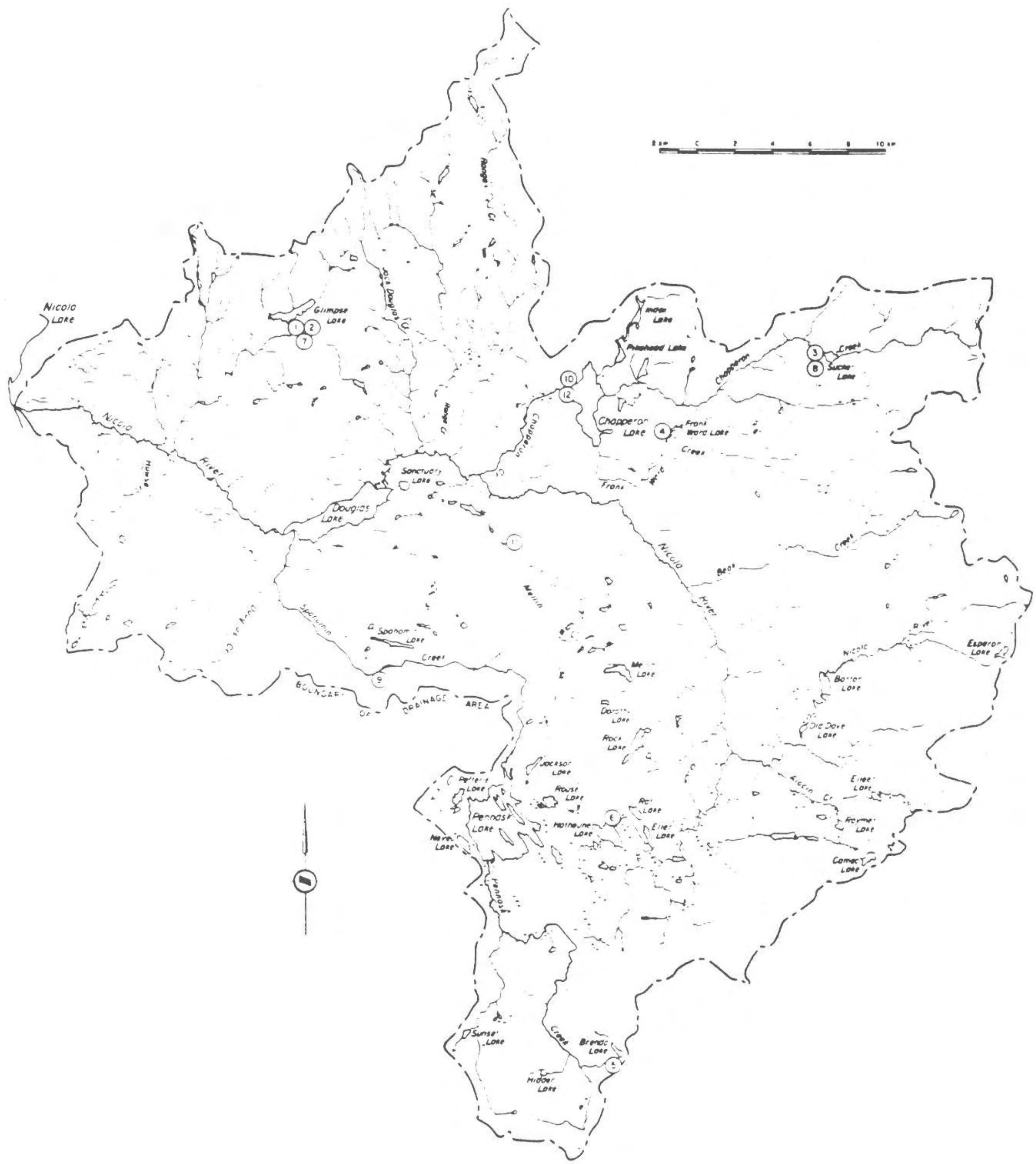


Figure 4.1
Upper Nicola Watershed

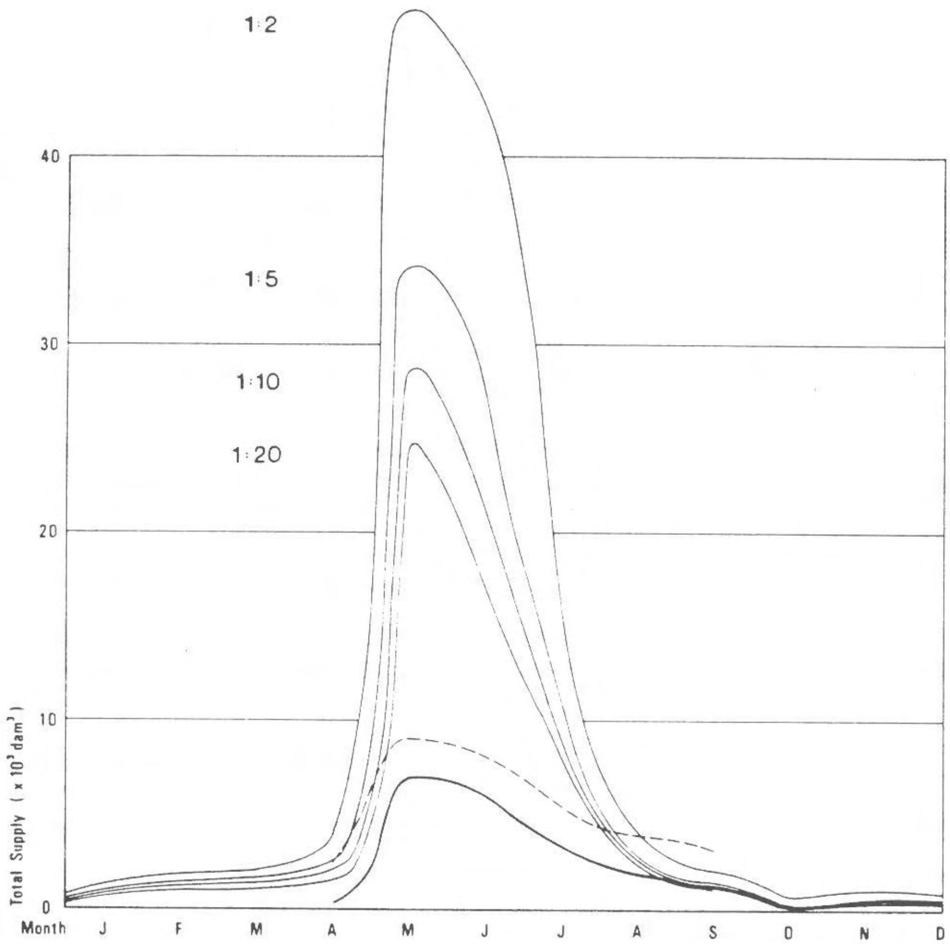


Figure 4.2

Hydrograph of Supply and Demand - Upper Nicola

——— Consumptive Use

------ Combined Fishery Maintenance Flows and Consumptive Use

Management Options

Resource management objectives are not fully achieved in the Upper Nicola watershed at present. Fishery maintenance flows are not provided for except in wet years and water quality enrichment threatens fish spawning and rearing potential. In the future, large expansion of irrigated acreage would require additional water supplies in the summer months. The management options for the watershed are outlined below.

1. Increased Storage

Douglas Lake would provide the only substantial increase in storage in the watershed. Chapperon Lake was not considered because the outlet is at a low gradient and would require considerable excavation to develop negative storage and a substantial number of acres of farmland would be flooded if the lake was raised.

Because of land use development around Douglas Lake, raising the lake would be limited to storage development of around 0.6 m or 4000 dam^3. This water could be used to provide instream flows of resident and anadromous fish or to support increased irrigation or some combination of both.

If all the water was allocated to agriculture, an additional 1000 hectares of land could be irrigated. The present value of increased hay production is estimated at $1.6 million net of land development costs, assuming a 10 year development phase and summed over 25 years at a 10 percent discount rate.

The water could also be allocated to support resident and anadromous fisheries. In the case of resident sport fisheries, there would be an estimated increase in sport fish harvest in Nicola Lake to support an additional 44,000 angling days annually. Assuming a value of $21.00 per angling day and the full development of this fishery over 5 years, the present worth of this fishery would be approximately $5.3 million. In addition there would be an increased steelhead production of 1200 adults worth $300,000 to the Fraser commerical fishery and the recreational fishery in the Thompson and an increase in chinook salmon production. The increase in salmon production has not yet been quantified in biological and economic terms.

A very preliminary estimate of a storage dam is around $300,000 and assuming an annual operation cost of $7,000 the present worth of this structure over a 25 year period would be $355,000. Consequently, the storage development would be economically beneficial with the water allocated either to agriculture or to fisheries. Assuming that there is a potential demand for 44,000 additional angling days per year in Nicola Lake, the value of each day could be as low as $6.50 to provide recreational fishery benefits of $1.6 million (present value) or the same as the net value of irrigation expansion.

Providing storage in Douglas Lake is clearly worth evaluating in detail at the operational level. Because the storage dam would be constructed on Indian lands, provision should be made to increase irrigation water supplies for agricultural development on the reserve. The precise allocation of storage between agriculture and fisheries would be assessed at the operational planning level, using a hydrologic model of the watershed.

Additional headwater storage would be required to support future expansion of irrigation upstream of Douglas Lake. Thus additional monitoring of stream flows and storage site reconnaissance should be included in the Ministry's future management programme in this watershed.

2. Efficient Use of Licenced Withdrawals.

Because additional storage is limited due to site and cost constraints, plus the high social and economic benefits associated with providing in-stream fishery maintenance flows, a second option for managing water supplies for irrigated agriculture is to make more efficient use of existing diversion flows. At present, a substantial acreage of land, mainly on the Upper Nicola Indian Reserve, is irrigated by open ditches. If some of the open ditch systems were converted to piped systems, less water would be lost through seepage and evaporation along the ditches to the fields. Consequently, less water would need to be withdrawn from the stream, thus making more water available for either instream uses or irrigating additional acreage.

To assess this option, the following information would be required:

i) the current land area irrigated by ditch;

ii) estimated savings by converting from ditch to pipe and sprinkler systems through monitoring both ditch and sprinkler systems in the watershed;

iii) estimated capital, operating and maintenance costs required to convert from ditch to sprinkler;

iv) increases in crop productivity resulting from the conversion of ditch to sprinkler irrigation.

If these analyses indicate that some ditch irrigation should be converted to closed irrigation systems, then the Ministry should explore institutional means for encouraging the conversion. This would involve financial incentives to support the capital financing and operation costs (mainly power supply) of sprinkler irrigation systems and improved monitoring of actual withdrawals to ensure more efficient allocation of water for competing uses.

3. Water Quality Improvement

The major sources of nutrients that are enriching the Upper Nicola appear to come from over-wintering of cattle along the river bank. At present, nutrient concentrations do not appear to be limiting fishery productivity. However, if fishery production is increased through the allocation of water to meet minimum flow requirements, then further monitoring should be undertaken on the stream to pin-point nutrient sources. The

Ministries of Environment and Agriculture and Food should combine forces to consider low cost means of retarding direct runoff from cattle feeding areas during thaws and spring runoff.

MIDDLE AND LOWER NICOLA

The Middle and Lower Nicola watershed includes Nicola Lake and the entire mainstem Nicola River down to its confluence with the Thompson at Spences Bridge. The Nicola River flows are mainly supplemented by the two major tributaries draining the wetter coast ranges - Coldwater River and Spius Creek. Because management options can affect the entire mainstem Nicola, it has been subdivided into three reaches:

1. Nicola Lake to confluence with Coldwater River (Figures 4.3 and 4.4).
2. Coldwater River to confluence with Spius Creek (Figures 4.3 and 4.5).
3. Spius Creek down-stream to confluence with Thompson River at Spences Bridge (Figures 4.6 and 4.7).

Present Situation

1. All current irrigation demands met. No full term licences issued since 1970.

2. Fishery maintenance flows:
   Thompson River - Spius 200 cfs (5.66 cms)
   Spius - Coldwater 110 cfs (3.12 cms)
   Coldwater - Nicola Lake 60 cfs (1.70 cms)

Resource Potentials

1. Over 3400 additional hectares of land could be irrigated along mainstem plus land on the lower benches of Guichon and Clapperton Creeks.

2. Surplus water yield of 175,800 dam^3 or 7 m (in average runoff year) of storage on Nicola Lake. Due to land constraints, maximum additional

Present Situation	Resource Potentials
Flows met in average years due to storage on Nicola Lake. without storage there would be severe droughts.	storage on Nicola is limited to approximately 2 m or 52,600 dam^3.
3. Current adult fish production Steelhead 4,900 Coho 1,300 Chinook 18,260 Pink 2,690+ Production limited in Reach 1 due to high water temperatures and heavy siltation.	3. Anadromous fishery potential Steelhead 12,000 Coho 2,850 Chinook 28.000 Pink 2,960+
4. Ambient water quality objectives for irrigation use are met. Problems with temperature and siltation for fisheries.	4. Nutrient loadings from Merritt STP will increase as population grows.
5. Nicola Lake is eutrophic with blue-green algal blooms each summer, causing an aesthetic impact for water-based recreation.	5. Water-based recreation on Nicola Lake is expected to increase with improved access from Kamloops and Lower Mainland.
6. Potential for flooding around Nicola Lake and downstream of Merritt at 1:200 yr. flood.	

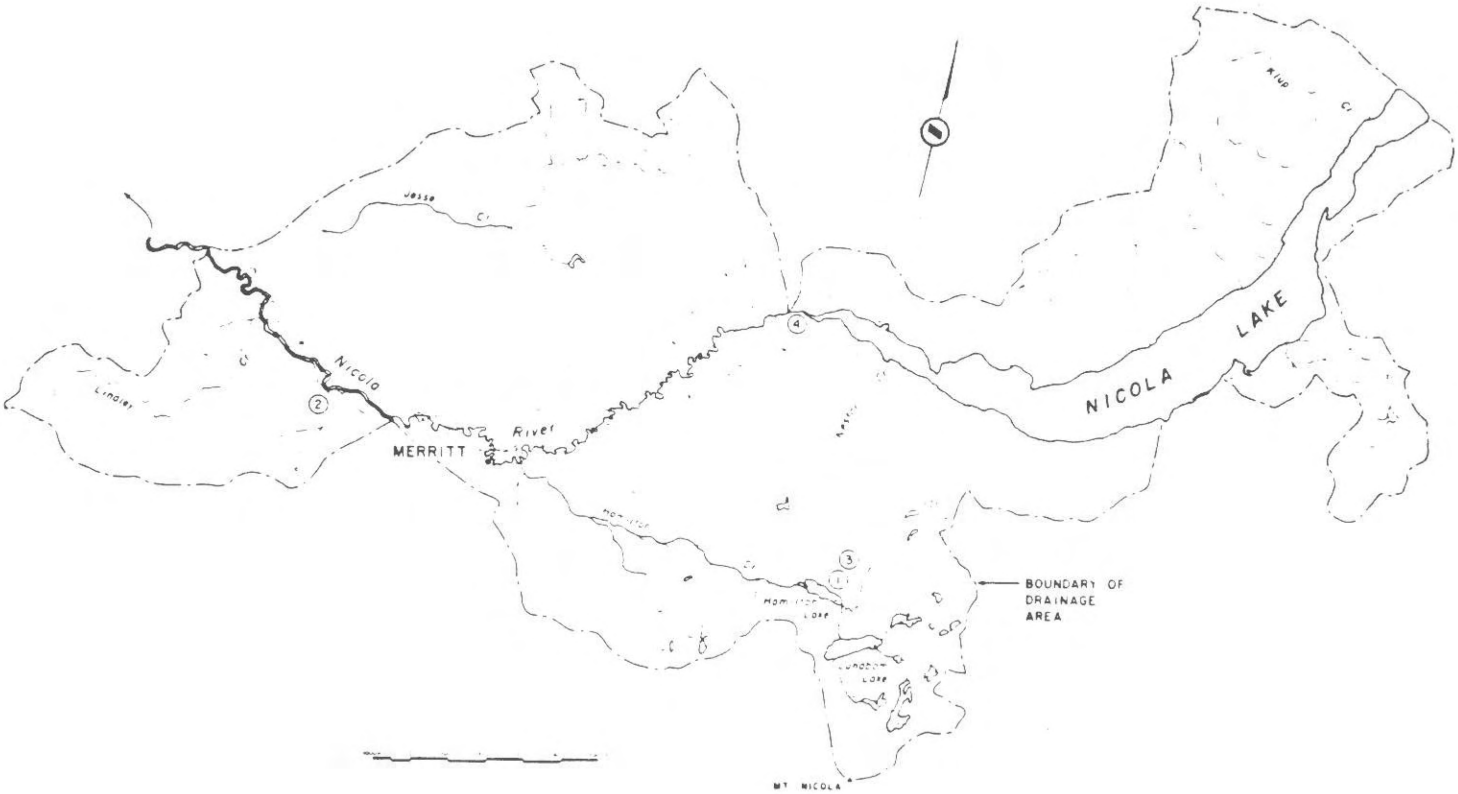


Figure 4.3
Middle Nicola Watershed

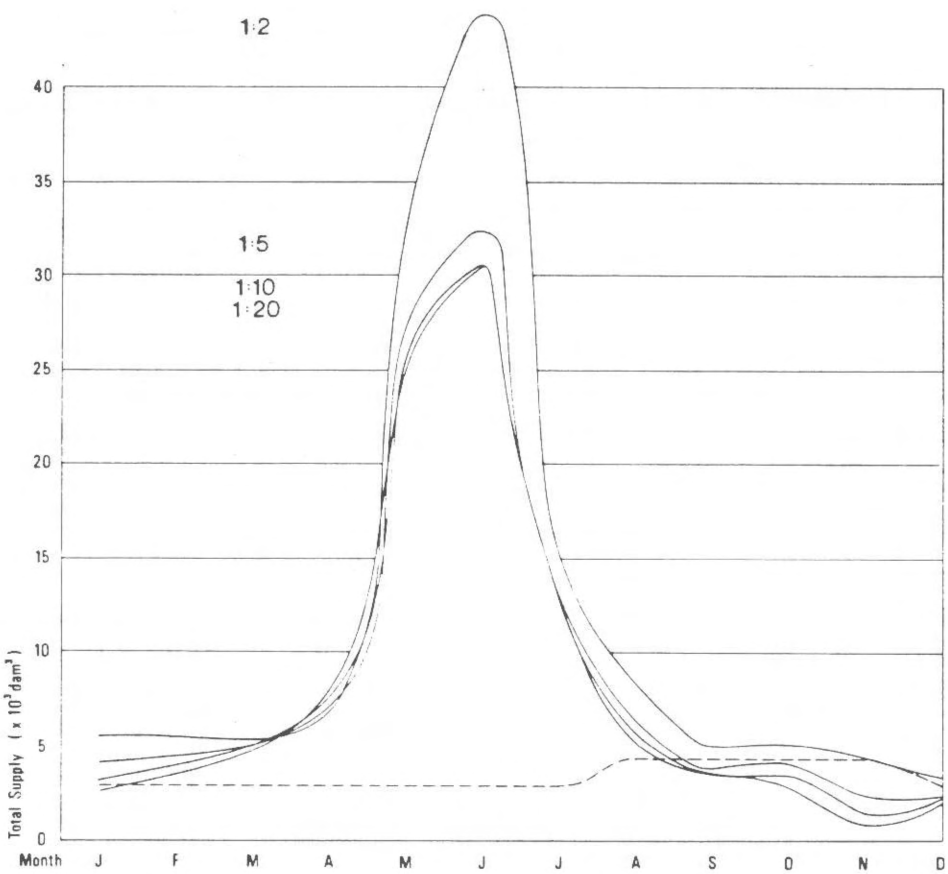


Figure 4.4

Hydrograph of Supply and Demand - Nicola River
(Nicola Lake to Coldwater River)

---- Fishery Maintenance Flows

NOTE: The backwater effect of Coldwater R. affects gauging readings. For analysis purposes the consumptive uses have been accounted for. Therefore, residual flows are presented.

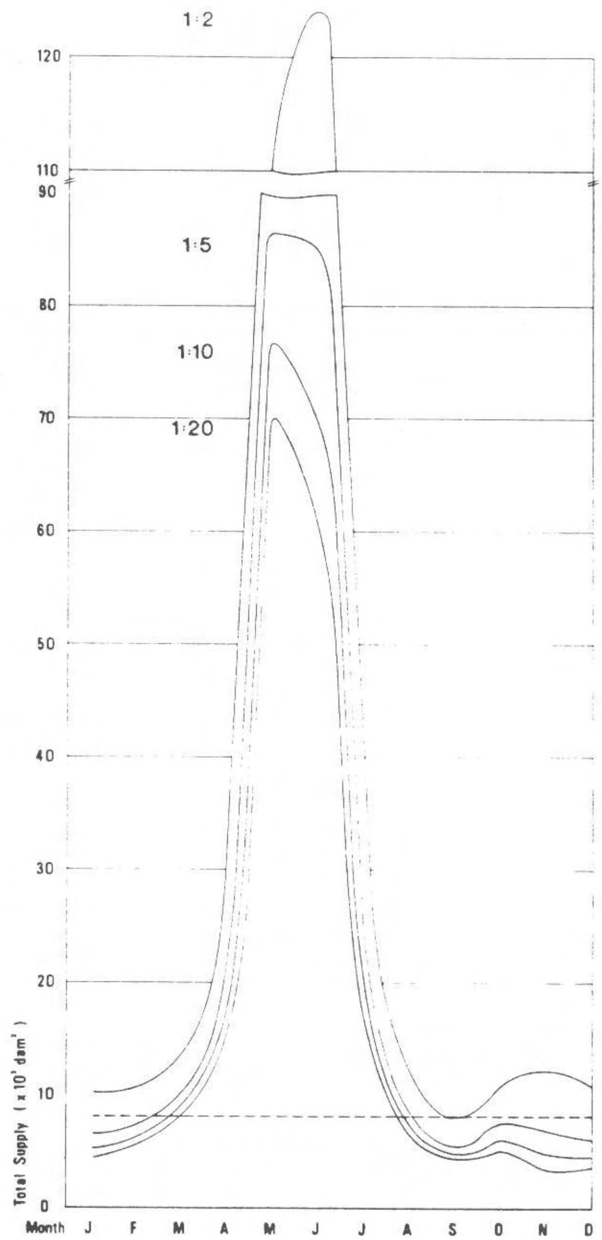


Figure 4.5

Hydrograph of Supply and Demand - Nicola River (Coldwater River to Spius Creek)

---- Fishery Maintenance Flows

NOTE: Residual Flows - Consumptive Uses are accounted for.

Figure 4.6
Lower Nicola Watershed

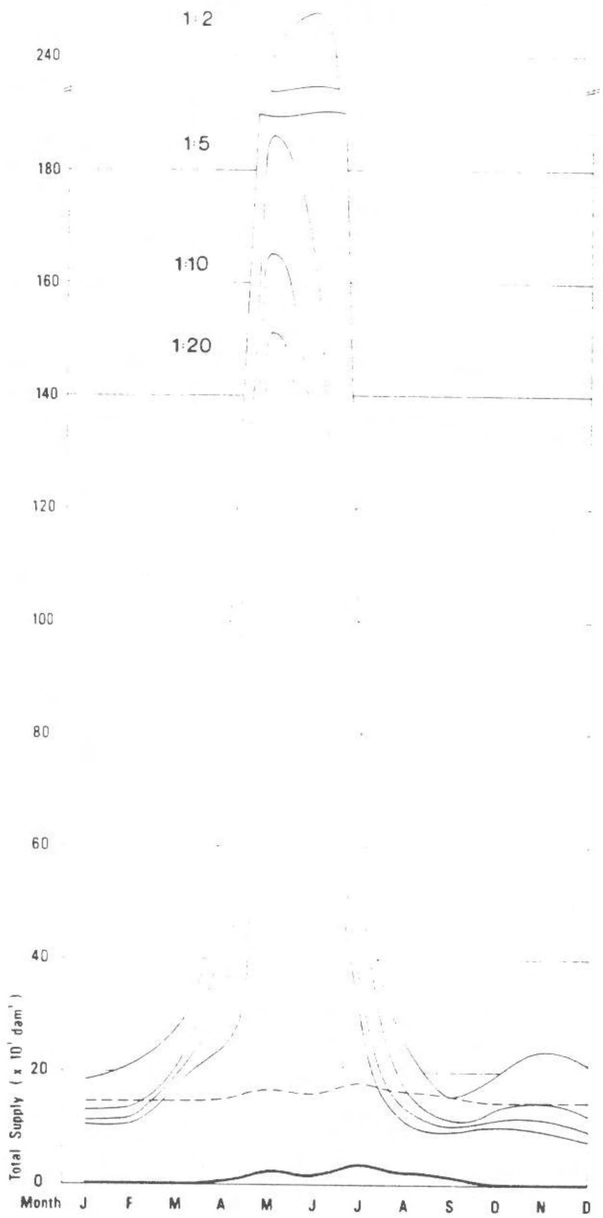


Figure 4.7
Hydrograph of Supply and Demand - Lower Nicola

——— Consumptive Use

------ Combined Fishery Maintenance Flows and Consumptive Use

Resource Management Options

The key to mainstem Nicola water management is storage on Nicola Lake. The present dam was built in the late 1920's and needs to be repaired or replaced within the next couple of years. Because one or the other of these options must be undertaken in the near future, the base case against which they should be evaluated is the removal of the dam. In this event, the following situation in the mainstem Nicola is assumed to occur:

Agriculture: Irrigation of 1640 hectares of land along mainstem Nicola would cease after June 30, resulting in 40 percent reduction in hay production (5400 tonnes). This has a present value of $1.1 million (McNeil, 1982).

Nicola Ranch Ltd. would have to make a captial outlay of $1 m over 5 years to repair dams on Clapperton Creek. This investment could be foregone if new storage was provided on Nicola Lake. Present worth of this capital cost is $758,000.

Fisheries: If irrigation ceased after June 30, it is assumed that in-stream flows on the Nicola would be reduced below fishery maintenance flows, and that there would be some loss in current production. This loss has not been quantified. However, there would be no effort to restore populations to optimum levels because required in-stream flows cannot be guaranteed. This represents an opportunity foregone with a present value of $2.2 million, net of stocking costs.

The removal of the dam would not permit any of the water and related resource management objectives stated at the beginning of this chapter to be met. The following alternative water management measures have been evaluated to determine the degree to which the resource management targets could be met.

1. Repair Nicola Dam - Little or No Additional Storage

Preliminary estimates of repairing the present structure are estimated at around $300,000 with approximately $7,000 annual operating costs. Total present value of this measure would be around $355,000. Regulation of this storage could follow two alternative allocation priorities.

i) Allocate primarily for diversion uses (agriculture) at the expense of in-stream uses (fisheries).

This would result in the restoration of the current hay production (present value $1.1 million), plus the full irrigation of some 230 hectares which have licences restricted by 'fish clauses' after July 1, (present value of $230,000) plus the development of an additional 220 hectares along the mainstem (present value of $365,000). The present worth of total agricultural benefits would be approximately $1.7 million (Table 4.1).

Under this option Nicola Ranch Ltd. could transfer some of its licences to Nicola River to irrigate some of the additional 220 hectares that would be available. This shift would save the Ranch a portion of the repair costs of $1 million required to upgrade the present dams on Clapperton Creek. It is assumed here that the cost savings would be approximately the same as the value of hay production ($365,000) and thus there would be no overall net benefit to the Ranch. This benefit may be underestimated when detailed analysis is undertaken as part of the operational plan for Nicola River.

Fishery values would not change from the base case as all the storage would be allocated to agriculture and used/released during the July - September period. In stream flows would be below required maintenance flows in all but wet years. Measures to increase anadromous stocks would not be undertaken.

ii) Allocate storage to provide in-stream flows for fisheries and protect existing licence users.

TABLE 4.1

PRELIMINARY EVALUATION OF INCREMENTAL COSTS AND BENEFITS OF WATER MANAGEMENT OPTIONS FOR MAINSTEM AND UPPER NICOLA AND COLDWATER WATERSHEDS ($,000)[1]

Option	Benefits			Opportunity Costs		Financial Costs Capital and Operating	Total Net Benefits
NICOLA RIVER	Agriculture[2]	Fisheries Anadromous[3]	Fisheries Resident	Agriculture	Fisheries		
1.(a) Repair Nicola Dam[4] Same water allocation as at present	$1430	$2230[4]	Nil	Repair storage dams on on Clapperton Creek ($758) Forego increased expansion ($230)	Some loss to fishery opportunities ($2210)	$360[9]	$3280
(b) Same as 1(a) but develop storage on Douglas Lake	$1430[5]	$2540	$5310[6]		Nil	$360[7]	$8690[6]
2. Replace Nicola Lake Dam with Increased Storage	$4570[8]	$2230	Nil	Nil	Nil	$2020	$4780
COLDWATER RIVER							
1. Designate in-stream flows for fisheries	Nil	$1430	Nil	Increased irrigation requires storage	Nil	Nil	$1430
2. Designate in-stream flows for agriculture	$ 265	Nil	Nil	Nil	Enhancement opportunities foregone loss to existing fishing	Nil	$ 265

Footnotes

1 Costs are given as present values, i.e. a summation of annual costs discounted to 1982 dollars at 10 percent. Values presented are rough indications only of the benefits and costs associated with each option. Before any water allocation decisions are made, more in-depth analysis is required. Costs and benefits are incremental, not total.

2 Agricultural benefits are measured as the value of forage production less the annual operating costs of harvesting which include irrigation, fertilizer, labour and machine costs. If new land is to be brought into production, the costs of developing the land and setting up the irrigation system is included.

3 Benefits from anadromous fish production (salmon and steelhead) accrue to commercial fishermen and processors, recreational fisherman and the Indian food fishery. Commercial harvest is valued at the wholesale value of the salmon products net of harvesting and processing costs. Indian food fish harvest is valued as for commercial harvest to represent the opportunity cost to the commercial fishery. The costs of increasing anadromous fish populations include the costs of fry stocking over a five year period to bring production up to 'optimal' levels. For resident fish, the costs include the capital costs of the enhancement facility and ongoing annual operating costs. These costs are substracted from the gross values.

4 Assumes a base case that Nicola dam will be removed. Loss of 40 percent of current forage production estimated at a present worth of $1,820,000 in 1982 dollars and foregoing of all fishery restoration benefits, estimated as a present worth net value of $2,210,000 (total benefits minus stocking costs). There would be some loss to existing fish production but this loss has not been quantified.

5 Increased storage on Douglas Lake will provide some additional water for agriculture either in the Upper Nicola and/or the mainstem depending on allocation for instream uses.

6 There will be an increase in salmon and steelhead production in the Upper Nicola. Only steelhead values have been estimated ($306,000). Increased flows in Upper Nicola will support kokanee enhancement in Nicola Lake. This will provide an estimated increase of 30,000 harvestable fish, around 20,000 angling days.

7 Total costs are assumed to be $300,000 to repair Nicola dam and $7,000 in total annual operation and maintenance costs. Douglas Lake storage costs are unknown at this time.

8 Assumes the total storage of 2.15 metres (7 feet) would be sufficient to irrigate up to 4,360 hectares and meet all fishery maintenance flows.

The full fishery benefits at optimal levels of production given existing stream capacity ($2.2 million) would be available, plus the value of 40 percent of present forage production ($1.1 million) since this loss would be avoided. However, there would not be surplus water to assist licences presently restricted by fish clauses or to assist Nicola Ranch Ltd. shift its licences which require storage on Clapperton Creek to the Nicola River.

2. Increase Storage on Nicola Lake

The total cost of a new dam on Nicola Lake has been estimated at $1.9 million (Crippin Engineering, 1982). Assuming operational costs of around $10,000 annually, the present value of this project would be $2.02 million. It would provide the following benefits:

- in-stream fishery flows would be provided - stocks restored to historic levels
- loss to existing production in the mainstem assuming the base case of removing the dam would be avoided ($1.1 million)
- increase in the availability of water for additional agricultural lands; restricted licenses granted full term, outstanding applications would be honored.

The incremental costs of replacing the dam compared with repairing it (approximately $1.5 million) would have to be supported by agricultural and fishery beneficiaries.

3. Repair Nicola Lake Dam; Increase Storage on Douglas Lake

The benefits of storage on Douglas Lake have already been noted. However, it could be possible to improve water supplies in the entire Nicola for both instream and irrigation uses if storage on Douglas was regulated in conjunction with Nicola Lake.

There would be benefits to both anadromous and resident sport fisheries in the Nicola, plus irrigation benefits in both the Upper and mainstem Nicola watersheds.

There would also be additional benefits to agriculture, but these would have to be shared by irrigators in both the Upper and mainstem Nicola.

Table 4.1 provides a preliminary evaluation of these options, based on the assumptions used in the text. The values quoted could be subject to significant change when more detailed evaluations are available as the result of an operational plan based on a hydrologic model of the entire Nicola River system. Based in this preliminary information, it appears that if the Nicola Dam was repaired, but not replaced, there are greater benefits obtained by allocating storage to meet in-stream requirements, than to allocating it all for agricultural purposes. Consequently, the strategic plan will recommend that in-stream flows in the mainstem Nicola be protected.

It is not clear from this analysis whether maximum net benefits would be obtained from the repair of the dam or its replacement. There certainly seems to be a benefit to tying the regulation of Douglas and Nicola Lake storage. It may also be possible to increase storage in Nicola using the existing structure but with a better design than the present dam. All these options should be examined in detail using a hydrologic model and updated engineering assessments of dams at both lakes, before a final decision is made.

SUMMARY OF OPTIONS

Waste that would be provided on Nicola Lake from each option

1. Repair Nicola Lake Dam - 3.00 ft. 18,525 AF (dam^3)
2. Replace Nicola Lake Dam - 7.31 ft. 45,156 AF (dam^3)

Irrigation and Fishery Water Demand (In feet of water required on Nicola Lake)

Existing Irrigation and Fishery Flow Demand		Potential Irrigation Demand
1:2	.64	2.44
1:5 Irrigation	3.12	4.90
1:2 Season Rest of Year		
1:5	4.09	6.17
1:15	5.01	7.08

4. Improved Water Use Efficiencies

At present, actual withdrawals for irrigation along the mainstem Nicola are less than licenced amounts, because approximately 30 percent of the licences are not used at present and because in some cases, irrigators have switched from ditch to more efficient pipe distribution systems. Thus the tables in Appendix XI summarizing water supply and demands for the mainstem Nicola based on licenced records indicate a greater shortage for in-stream flow requirements than is actually the case.

This situation emphasizes the benefits available for irrigation through reducing losses in ditch irrigation systems. Because of the high costs of providing additional storage and the costs of water application via ditches, there should be a detailed assessment of ways of improving use efficiences such that existing licenced use can irrigate a greater area or alternatively extend the length of the irrigation season for lands with presently restricted licences.

5. Flood Control

Increased storage on Nicola Lake would help to control flooding under extreme runoff conditions. The benefits of flood control have not been calculated, but would be relatively small on an annual basis, since the frequency of flooding is small.

If the same level of storage was provided, flood control would be best provided through the designation of a river corridor along the entire length of the mainstem Nicola as recommended in the recent report from the Ministry's Water Management Branch (McMullen, 1982). This would be designed to protect fishery values, protect areas of rapid erosion through limited bank protection works and restrict all future development to areas outside the designated corridor.

6. Improvements to Water Quality

The key parameters that are not being met to provide adequate ambient water quality for fisheries are siltation and water temperature.

The town of Merritt has recently completed a study on the options for controlling effluent discharge from the STP to current pollution permit requirements. In the long run, nutrient concentrations can be reduced most effectively through land disposal. However, costs of this option are high unless arrangements can be made to use the treated effluent for irrigation on nearby private agricultural lands. The city is now considering improving the secondary sewage treatment facilities to reduce toxicity caused by over-chlorination and also the levels of suspended sediments. This improved level of treatment would make it safe for irrigation. However local ranchers remain concerned about the use of effluent for irrigation and the costs of conveyance and distribution.

The water quality benefits (decrease in concentration levels) that would be derived from storage increase on Nicola Lake have not been determined. Any study of the options for the Merritt STP should include the analysis of storage increase and the impact on water quality in the Nicola River.

The heavy siltation in the Middle Nicola is caused by silt boils in the river. Though these silt boils may be features of natural discharge, excessive irrigation on the adjacent benchlands may augment grouindwater discharge thereby increasing siltation. Better control of irrigation water may alleviate this problem. Possibly placing sand bags over some of the silt boils may reduce or eliminate the quantity of silt discharged to the river.

High water temperatures during low flows in August-September approach lethal levels for salmonids. These temperatures are a result of releasing the warm surface waters from Nicola Lake. The principal management options would be storage on the Coldwater River, or increased flows down Clapperton Creek as a result of switching diversions from the creek to the Nicola River. This move would increase fishery production on Clapperton Creek as well as the Middle Nicola. Release of cooler (deeper) water from Nicola Lake would be a very expensive option since a pump and about 5 km of pipe could be required to access cooler water.

7. Groundwater

As population in the mainstem Nicola grows, further demands will be placed on the groundwater resource. Additional information on potential yields will have to be obtained over the next five years. This work should be undertaken in two phases.

The first step would be an upgrading of existing well data through field inventories. Data to be collected include well depth, water level, well log, well yields and water quality. This activity would cost around $7500.

Following the assessment of these data, a groundwater exploration programme would be required. Drilling costs are estimated at between $11,200 and $22,000 for 30 metre and 90 metre wells respectively (Appendix XII).

QUILCHENA

The Quilchena watershed has a topography similar to that of the Upper Nicola (Figure 4.8) with rolling hills and a scattering of small lakes. The southern portion of this watershed rises to an elevation of 1350 m, enabling it to pick up some moisture from the coastal weather systems. Much of the area is privately owned by ranchers, with extensive irrigation in the benchlands along the lower reaches of the river.

The hydrograph (Figure 4.9) displays a high level of runoff variability from the average (1:2) to dry years (1:20), with a sharp drop off in all years by the end of July.

Current Situation

1. Licenced irrigation use to support 734 hectares met 4 years in 5 through storages (5000 dam^3) and stream diversions 9590 dam^3)

2. Fishery maintenance flows of 7 cfs (0.2 cms) are not met in dry years (1 in 5).

3. Ambient water quality adequate for irrigation and fisheries, through nutrient concentrations are high.

Resource Potentials

1. Approximately 1000 dam^3 could be stored.

2. Likely expansion of irrigated area estimated to be small (under 200 hectares).

3. Fishery potential low to moderate. Some rainbow trout and kokanee spawning to Nicola Lake fishery.

4. Increased cattle populations would add to nutrient loadings.

Management Options

The major management objective (for irrigation use) is being met at present. Given the potential to increase irrigated agriculture and the

Figure 4.8
Quilchena Watershed

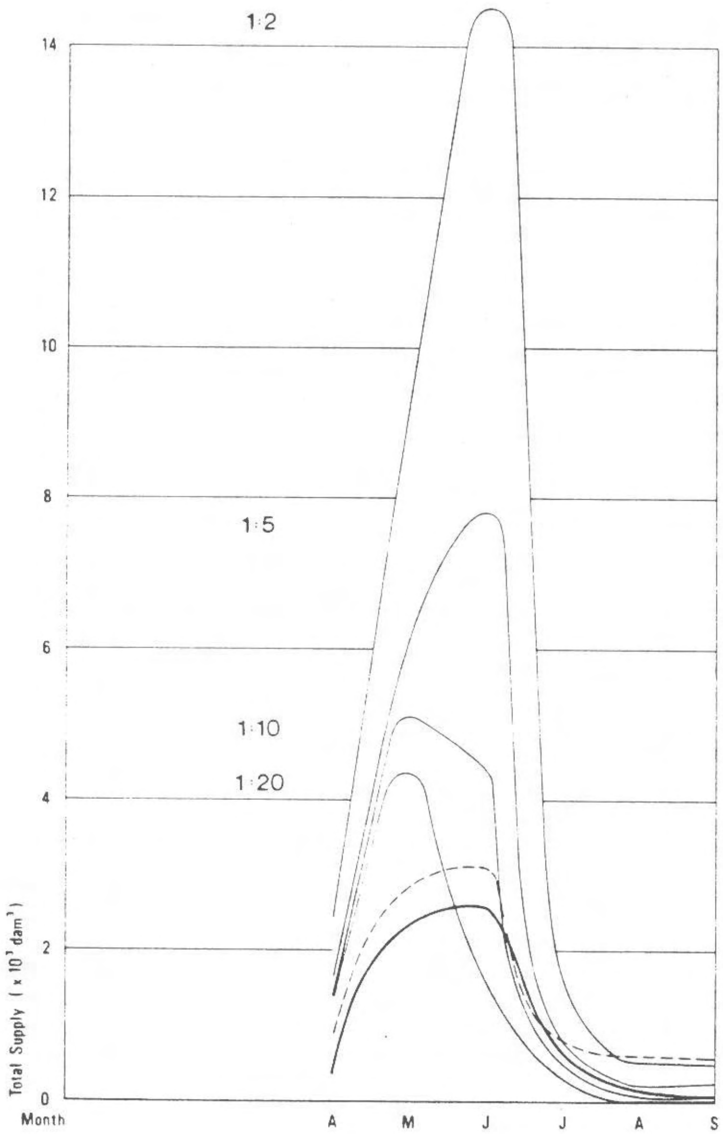


Figure 4.9
Hydrograph of Supply and Demand - Quilchena Creek

——— Consumptive Use

------ Combined Fishery Maintenance Flows and Consumptive Use

potential to divert more water for that use, a number of options might be considered over the next decade.

1. Storage Development and Monitoring Program

Flow records are fair at best and there is limited information on storage potential in the watershed. Additional monitoring and reconnaissance of storage sites should be undertaken if the potential for expansion of irrigation acreage in the Nicola becomes promising.

2. Adjustments to Irrigation Diversions and Improved Water Use Efficiencies

Given the limited storage potential, increased flows for irrigation and for fisheries could be obtained from making adjustments to irrigation diversions. One option would involve the transfer of diversions from the lower reaches of the river onto Nicola Lake. The second option (not mutually exclusive) would be to change open ditch systems to piped, sprinkler units.

3. Improvements to Water Quality

In view of the very high nutrient concentrations in this watershed, ambient monitoring should be considered to pin-point sources and, where appropriate, controls on direct runoff from cattle feeding areas and surface waters should be implemented.

4. Fisheries Habitat Reconnaissance

Further inventory studies to identify and priorize factors limiting fish production in Quilchena are required. It appears that the limiting factors are low flows and habitat constraints (lack of side channels and spawning and rearing habitats).

MOORE-STUMP

The Moore-Stump watershed is generally characterized by rolling grassland terain with middle-high elevation plateaus (Figure 4.10). There are a few lakes of moderate size in the watershed (Stump, Peterhope, Frogmore) which eventually feed into Nicola Lake. Intensive agricultural activities and the high biophysical potential for expansion is limited by water availability. The watershed displays very high flows in April which drop rapidly during the summer period (Figure 4.11).

Present Situation

1. Licenced irrigation for 960 hectares not met in most years. Present storage (5460 dam^3) and diversions (1925 dam^3) are not sufficient.

2. Fishery maintenance flows of 2 cfs (0.05 cms) not met except in very wet years.

3. Water quality suitable for irrigation and fishery use. Nutrient loadings contribute to Nicola Lake eutrophication.

Resource Potentials

1. Little surplus water for storage, but hydrologic records are poor.

2. Few storage sites available.

3. Biophysical capability for agriculture is high, but expansion is expected to be minimal.

4. Some groundwater potential near Lower Moor Creek.

5. Fishery potential is limited.

Management Options

Resource management objectives are not achieved in the Moore-Stump watershed. Limiting water supplies are most severe in this watershed rela-

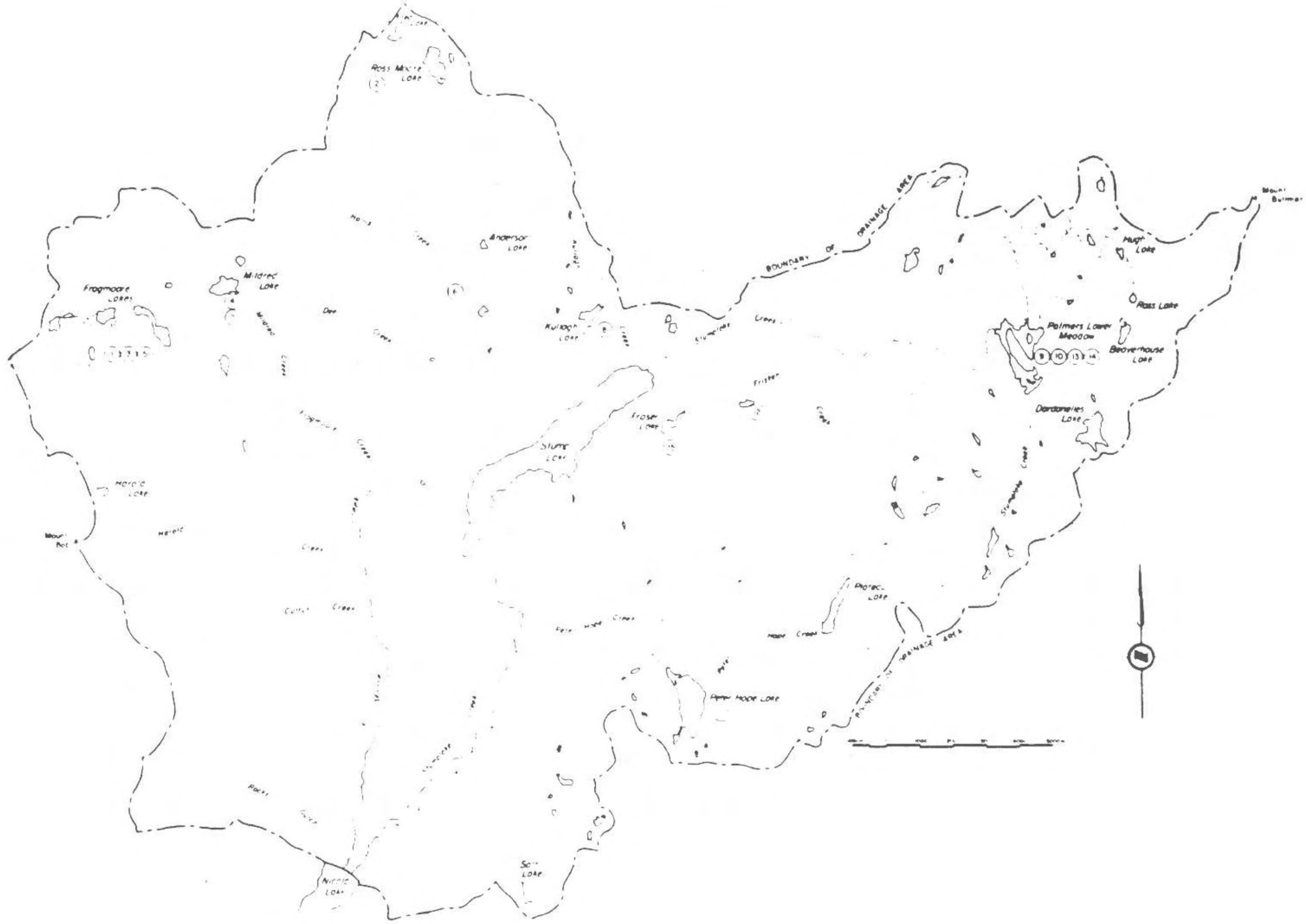


Figure 4.10
Moore-Stump Watershed

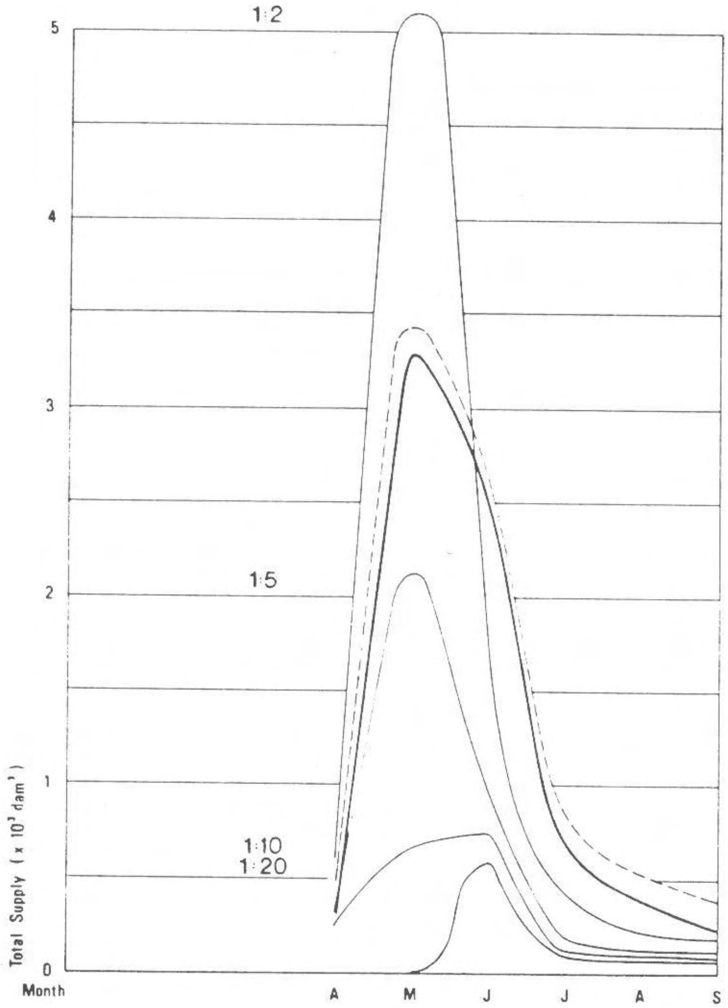


Figure 4.11
Hydrograph of Supply and Demand - Moore-Stumplake Creeks

——— Consumptive Use

- - - - - Combined Fishery Maintenance Flows and Consumptive Use tive to the rest of Nicola basin. This limits the current agricultural development and does not provide any maintenance flows for fisheries.

1. Improved Water Use Efficiencies - Storage Development

Limited water yields and lack of major storage opportunities, limit future management to the development of small scale storage improvements, e.g. diversion of Moore Creek into Stump Lake and improvements to the efficiency of irrigation practices. Improvements to flow regulation and perhaps changing diversion points should also be examined.

2. Increased Storage and Monitoring Program

Small increases in storage developments on small lakes may improve the distribution of water over the summer period, but only for a small acreage. Further monitoring and assessment of inflow estimates to Lower Palmer Meadows, Frogmore Lake and Stump Lake should be undertaken.

3. Groundwater Supplies

Surface flows may be augmented with groundwater supplies. Studies concerning conjunctive use of surface and groundwater should be considered.

4. Water Quality Improvement

Management to improve water quality should concentrate on control of winter feedlots close to tributary streams.

CLAPPERTON

The Clapperton watershed is the smallest watershed in the Nicola basin (Figure 4.12). This is also reflected in the small number of storage lakes and the low flows recorded in the Clapperton tributary relative to the other watersheds in the Nicola basin. Surface water supplies, although limited,

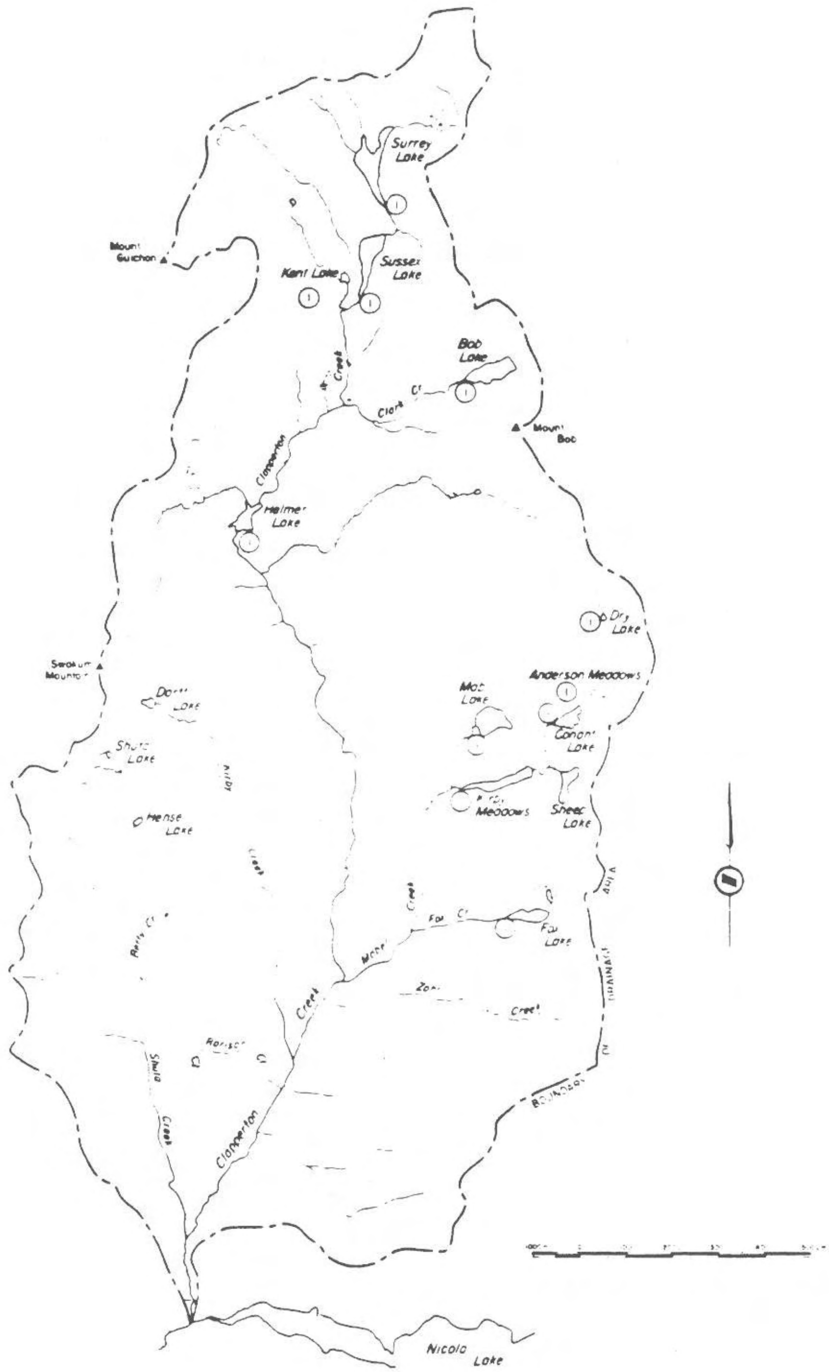


Figure 4.12
Clapperton Watershed

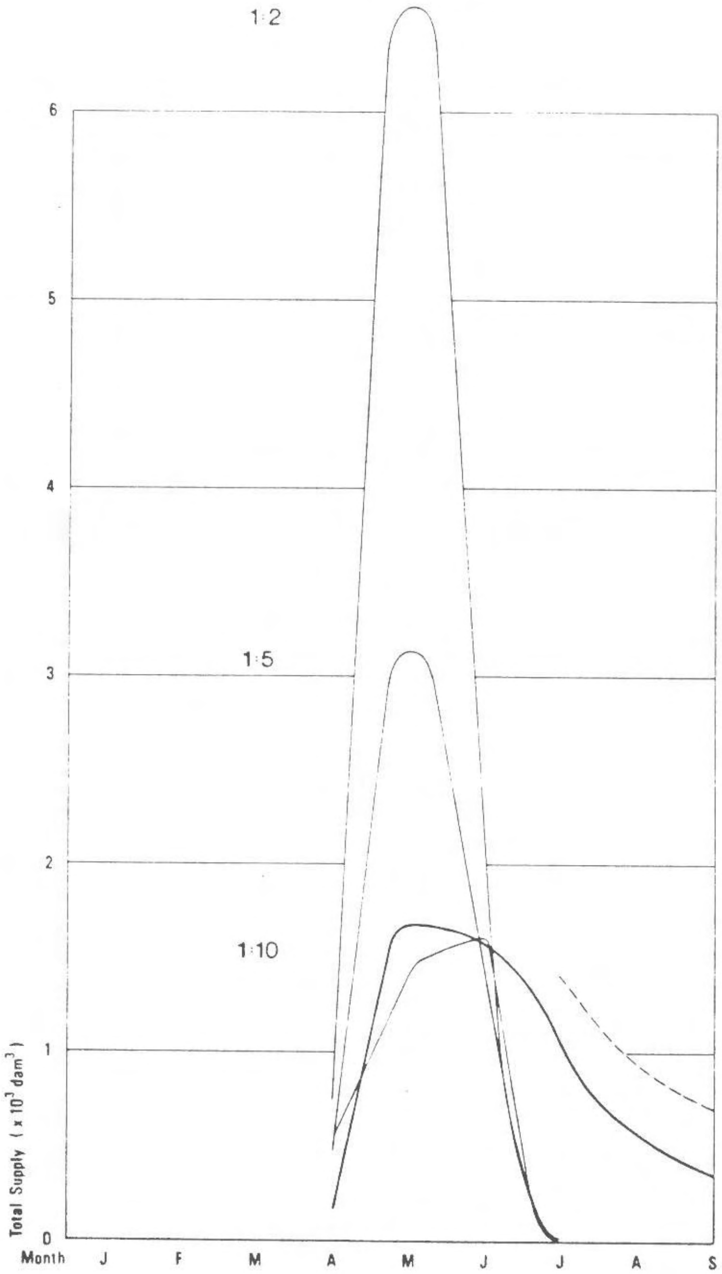


Figure 4.13
Hydrograph of Supply and Demand - Clapperton Creek

——— Consumptive Use

------ Combined Fishery Maintenance Flows and Consumptive Use

display the high spring peaks (May) which drop to extremely low flows during the latter part of the summer (Figure 4.13). Hydrologic information is very limited (2 years of actual record), so supply data are unavailable.

Present Situation

1. Irrigation requirements for 875 hectares met only during spring and early summer through storage (3084 dam^3) and stream diversion (6263 dam^3).

2. Storage dams require major repairs over the next few years.

3. Fishery flows of 5 cfs (0.15 cms) are not met in late summer and fall.

4. Water quality meets requirements for irrigation and fisheries.

Resource Potentials

1. Poor hydrologic records limit assessment of potential yields.

2. Potential storage sites in headwaters (Sussex Lake, Kirby Meadow and Helmer Lake).

3. Small scale expansion of irrigation.

4. Fishery potential moderate -200 steelhead adults (before harvest); plus some coho.

5. Potential groundwater development.

Management Options

1. Change Diversion Points to Pumpted Systems from Nicola River

Given that the storage dams in Clapperton require up to $1 million repair costs over the next few years, the most obvious option is to transfer some licences from Clapperton to Nicola River once storage is provided on Nicola Lake (See Table 4.1). This measure would produce a number of benefits, namely:

. cost savings on headwater dam repairs
. increased in-stream flows to support coho and steelhead production
. avoidance of fish losses into irrigation ditches
. moderation to Nicola River water temperatures below Nicola Lake due to higher in-stream flows
. reduction to 'silt boil' problem in Middle Nicola if water applications were reduced

2. Groundwater Development

Groundwater development in conjunction with more appropriate diversion points may provide additional supplies to meet anticipated increases in domestic water use.

3. Storage Development and Monitoring Program

Increased storage development is not recommended until more reliable hydrologic records are available and indicate water surplus for storage. Monitoring program is proposed and included stations at selected points along the tributary.

4. Water Quality Improvement

Nutrient loads in the Clapperton watershed could be decreased through control of winter feedlot operations. Monitoring is required, but at a lower priority than upper and mainstem Nicola and Guichon Creek.

GUICHON

The Guichon watershed consists of a fairly broad valley and rounded hills of middle to high elevation (3500-6000') (Figure 4.14). There are some scattered lakes along the main tributary, the main ones being Mamit Lake and Lac le Jeune. The Guichon Valley supports a mixture of resource activities, the most notable being the copper industry. The diversion of

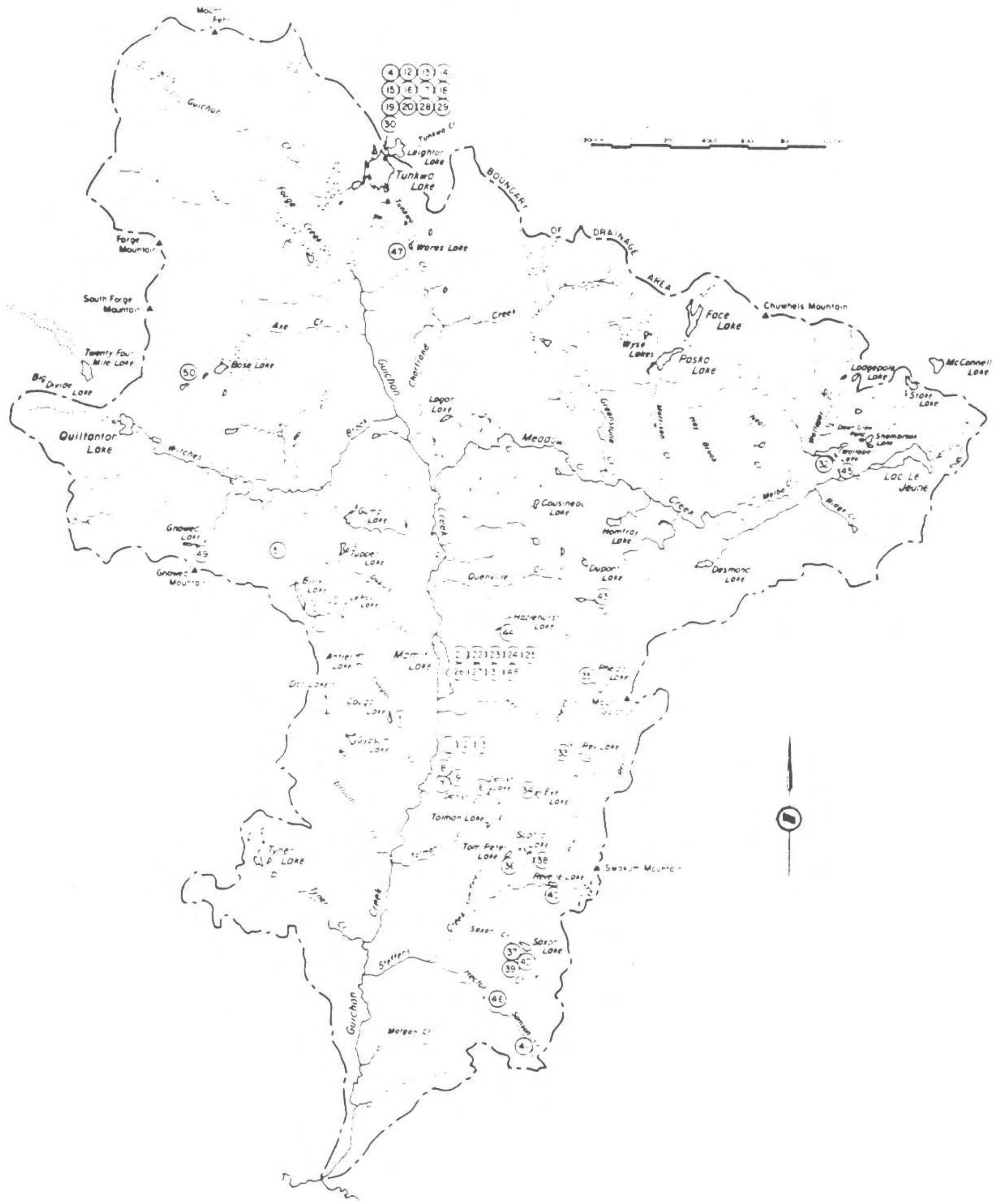


Figure 4.14
Guichon Watershed

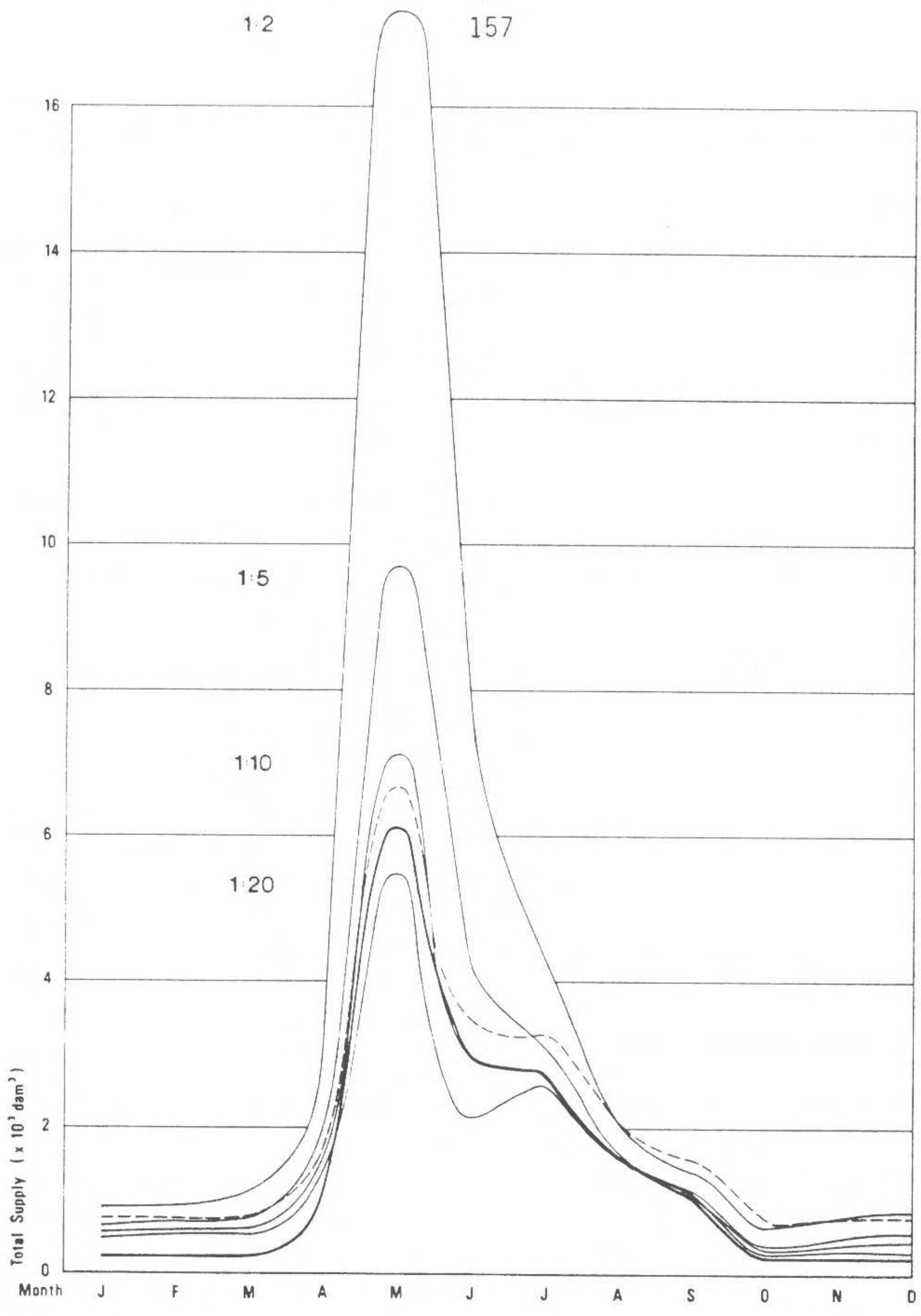


Figure 4.15
Hydrograph of Supply and Demand - Guichon Creek

——— Consumptive Use

------ Combined Fishery Maintenance Flows and Consumptive Use

water for irrigation in the valley has virtually eliminated a once important run of chinook and steelhead.

Present Situation

1. Irrigation licences for 2235 hectares are just met 4 years in 5 years (Figure 4.15).

2. There are 15 outstanding licence applications for 3543 dam^3.

3. Fishery flows of 7 cfs (0.20 cms) are not met at mouth due to diversions. These flows are available upstream.

4. Water quality objectives are met for irrigation, but there are occasionally high concentrations of selected heavy metals for fisheries.

5. Groundwater is used to supply the town of Logan Lake.

Resource Potentials

1. Surplus water of at least 3000 dam^3 is available for storage.

2. Considerable expansion of irrigation is possible (around 1800 hectares) depending on water availability.

3. Potential to produce 1440 adult steelhead plus an unquantified number of coho and chinook.

4. Mining expansion could lead to greater amounts of heavy metals reaching surface water.

5. There appears to be significant groundwater potential in Highland Valley and Lower Guichon.

Management Options

Many of the water management objectives are just met e.g. irrigation water supplies and water quality objectives for fisheries, but fishery objectives are not met. Any expansion of demand in the watershed will require some of the following management measures to be implemented.

1. Storage Development and Flow Regulation

Mamit Lake appears to be the most favourable storage development site. Approximately 7000 dam^3 could be stored if negative storage was considered, but more hydrometric monitoring is required to estimate the assured inflows. No cost estimates of development are available, so no economic analysis of this storage can be undertaken at present. However the benefits from increasd steelhead production alone would have a present value of around $250,000. Irrigation benefits would accure from a more assured supply of water to currently developed land plus the development of additional acreage.

2. Increased Fish Production

Increases in anadromous production could be realized 1) from screening irrigation uptakes, 2) providing maintenance flows (either through increased storage or change of diversion points), and 3) stocking programs (coho 120 000 unfed fry; steelhead 142 000 unfed fry).

3. Improved Water Use Efficiencies

Because of large diversions near the mouth of Guichon Creek, fish cannot migrate to the upstream reaches where water is available. Thus one option is to transfer the diversion points from the tributary to the Nicola River itself. This action should be undertaken only after storage on Nicola Lake is adequate to support additional stream diversions for the river and yet protect in-stream fishery flows.

4. Water Quality Improvement

A monitoring programme should be initiated with the mining industry to ensure that water quality meets the objectives required for downstream water users.

5. Groundwater Development

Groundwater development may augment surface water supplies in the lower portions of the Guichon tributary. However, this option may be expensive to implement and may provide water for only relatively small irrigation development (Appendix XII).

COLDWATER

The topography of the Coldwater watershed is typically V-shaped and bordered by rugged terrain (Figure 4.16). There are a few scattered lakes in this watershed, however, the main source of water for irrigation is obtained from tributaries that feed the Coldwater River. The river can generally be characterized as a cold, clear-running tributary of moderate-high gradient. The hydrograph exhibits the typical flow regime characteristics of the Nicola basin, however, increases in the winter can be attributed to the absence of any natural storage reservoirs and very little developed storage (Figure 4.17).

Present Situation

1. Irrigation water for 1058 hectares met in all years through storage (1295 dam^3) and diversions (6950 dam^3)
2. Fishery flows of 50 cfs (1.42 cms) are met in average runoff conditions. Average annual adult production 3146 chinook, 1980 coho, 265 steelhead.
3. Water quality adequate for irrigation and fisheries except for some siltation due to logging and toxiicity at Merritt STP.

Resource Potentials

1. Water storage potential of 75,000 dam^3. Irrigation expansion appears to be limited.
2. Potential fish production 6000 chinook; 9000 coho; 4800 steelhead.
3. Growing population in Merritt will increase effluent discharge.

Figure 4.16
Coldwater Watershed

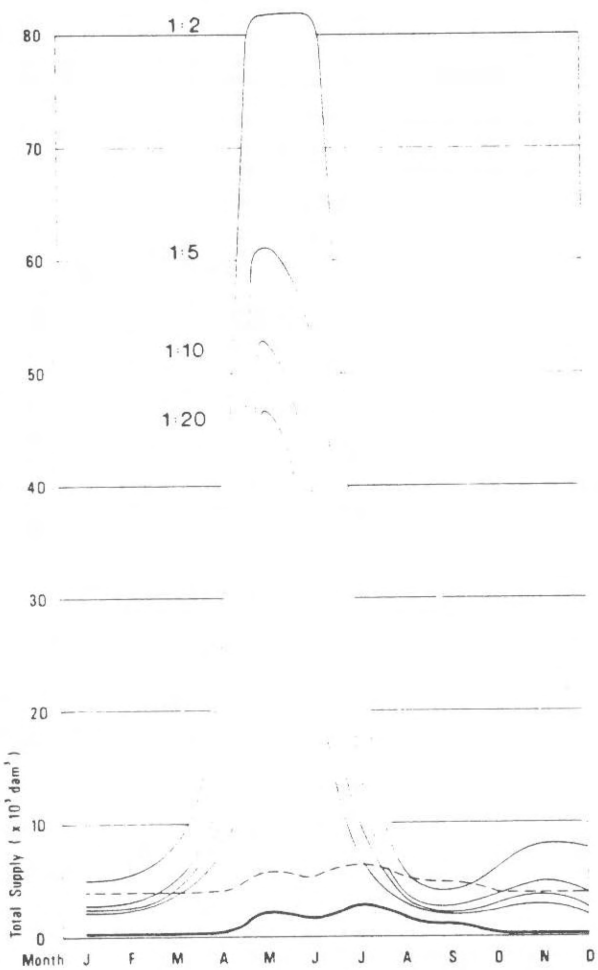


Figure 4.17
Hydrograph of Supply and Demand - Coldwater River

——— Consumptive Use

- - - - - Combined Fishery Maintenance Flows and Consumptive Use

Management Options

Because average flows in the Coldwater presently equal required maintenance flows for fisheries, any further diversion for irrigation expansion will reduce fishery potential. A preliminary evaluation of the option of giving diversion uses and in-stream uses respective priority in the future indicates that greater net benefits would be achieved through protecting in-stream uses. The fishery potential in the Coldwater has a net value of $1.4 million (present worth), whereas the present worth of agricultural uses is only $265,000.

Thus the management options are as follows:

1. Develop small storages on tributaries to the Coldwater to provide for small increases in agricultural expansion.

2. Improve the efficiency of existing licenced water use to expand agriculture.

3. Reduce effluent discharges at Merritt as discussed under the Nicola water management options and control land disturbances due to logging and the Coquihalla Highway through the referral process and on-site monitoring.

SPIUS

Unlike the other watersheds in the Nicola basin, Spius Creek is essentially unregulated with no storages or major diversions. The watershed has remained relatively unaltered except for some logging activities. The sharp V-shaped valley and fast flowing river combine to create one of the more aesthetic areas in the Nicola basin (Figure 4.18). The hydrograph peaks in the spring period and drops to lower flows during the early fall and winter months (Figure 4.19). Winter runoff and precipitation augment flows slightly.

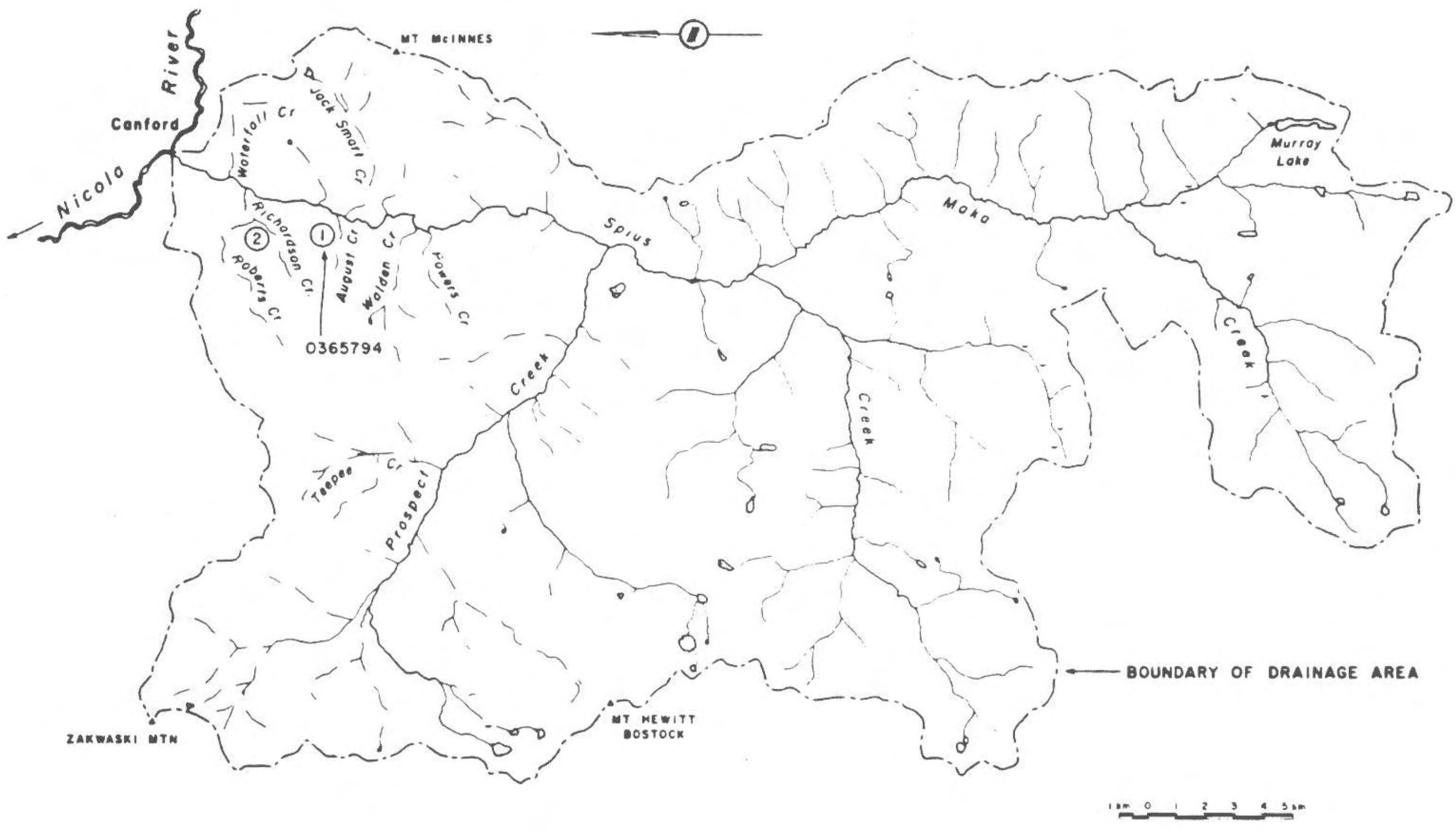


Figure 4.18
Spius Watershed

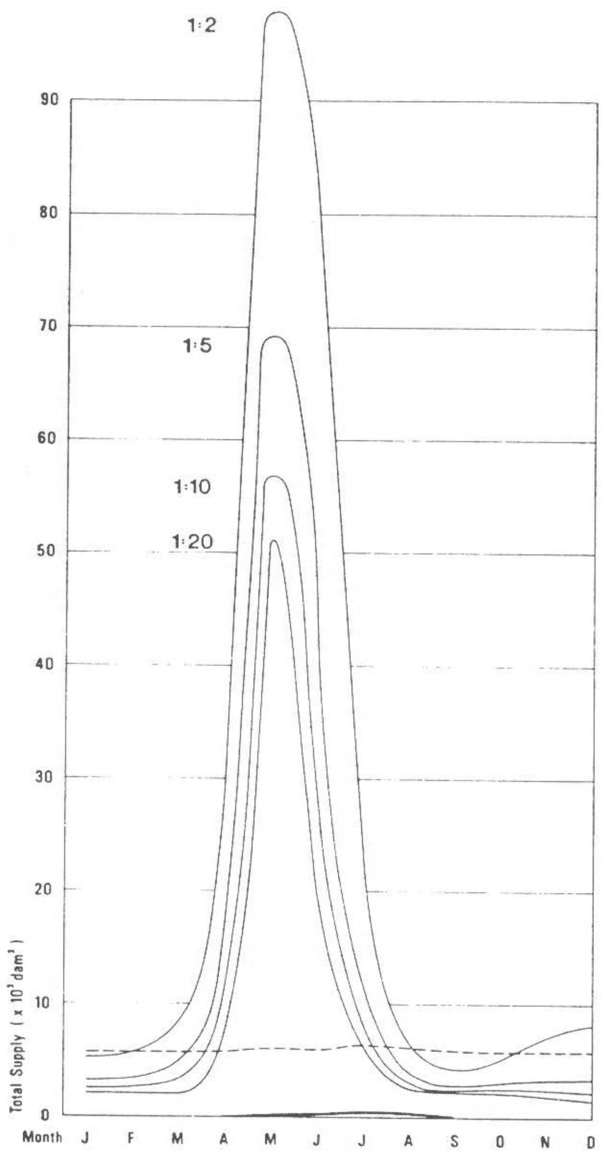


Figure 4.19
Hydrograph of Supply and Demand - Spius Creek

——— Consumptive Use

------ Combined Fishery Maintenance Flows and Consumptive Use

Present Situation

1. Irrigation water for 222 hectares met in all years, largely through stream diversions.

2. Fisheries flows met in average runoff conditions, supporting 745 chinook; 924 coho and 800 steelhead.

3. Water quality suitable for all uses.

1. Surplus water available, but no storage sites identified.

2. Potential fish production 3000 chinook; 1800 coho and 3000 steelhead.

Management Options

The water and related management objectives are currently met in Spius Creek. Because agricultural potential is very limited, the only management option is to maintain the river in its present near-natural state and increase anadromous fish production through stocking programmes.

SUMMARY

The monthly analysis of supply and demand is summarized:

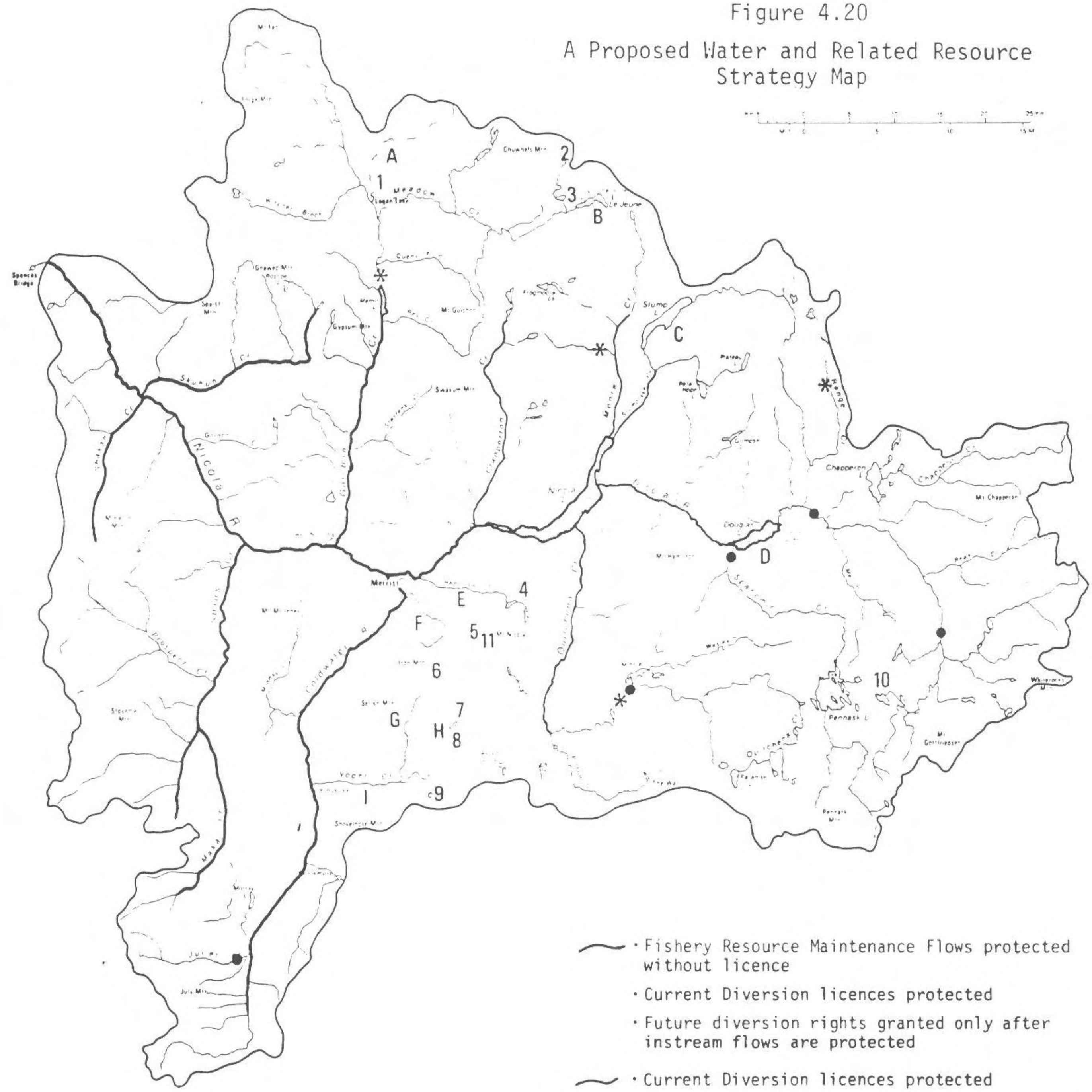
WATER SUPPLY AND DEMAND

Upper Nicola Guichon, Quilchena	. all licenced diversion requirements met . in-stream flows for fisheries not met except in wet years . potential for increased storage to support increased irrigation and/or fishery flows
Middle and Lower Nicola Coldwater and Spius	. all licenced diversion requirements met at present . Nicola lake storage (storage licenced for power, not irrigation) provides upstream storage support for licenced diversion requirements on Nicola River . in-stream fishery flows met in average runoff conditions with current levels of storage on Nicola River; with drought runoff conditions significant shortfalls occur . potential for increased storage and irrigation development . no additional diversions could occur without affecting in-stream flow requirements unless supported by storage
Clapperton Moore Stump	. licensed diversions not met in dry years . in-stream flows for fisheries not met except in wet years . little surplus water or storage potential

A summary of proposed water use designations and priority water management alternatives by watershed is provided in Table 4.2 and portrayed in Figure 4.20. To complement this strategy, a priority listing of a proposed anadromous fishery stocking programme is listed in Table 4.3 by watershed. The success of this programme depends upon the maintenance of adequate recruitment of adults back into each watershed, the provision of fishery maintenance flows and the protection of habitat, especially in the Nicola River corridor where the bank protection works must be carefully designed to maintain the carrying capacity of this system. The potential benefits of the anadromous fishery programme are high - over $3 million present worth. However the total stocking costs would be around $450,000. This investment would have to be priorized against other measures to increase anadromous fish production in the Thompson-Fraser system.

Figure 4.20

A Proposed Water and Related Resource Strategy Map



- Fishery Resource Maintenance Flows protected without licence
- Current Diversion licences protected
- Future diversion rights granted only after instream flows are protected

- Current Diversion licences protected
- Future diversions and instream flows must both be licenced and granted on basis of overall social and economic benefits

priority sites for increasing storage

* proposed hydrometric stations

● proposed water quality monitoring stations

Waterfowl Enhancement

A Upper Chartrand Cr
B Lac le Jeune
C Stump L & Stumplake Cr
D Douglas L
E Hamilton Cr
F Godey Cr
G Howarth Cr
H Kanevale Cr
I Voght Cr

Fishery Enhancement

1 Logan L
2 Lodgepole L
3 Walloper L
4 Little Lundbom L
5 Garcia L
6 Edna L
7 Kane L
8 Englishman L
9 Shea L
10 Hatheaume L
11 Marquette L

TABLE 4.2

SUMMARY OF A PROPOSED WATER MANAGEMENT STRATEGY FOR NICOLA BASIN

WATERSHED	PROPOSED PRIORITY USE DESIGNATION(S)	MANAGEMENT MEASURES	COMMENTS
Upper Nicola	Fisheries and Irrigation	•Study headwater lake storage and feasibility •Improve irrigation use efficiencies	Tie-in with Nicola River Operational Plan
Mainstem Nicola	Fisheries and Irrigation	•Increase storage on Nicola Lake •Improve irrigation efficiencies •Monitor Nicola Lake outlet	Operational Plan to be completed summer of 1983
Coldwater	Fisheries Irrigation	•Storage reconnaissance •Irrigation diversions to be supported by storage	
Spius	Fisheries	•Any additional withdrawls must be supported by storage	
Guichon	Irrigation and Fisheries	•Study storage development on Mamit Lake •Study changing diversion points to Nicola River •Monitoring of Mamit Lake inflow	Operational Plan to be completed by spring of 1985
Quilchena	Irrigation	•Storage reconnaissance •Additional monitoring	To be completed by 1986
Moore-Stump	Irrigation	•Storage reconnaissance •Additional monitoring •Study Moore Creek diversion to Stump Lake	To be completed by 1986
Clapperton	Irrigation	•Study changing diversion point to Nicola River	To be evaluated by summer of 1984

TABLE 4.3

SUMMARY OF PROPOSED PROGRAMME FOR ANADROMOUS FISHERIES IN THE NICOLA BASIN

PRIORITY	MEASURE			PRODUCTION CURRENT	PRODUCTION POTENTIAL	STOCKING REQUIREMENT (UNFED FRY)
HIGH	Coldwater	fry stocking maintenance flows	coho	2000	9000	847 000
			chinook	3300	6000	600 000
			steelhead	265	4800	1 078 000
	Spius	fry stocking	chinook	825	3000	180 000
			steelhead	800	3000	334 000
	Maka	fry stocking	coho	1000	1800	45 000
			steelhead			62 000
	Lower Nicola	maintenance flows fry stocking screen irrigation diversions	chinook			
			steelhead	4900	12,000	
MODERATE	Middle Nicola	water quality - temperature - suspended sediments - nutrients loading	chinook	16,500	28,000	920 000
			coho	1200	2850	1 000 000
			steelhead	2691	2691	
			pink			
	Guichon	screen irrigation diversions maintenance flows fry stocking	coho			120 000
			steelhead	216	1440	142 000
	Skuhun Nuaitch		steelhead	145	480	40 000
	Skahan	screen irrigation diversions maintenance flows improve spawning habitat	steelhead			
	Clapperton	screen irrigation diversions maintenance flows fry stocking	steelhead	36	200	
LOW	Upper Nicola[1]	maintenance flows fry stocking	steelhead		1600	
			coho			
	Quilchena	screen irrigation diversions maintenance flows	steelhead			

[1] This option would receive a higher priority when resident fishery values are included.

SPORT FISHERY MANAGEMENT

MANAGEMENT OBJECTIVES

Taking into account what is known about the biophysical capability of lakes in the Nicola area, the present and future demand pressures, and a general impression of the regional priority of the Nicola basin, the following objectives are set for fisheries management in the Nicola.

1. To provide enough recreational angling opportunities to meet the expected increase in demand with a catch success rate at or above an average of one fish per angler-day through a combination of enhancement and regulation measures.
2. To maintain the diversity of angling opportunity available on the developed, natural and wilderness environment lakes in the area.

MANAGEMENT OPTIONS

Given the preceding analysis of supply and demand, three broad options for fisheries management can be identified for the Nicola planning unit:

1. Small Production Increase; increased emphasis on regulation of angling activity.
2. Medium Production Increase; employ current mix of enhancement and regulation measures.
3. Large Production Increase; emphasis on enhancement measures.

Table 4.4 summarizes the implications of these three options for fisheries management over the next ten to twenty years. The types of measures each option involves is discussed below.

OPTION # 1: SMALL PRODUCTION INCREASE

Table 4.5 outlines the fisheries management activities which are currently being undertaken in the Nicola planning unit and those which are

TABLE 4.4

SPORT FISHERY MANAGEMENT OPTIONS FOR THE NICOLA BASIN

OPTION	INCREASE IN FISH PRODUCTION	INCREASE IN[1] ANGLER-DAYS	SUCCESS RATE	COMMENTS
1. Small Production Increase	121,500-132,000	46,000-63,000	No lower than 1 fish/day	Emphasis on regulation of anglers (i.e., catch and release fisheries). Slower than potential growth in angler effort.
2. Medium Production Increase	286,000-296,500	122,000-144,000	Maintain Current Average success rates.	Combination of enhancement and regulation measures. Full potential demand growth to 1990; slower growth thereafter.
3. Large Production Increase	Up to 421,000	Up to 232,000	Increase Current average success rates.	Emphasis on enhancement measures. Full potential demand growth to 1990 and beyond.

Note:

[1] Increases in angler days are based on an average success rate of around 2 fish per ;day because much of the increased production involved Kokanee. The figure of 1 fish per day used in text refers to rainbow trout fishery. See page 64 for further explanation.

TABLE 4.5

CURRENT AND PLANNED FISHERIES MANAGEMENT ACTIVITIES IN THE NICOLA BASIN

(MANAGEMENT OPTION 1)

ACTIVITY	LAKES INVOLVED	ANTICIPATED HARVESTABLE PRODUCTION	ANTICIPATED[1] INCREASE IN ANGLER-DAYS	COST[2] CAPITAL	COST[2] OPERATING
1. Lake Stocking	- 33 lakes currently	Included in current estimate.	-		$50,700
	- 2 lakes planned	5000	3800-4500		$ 1,200
2. Lake Renabilitation	Hatheume Kane (left & right) Englishman Marquette Shea	10,500-20,800	8100-18,900	$20,000	$ 2,500-5,000
3. Lake Aeration	Lodgepole Logan Walloper Edna Centre Little Lundbom	11,000	8500-10,000	$30 000	$2 650
4. Provision/ Improvement of Access	Ellen Garcia Marquette Menzies Mildred Pikehead Rat		15,500-18,400	Staff Time Committment	
5. Kokanee Stocking	Stump	65,000	20,000		$28,000
6. Kokanee Enhancement-pilot program	Nicola	18,000-30,000	6000-10,000		$15,000
TOTAL		121,500-131,800	46,400-63,400	$65,000	$60,100

Notes:

[1] These figures do not include increased angler-days due to improved access.

[2] Costs are not discounted and do not take inflation into account. Capital costs represent one-time investments, operating costs are annual investments.

planned for the next year. These activities are justified given the level of funding available for fisheries management in the Thompson-Nicola region and the relative priority to direct funds to the Nicola basin.

Kokanee stocking programs such as that planned for Stump Lake will provide the single largest increase in angling opportunity and is a high regional priority. Improvement of natural spawning areas for kokanee in the future would allow production to continue independent of the Provincial hatchery program. The success of the pilot project planned to re-establish the kokanee run in Moore-Stump Creek could lead to larger scale programs of this kind in the future.

If all the activities listed in Table 4.5 are carried out according to plan, fish production will be increased by about 121 500 - 132 000 fish. Given the expected increase in demand, this level of production increase alone would not meet the objective of maintaining success rates at or above one fish per angler-day, beyond 1985. Increased emphasis on regulation of demand would be necessary in order to maintain catch success rates, possibly at the expense of total harvest. Angling opportunities provided would be roughly evenly distributed among the three lake types, satisfying the objective of diversity, with full production increases realized in five to ten years.

OPTION # 2: MEDIUM PRODUCTION INCREASE

Table 4.6 summarizes enhancement measures in addition to those presently planned in the Nicola. It is clear that there are many opportunities to provide the production increase necessary to satisfy angling demand to 1990 and increase catch success rates in the Nicola.

Under Option 2, a moderate increase in production over the present programme would be obtained from a full-scale program of kokanee enhancement to support increased angling on Nicola Lake. Water flow between Nicola and Douglas Lakes would have to be increased through storage on Douglas Lake. In other lakes, water storage rights are privately controlled and projects

TABLE 4.6
SPORT FISHERY ENHANCEMENT OPPORTUNITIES FOR THE NICOLA BASIN TO 1990

MANAGMENT OPTION 2

ACTIVITY	LAKE(S)*	MAXIMUM POTENTIAL PRODUCTION	MAXIMUM POTENTIAL INCREASE IN ANGLER-DAYS	COST CAPITAL	COST OPERATING
1. Lake Stocking	7 lakes	34,300	26,400-31,200		8300
2. Lake/ Rehabilitation	1 lake	1000	800-900	5000	250
3. Lake Aeration	2 lakes	5,400	4150-4900	20,000	1300
4. Improvement of Kokanee Spawning Habitat; Artificial Enhancement	Nicola	124,000	44,000	50,000	15,000
Option 2 Increase		164,700	75,400-81,000	75,000	24,800
Total Option 1		121,500-131,800	46,400-63,400	65,000	60,100
Total Option 2		286,200-296,500	121,800-144,400	140,000	84,900
MANAGEMENT OPTION 3					
6. Lake Stocking	8 lakes	39,200	30,100-35,600		9500
7. Lake Aeration	2 lakes	5400	4150-4400	20,000	1300
8. Improvement of Kokanee Spawning Habitat; Artificial Enhancement	Douglas	30,000-45,000	10,000-15,000	100,000	15,000
9. Spawning Improvement	Various Opportunites	30,000	23,100-27,300		
10. Water Level Control	Skunk (Other opportunities to be identified through survey work.)	5,000		50,000	3800-4500
Option 3 Increase		109,600-124,600	71,200-87,300	170,000	25,800
Total Option 2		286,200-296,500	121,800-144,400	140,000	84,900
Total Option 3		395,800-421,100	193,000-231,700	310,000	110,700

*Refer to Appendix VII for candidate lakes for each activity.

require agreement with individual ranchers in order to manipulate flows at critical spawning times.

Production increases of 296,000 to 307,000 harvestable fish could be obtained from a mix of enhancement opportunities outlined in Table 4.6 (Option 2), and would accommodate demand growth in the Nicola to 1990 at current average success rates without increasing emphasis on angling regulation. Beyond 1990, success rates would decline and greater control on use through harvest regulations would be necessary to protect fish populations.

OPTION #3: LARGE PRODUCTION INCREASE

The potential exists in the Nicola to increase fish production to a level that would meet the projected increase in angling demand at a higher success rate than is currently being realized (Table 4.6). This could be achieved by implementing all possible enhancement measures available in the basin to increase production of the maximum sustained yields of up to 750,000 fish. In this event, demand regulations would not change significantly from current practice. However, this option would require over $300,000 investment in capital costs, plus a total undiscounted and uninflated annual operations cost of $110,000.

SUMMARY

The Nicola Basin provides fishing managers with a wide array of options both in the supply and demand side. Its location will make it subject to increasing angling pressures over the next 20 years, but its lakes have the biological productivity to provide a sustained harvest to satisfy this demand, assuming that funds are available. The economic value of sport fishing at $21.00 per angling day will far outweight the costs of enhancement.

The level of production increases in the basin will depend on budget constraints and the relative importance of the Nicola in the context of

Provincial and Regional priorities. Option 1 could be implemented immediately under the funds now available through the Inland Fisheries Enhancement programme, but a final decision on the longer-turn management strategy should await the completion of a Regional fishing policy statement based on the completion of first draft to sport fishery strategic plans for the four other planning units in the Thompson-Nicola Region.

WILDLIFE MANAGEMENT OPTIONS

NON-GAME SPECIES

The Nicola basin contains a diversity of dry-land wildlife habitats supporting a wide variety of non-game species. It is important that this diversity be preserved over time because the Nicola basin represents one of the most significant areas of the Province where this range of dry-land habitats is still available. Over the next five years, an inventory analysis of key dry-land habitats that support this array of species should be undertaken. Such an inventory is currently underway in a trial basis in the Dewdrop area. Once these habitats have been identified, the Ministry will work with the Ministry of Forests and the local ranchers to ensure that a representative sample of these habitats are preserved over time. One way of achieving this objective is to encourage biological control on forest infestations to reduce the amount of clear cutting and the consequent damage to mature forest habitats. The strategic plan will be updated over the next five years as results of this inventory analysis become available.

GAME SPECIES

MULE DEER

The general objective for deer management in the Nicola is to obtain optimum output from the habitat base in keeping with Regional priorities. Because other planning units in the Region have more important big game populations, only a relatively modest management programmme can be supported in the Nicola. The following represent the objectives for deer management based on the preceding supply/demand analysis and the relative priority of the Nicola in its Regional context.

1. Regulate hunting activity and harvest of deer such that success rates are maintained at an average of 35 hunter days per deer killed over the next 5 years.
2. Maintain healthy herds (appropriate age structure), of deer in all major deer habitats to a total population of 3500 ± 1000 animals average over time.
3. Provide opportunities for high quality and diversified non-consumptive use of deer in their natural habitat.
4. Protect and enhance critical deer habitat.

To achieve these targets, the average population of mule deer in the basin should be increased by approximately 20 per cent in around 500 - 700 animals. This increase can be achieved by more intensive habitat management in both the grassland and Douglas Fir zones noted in Figure 3.11. The key measures to be pursued at the operational level of planning would be:

1. coordinated resource management of Crown rangelands
2. selective logging and prescribed burning on Crown Forest Lands
3. referral processes to protect present high quality habitats
4. harvest regulation to protect the biological viability of deer populations

With the demise of the current ARDSA programme, the future viability of co-ordinated land use planning is in doubt. Thus, over the short term, the main emphasis should be placed on co-operative land use planning with the Forest Service.

Given other wildlife management priorities in the Thompson-Nicola Region, the maximum budget that could be allocated to mule deer enhancement and protection over the next 5 years is $. This represents a reasonable level of management given other regional priorities and the value of other land uses in the basin.

WATERFOWL

In Chapter 3, it was projected that the demand for duck hunting would increase by around 40 percent over the next five years, i.e. around 12 000 days. This level of effort would require a sustainable harvest of between 7000-7500 birds.

The main enhancement areas are shown on Figure 4.20. Financial support for this programme would be provided by Ducks Unlimited, which is active in the Thompson-Nicola Region. The managers of that programme should ensure that the implementation of a waterfowl enhancement strategy is integrated as part of the operational level of planning in the Nicola. It is important that these priority measures be co-ordinated with water and lake fisheries management activities to avoid conflicts in resource use.

CHAPTER 5 RESPONSE TO THE STRATEGIC PLAN

INTRODUCTION

This chapter attempts to summarize public input received during the planning process. It includes comments received at all public mettings, in letters and briefs, the minutes of the Nicola Valley Water Resource Management Working Committee, and the completed questionnaires from the newspaper insert.

Detailed information on the "dialogue" with the public is contained in the appendices to this chapter, a brief overview is presented in the following section.

PUBLIC INVOLVEMENT PROCESS

The public involvement process was designed in consultation with the Nicola Valley Water Resource Management Working Committee, major interest groups and media in the area, and the MOE's Regional Headquarters. The objective of the process was to establish an on-going dialogue with the public. In terms of disseminating information, information depots, news media releases, personal and written correspondence, meetings, and the newspaper insert were among the vehicles used. Input was collected through meetings, personal and written correspondence, and questionnaires.

The public involvement process was open to any individual or organization who seemed themselves interested in the plan or the Nicola area. This included resident and non-resident interests, individual citizens, interest groups and private industry.

The input received from the public is documented in this chapter and will represent one data set in making decisions about the plan.

WATER MANAGEMENT - GENERAL

The Nicola Valley Water Resource Management Committee reiterated several concerns about the draft plan:

1. that watershed priorities should not be based exclusively on economics and should clearly be combined methodologies;
2. that realistically costs should be borne by the government since the beneficiaries of capital water works extend beyond the region and into the future; and
3. that additional information is required to appraise the option's for institutional arrangements.

The Nicola Valley Indian Administration repeatedly mentioned their concern that the plane seems to focus too narrowly on the Nicola mainstem rather than headwater and tributary storage. They shared a concern of a number of area residents - of a loss of local control over resource management.

There also seemed to be some disappointment that the strategic plan did not provide more specific resource management direction. The importance of water was reflected in the suggestions to licence groundwater and for the Ministry to investigate incentives for water use efficiency.

Of critical importance to the discussion of water management is financing capital improvements. Although it was recognized that a system whereby those who benefit contribute to the cost the distribution and absolute size of levy for each benefactor was not resolved. Both fisheries and agricultural interests sought to justify a lower argument of costs on the basis of the primary of their claim to water resources and to expand the scope of benefits occurring to their sector. It finally came to the point that capital expenditures should be funded from government revenues given the wide range of people who indirectly benefit along with a modest levy to those who benefit directly (i.e. to avoid assigning an onerous financial burden during a period of economic recession).

WATER MANAGEMENT OBJECTIVES

For response to a question, the Ministry indicated that the objectives may not always be met and that the order of the objectives does not reflect their importance. Residents were assured that the seniority of licences would be honoured and that licences would be issued down to minimum flows. Additional licences would only be issued if supported by additional storage.

On several occasions, ranchers explained that assurances of irrigation water flows 4 in 5 years was inadequate and 9 in 10 years is more appropriate as a water management objective.

Ministry personnel explained that although floodplain management and property protection was a water management objective this would only be undertaken subsequent to a flood and where the number of affected properties justifies the expense of dyking. In any event, Indian lands would not enjoy this protection.

ANADROMOUS FISHERIES MANAGEMENT

The bulk of public comment regarding anadromous fisheries was received in response to the questionnaire. The findings are as follows:

Maximize production	10
Increase in high priority systems	6
Maintain current production levels	4
Undecided	-
Other	1

Those who wanted to maximize production (10 mentions) suggested that the fishery should be returned to historic levels (2 comments), provides an important food source (2 comments), and is economically justified. It was also noted that people outside the area benefit from this production (2 comments) but it should not jeopardize beef production.

Those who wanted the increase in high priority systems (6 mentions) generally felt it would be a cost-effective approach.

Those who would maintain current production levels (4 mentions) felt the benefits of an increase would only accrue to outside interests (2 comments), pessimism about attempting an increase given the pollution in the Nicola River and causing over-fishing.

WATERSHED ANALYSIS - UPPER NICOLA

There were very few comments specifically about the Upper Nicola watershed. However, runoff from agricultural operations (fertilizer runoff and overwintering cattle near streams) was thought to contribute to the eutrophication of Nicola Lake. There appears to be some uncertainty about the suitability of Douglas Lake for increased storage because of a low floodplain, the presence of Indian lands and concerns of the Douglas Lake Ranch about negative effects of a raised water table. It was acknowledged that further study would be required.

WATERSHED ANALYSIS - MIDDLE/LOWER NICOLA

It was agreed that natural regulation of Nicola Lake was unacceptable however, there were several caveats attached to any capital works. People wanted more information on the specifications of the dam (e.g. greater capacity for freshet control, and to permit discharge flows when lake is low) as well as the total costs and benefits of the dam along with an understanding of the distribution of those costs and benefits. Individuals requested and were given assurances that there would be an opportunity for the public to provide input to specific dam plans.

A number of resource management options were presented for the Nicola mainstem, the findings are somewhat unclear:

Total Number of Respondents	21*
Replace Nicola Dam, provide additional storage	13
Improve irrigator efficiencies	10
Repair Nicola Dam, create Douglas Lake storage	5
Repair Nicola Dam, no additional storage	2

* Number multiple responses

While replacing the dam and providing additional storage (13 mentions) was the most frequently chosen option many individuals did not necessarily construe that the additional storage would occur on Nicola Lake. Indeed, the bulk of public input indicates a belief that replacing the dam would be more cost-effective than repair, over the long run (4 comments) and many felt that the additional storage would occur in headwater and tributary storage (4 comments). Those that commented felt both fish and agriculture should enjoy any benefits (2 comments).

However, comments received in letters and during meetings suggests a strong negative reaction to changing the level of Nicola Lake - particularly from waterfront property owners and natives. The waterfront property owners were concerned about further reductions in lot sizes from increased water levels, and increased risk of floods. Many individuals felt there was a cause-effect relationship between higher water levels and deteriorating water quality in Nicola Lake. Similarly, there was strong negative reaction to providing 'negative storage' on Nicola Lake and the unknown effect on the water table, downstream water users and the costs to renovate waterworks (e.g. dig wells deeper).

Improving irrigator efficiencies (10 mentions) was the second most frequently mentioned option. The supporting comments indicate that this should be a cornerstone of water resource management which may preclude the requirement for additional storage. The Nicola Valley Water Resource Management Working Committee was uncertain about how to encourage this (e.g. subsidier ?) and secured assurances that the Ministry would regulate water diversions not privately-owned storages and that licenced rights and storages would be respected.

Those who chose repairing the Nicola Dam and storage on Douglas Lake (5 mentions) explained that it was important to provide storage for runoff and that all opportunities for headwater and tributary storage should be considered. There were some strong reservations about the suitability of Douglas Lake for storage (see "Watershed Analysis - Upper Nicola").

There were relatively few comments about flood control on the Middle/Lower Nicola although it was perceived that increased storage capabilities would reduce the risk of freshet flooding. However, renovations to the Nicola Lake dam which allowed greater drawdown were seen as a cause of downstream flooding if not properly managed.

There was considerable concern about water quality in the Middle/Lower Nicola related to Nicola Lake, the Merritt Sewage Treatment Plant and heavy metals. It is popularly - held that the residence time of water in Nicola Lake (from the current above-normal lake levels) and the inflow of upstream agricultural runoff is in large part responsible for the deteriorated water quality which is evident in algae blooms, fish kills, surface scum, the loss of swimming opportunities and use of the water for drinking. Graphic and detailed accounts of the inadequate sewage treatment in Merritt were frequently recounted. It seems that there is a long history of abuse of water quality which has not been adequately addressed to date. In addition, there are concerns about the presence of heavy metals flowing into the Nicola from the Guichon.

Given the current lack of knowledge about groundwater the Nicola Valley Water Resource Management Working Committee indicated its opposition to increased use of groundwater. This concern about groundwater was also evident in the opposition to negative storage on Nicola Lake.

WATERSHED ANALYSIS - QUILCHENA

Many people responded positively to the suggested option for storage development and a monitoring program. A number of headwater and tributary sites were tendered from consideration on storage for freshet flows (e.g. Pothole Lake). This is also reflected in the response to the questionnaire (see "Watershed Analysis - Clapperton"). Again the question of cost sharing arrangements to finance capital was raised.

WATERSHED ANALYSIS - MOORE-STUMP

One individual indicated that there are not many water storage opportunities in the Moore-Stump watershed but that diverting floodwaters from Moore Creek to Stump Lake would be worthwhile. Further insight was provided in the questionnaire (see "Watershed Analysis - Clapperton").

WATERSHED ANALYSIS - CLAPPERTON

There was relatively little input regarding the Clapperton watershed. However, the conclusion in the plan that fisheries potential is low in this area was successfully challenged - especially since Clapp Lake is seen as a very productive lake for fish.

For the questionnaire, the Quilchena, Clapperton and Moore-Stump watersheds were grouped together because of the similarity of the current resource management situations and the proposed management options. The findings are as follows:

	Total Number	21*
Increase storage		12
Improve irrigator efficiency		11
Undecided		1
Other		1
No answer		2

* Number multiple responses

A number of respondents chose more than one option (i.e. increasing strorage <u>and</u> improving irrigator efficiency).

Those individuals who chose increasing storage (12 mentions) explained that the potential exists in a number of headwaters and tributaries (e.g. Stump Lake, Fox, Susan, and Surrey) which could capture freshet flows for disribution later in the year. It was suggested that both in-stream and consumptive uses should enjoy the benefits of increased storage, although there was some feeling that consumptive uses should be given priority.

Improving irrigator efficiency (11 mentions) was frequently mentioned. Pipe irrigation was recognized as reflecting better resource management than flood irrigation and should be encouraged (5 comments). Improving efficiency also represents a cost-effective solution to water shortages which will not disturb the natural balance.

WATERSHED ANALYSIS - GUICHON

There were a number of comments received about the Guichon watershed. The Nicola Valley Water Resource Management Working Committee mentioned that both the Guichon Creek Indian lands and the Highland Valley mining companies should be involved in operational plans for this area and the mining companies should share in any capital expenditures.

The response to the questionnaire was as follows:

Total Number	21*
Change diversion points and improve irrigator efficiencies	11
Develop storage, regulate flow on Mammit Lake	10
Undecided	2
Other	1
No Answer	1

*Number multiple responses

Those who chose changing diversion points and improving irrigator efficiencies (11 mentions) explained that this would be a good solution since efficiency is always a desirable goal. It was also pointed out that it would preclude the withdrawal abuses on the Guichon since pipelines could more easily be monitored. The fishery would benefit from better water management.

Those who chose developing storage and regulating flows on Mammit Lake (10 mentions) explained that small storages on tributaries could contribute to year-round flows which would benefit both agriculture and fisheries. Although the Mammit Lake storage facility may be inadequate, it may not be economical to improve. Further study of this facility was suggested.

The Nicola Valley Indian Administration, both as an independent organization and as a result of the Nicola Valley Water Resource Management Working Committee, experienced extreme apprehension about the transfer of water from the Guichon to Thompson-Bonaparte watersheds through Highland Valley mining operations and draining Quiltanton Lake. Their concern relates to the effect on creek drainage, groundwater levels, and downstream flows as well as moral concern about significant alterations to environmental systems. The NVWRMC also had concerns that water drawn off for mining precludes its use in agriculture, particularly since Indians in the area are becoming involved in intensive agriculture and require water for irrigation.

It was noted that historically, sockeye salmon were present in the Guichon and although not a high priority, Federal Fisheries has considered stocking the Guichon with coho salmon.

There were major concerns expressed by individuals and the Nicola Valley Water Resource Management Working Committee about the presence of heavy metals in the Guichon. It is claimed that levels of heavy metals exceed acceptable levels and are a direct consequence of mining operations in the Highland Valley. At present the water is felt to be unsuitable for irrigation and fisheries. Immediate remedial actions were suggested, the cost of which should be borne by the mining companies.

While groundwater was recognized as an additional source of water the NVWRMWC suggested that "limited use" should be more clearly delineated as should the feasibility of groundwater use.

WATERSHED ANALYSIS - COLDWATER

The Nicola Valley Water Resource Management Working Committee expressed strong disagreement with the designation of fisheries as the priority use of the Coldwater. The analysis leading to this conclusion were felt to be biased and did not recognize the need for multiple use of resources. The Committee and individuals felt that this designation would restrict further agricultural development in the area. This was felt to be unnecessary since there is enough water and storage sites in the headwaters to accomodate fisheries and agricultural development. The issue of cost-sharing for storage development was raised but not resolved.

In terms of water quality, the Merritt effluent discharges were mentioned (see "Watershed Analysis - Middle/Lower Nicola") as were sedimentation caused by forest harvesting. It was suggested that irrigation would control erosion and contribute to a reduction of suspended particulates in the water. It was noted that the strict enforcement of regulations would preserve stream quality and prevent erosion. There were not comments related to irrigator efficiencies on the Coldwater.

Further discussion of the Coldwater is included in the questionnaire summary of the following section of this chapter.

WATERSHED ANALYSIS - SPIUS

Both ranchers and natives were in strong disagreement with the option of maintaining the river in its present state and thereby restricting further agricultural development. It was pointed out that B.C. Hydro had found a potential dam site at Box Canyon which would not jeopardize fish populations. The construction of a fish hatchery by Federal Fish was perceived as reinforcing the strategic plan's designation of this watershed for fisheries.

In the questionnaire, the Coldwater and Spius watersheds were combined, with the following results:

Total Number	21
Protect fisheries flows	10
Develop storage on Coldwater	8
Undecided	3
Other	1

Those who chose protecting fisheries flows (10 mentions) explained that fisheries habitat damage from logging and low flows must be curtailed (3 comments) in order to preserve salmon spawning grounds.

It was suggested that storage on the Coldwater (8 mentions) could be developed subsequent to studies of the potential of headwaters and tributaries. This storage could provide increased control by containing freshet flows for distribution later in the year (4 comments). Storage facilities should be designed to benefit both fisheries and irrigation (2 comments). While the potential locations may be limited, Midday, Howarth, and Vaght Creeks were suggested.

SPORT FISHERY MANAGEMENT

On several occasions, the Nicola Valley Indian Administration explained that "sport fishery management" is a misnomer since they consider fishing a necessary subsistence activity, not a sport. Further, they point out that "coarse fish" reflects a value judgement based on the perspective of recreation rather than nutrition. Not simply a matter of semantics, the natives were also suggesting that the importance of their food fishery be reflected in sport fishery management.

A detailed submission from the B.C. Wildlife Federation challenged the target of 1 fish per angler day as being two low and contrary to the accepted provincial standard of 2 fish per angler day (per. Ministry of Environment - Island Fisheries Enhancement Plan - Sec. 1981). The Federation felt a lower target reflects a low esteem placed on the sport fishery, and, given the many factors which erode the success rate may well preclude the achievement of the 2 fish per day goal over the long term.

The findings of the questionnaire suggest that most respondents prefer at least a moderate increase in fish production.

Total Number	21
Maximum production increase	8
Moderate production increase	7
Small production increase	3
Undecided	1
Other	1
No answer	1

Those who chose maximizing production increase (8 mentions) mainly based their decision on the anticipated future requirement for fish, particularly as a consequence of the Coquihalla Highway traffic (6 comments). There was also some comment that this approach would be more economical over the long term and in cost per fish produced.

The choice of moderate production increase (7 mentions) appears to be a compromise solution which delivers more fish in recognition of increased requirements but without a major investment of funds.

WILDLIFE MANAGEMENT

There were relatively few comments about wildlife management beyond input included in the questionnaire. The B.C. Wildlife Federation interprets the absence of clear statements about wildlife as indicative of low esteem for the resource. The Nicola Valley Water Resource Management Working Committee inquired whether preserving diversity includes re-establishing historic species (e.g. elk).

The findings of the questionnaire follow:

Total Number	21*
Protect endangered species	11
Moderate increase in the population	9
Maintain current deer population	7
Maximize deer population	3

* Number multiple responses

Those who want to protect endangered species (11 mentions) explained that they do not perceive this as an option and that an immediate response through whatever means necessary (e.g. regulation and enhancing opportunities for survival) should be implemented.

A moderate increase in deer population (9 mentions) was thought to be a reasonable goal under multiple use resource management (i.e. forestry harvesting could enhance deer habitat) (3 comments). It was recognized that increased demand, and biophysical capability exist, however ranches limit the amount of winter range available and wildlife regulations need enforcement.

Those who chose maintaining current deer populations (7 mentions) mention a variety of reasons from satisfaction with the status quo, to not encouraging further hunting.

INSTITUTIONAL ARRANGEMENTS

There was little specific direction available from the public on institutional arrangements. One individual wondered whether the Okanagan Basin Implementation Board and their financing/taxation methods can be used as a model. Another person commented that the Ministry of Environment should be the management agency since the resource management expertise existed on staff. However, the bulk of opinion, repeatedly voiced by the Nicola Valley Water Resource Management Working Committee was that there was insufficient information provided to decide whether the Ministry of Environment or the Regional Districk should manager water storage.

ADDITIONAL COMMENTS

A wide range of additional comments were received, and include the following:

- the plan is approaching completion although many questions have remained unanswered for years (2 comments);
- storage should be maximized (2 comments);
- use ARDSA type programs to construct storage facilities and encourage pipe irrigation;
- use language and terminology in documents which is understood by lay-reader;
- increased fish and wildlife production will follow increased water control;
- the enforcement role of B.C. Cattlemen's Association in water quality abuse by ranchers;
- ensure water quality is maintained (2 comments);
- regardless of Coquihalla Highway, government's first responsibility is to Nicola residents (2 comments);
- concern re loss of local control over resource management (2 comments); and
- concern re methodologies used in agriculture-related calculations.

There were several comments which recognized the importance of public input to the planning process and expressed appreciation of the opportunity to participate. There was interest in further public participation both in reviewing the design for the Nicola Lake Dam and in the operational plans for this Basin.

SUMMARY OF COMMENT FROM GOVERNMENT AGENCIES

Written submissions were received from the Ministries of Health; Forests; Transportation and Highways; Lands, Parks and Housing; Agriculture and Food; and Energy, Mines and Petroleum Resources.

Although these comments covered a wide range, the most frequently mentioned related to:

- the Nicola Lake dam;
- the role of inter-ministry consultation, and RMC;
- inaccuracies in the data base;
- the responsibility attributed to various resource sectors for degrading water quality; and
- uncertainties regarding the planning process.

1. Ministry of Health (per W. P. Moorehead, Medical Health Officer and Director)
(letter to Regional Headquarters - Januay 12, 1983)

The Ministry of Health provided comments on three aspects of the plan;

1. Merritt Sewage Treatment Plant;
2. Water Quality Standards; and
3. Nicola Lake Dam.

1. The Ministry agreed with the long-term objective of discharging effluent to land rather than the Coldwater and Nicola Rivers, and would provide technical advice in this regard.

2. The Ministry has adopted National Health and Welfare's Guidelines for Canadian Drinking Water Quality - 1978 as its standards and suggests that this be reflected in the plan. Specifically, for drinking water, the maximum allowable concentrations should be as follows:

pH	6.5 - 8.5
nitrate	10 mg/litre
nitrite	1 mg/litre
fecal coliform	90% of raw water samples during a 30-day period should have total coliform density of less than 100 organisms per 100 ml and fecal coliform density of less than 10 per 100 ml (only simple disinfection of water should be required.
turbidity	5 nephelometric turbidity units (NTU) is acceptable with an objective concentration of 1 NTU.

3. Increasing water storage levels on Nicola Lake could flood private sewage disposal systems at the lower end of the lake (eg. Harmon Estates Subdivision) and create difficulties for establishing additional disposal fields.

2. Ministry of Forests (per A. B. Robinson, Regional Director)
(letter to Regional Headquarters - October 7, 1982)

The Ministry of Forests mentioned a number of specific concerns which had been drawn from the plan summary and technical analysis documents. They pointed out that:

- clearcutting is a standard agricultural practice for Lodgepole pine types and Spruce-subalpine fir types whereas dry-belt Douglas fir types are selectively (ref. plan summary p. 39);
- contrary to the inference extended, there is consultation between Forests and Environment (ref. plan summary p. 44);
- they disagree with the description of the forest industry's future which they perceive as being too pessimistic (ref. technical analysis, chapter 2, p. 14);
- Lands, Parks and Housing should be noted as being responsible for issuing tenures for Crown grazing leases (ref. plan summary p. 44 and technical analysis p. 179).

3. <u>Ministry of Transportation and Highways</u> (per W. P. Puhallo, Regional Aproving Officer) (letter to Regional Headquarters September 28, 1982)

The Ministry of Transportation and Highways expressed concern that fluctuations in lake levels has, to date, affected slope stability and caused roadbed settling problems. Further, on windy days with high lake levels, waves and spray blow across the highway. They recommend against significant increases in the level of Nicola Lake on the basis of degenerative effects on Highway 5 between Douglas Lake Road and the Quilchena Reserve Bridge.

4. <u>Ministry of Lands, Parks and Housing</u> (per A. B. Campbell, Regional Director) (letter to Regional Headquarters - October 18, 1982)

The Ministry of Energy, Mines and Petroleum Resourses noted several inaccuracies in the technical analysis document:

- whether heavy metals in the Guichon watershed occur naturally or are a result of mining activity (as is implied in the analysis) (ref. p. 7, 52, 75, 77, 80, 85, 151, 155);
- it is implied that only mining activity adversely affects fish (ref. p. 155);
- the plan incorrectly describes water use in mining. While Bethlehem and Highmont use groundwater for processing, Lornex uses it for potable water only. Lornex process water is provided by tailings watershed catchment, recycling and withdrawal from the Thompson River (ref. p. 38);
- Dekalb Mining Corporation is neither operating nor located in the Nicola watershed (ref. p. 15);

- it is appreciatively noted that groundwater supplies are adequate to meet domestic and industrial requirements at this time (ref. p. 43).

7. Ministry of Agriculture and Food (per J. D. Anderson, Director, Farmland Resources Branch)
(letter to Planning and Assessment Branch - January 10, 1983)

This submission included comments related to (1) the planning process, and (2) the Nicola Basin Strategic Plan, itself.

1. * the planning process is percieved as "unreasoned advocacy" as exemplified in:

- the increased allocation of water to anadromous fishery rather than agriculture;
- the "accusation" that agriculture is largely responsible for degrading water quality and fisheries;
- the use of unacceptable criteria in the cost-benefit analysis;

* the deference shown for guaranteeing water supply to mining and industrial and assurance of irrigation supplies 4 in 5 years.

It is also noted that budget allocations will not necessarily flow from the planning process. Consequently, reference to A.R.D.S.A. funding should be removed.

Relative to the Plan's options:

Upper/Middle/Lower Nicola - agreement on priorities of fish and irrigation and replacing the dam with increased storage if all benefactors contribute to the cost.

Quilchena, Clapperton, Moore, Stump - agreement on fisheries increase and irrigation priority as well as the principle of increased storage.

Guichon Creek - agree with priorities and further study on increased storage and relocated intakes.

Coldwater, Spius - recommend irrigation as a priority given the current and potential demand for cattle in this basin.

The submission also notes that efficient use of water should be a water management objective not an option. Finally, it is suggested that the plan should be build on consensus rather than conflict resolution.

A more specific critique of the draft plan listed the following concerns:

- uncertainty about evaluation methods for irrigation efficiency and impacts of agriculture on water quality (ref. p. 1, para. 1);
- cause-effect relationship between irrigation diversions and declining fishery flows felt to be misleading (ref. p. 4, para. 3);
- overstated impact of cattle operations on Nicola Lake eutrophication.

More specific comments were provided in an attached document prepared by the Farmland Resources Branch of the Ministry of Agriculture and Food, and are summarized below:

- Ministry of Agriculture and Food should participate in any research related to irrigation (ref. p. 2, para. 1);
- misleading statement that irrigation diversions negatively affect fisheries flows (ref. p. 4, para. 3;
- misleading statement that cattle operations affect Nicola Lake wate quality (ref. p. 8, para. 2);
- misleading prospectus for agricultural development (ref. p. 8, para. 3);
- water management objective should be to meet domestic and irrigation demand at all times, and in advance of industrial demands (ref. p. 10, point 2);

- missing reference to demands for licenced diversions in Middle and Lower Nicola (ref. p. 13);
- incorrect statement about land use assessment (ref. p. 14, para. 1);
- failure to include commercial over-harvest of anadromous fish as contributing to low local fish production (ref. p. 14, para. 2);
- more detailed soil surveys are required to assess agricultural capability (ref. Table 2 footnotes);
- information and consultation on methodology for economic and social assessment sought (ref. p. 19);
- incorrect reference that switch to sprinkler systems is a response to increasing costs of ditch irrigation (ref. p. 24);
- what are criteria for allocating 'saved' water (ref. p. 25, point ii);
- incorrect cost-benefit analysis of fisheries relative to agriculture (ref. p. 25);
- is per fish value of steelhead $191 as indicated? (ref. p. 26, footnote 7);
- concern re understated importance of agricultural development on Coldwater and Spius (ref. p. 28);
- absence of financial incentives for switching diversion from Lower Quilchena to Nicola Lake (ref. p. 31, Quilchena #2);
- concern re Regional District administration of waterworks and the distribution of costs (ref. p. 32-36);
- recommend federal government water quality standards (ref. p. 37, table 7);
- recommend monitoring the role of septic tank sewage and restricted flushing as contributing to Nicola Lake water quality problems (ref. p. 40);
- the active role of the Agricultural Environmental Services Program (AESP) in non-point discharges is noted (ref. p. 41, #3);
- Ministry of Agriculture and Food should be involved in operational level planning through C.R.M.P. and wildlife habitat considerations (ref. p. 49, para. 3; p. 53, point 8).

CHAPTER 6 CONCLUSIONS AND RECOMMENDED MANAGEMENT STRATEGY

On the basis of the technical analysis undertaken by the Ministry staff and the responses obtained by other government ministries and by the public, the main conclusions of the plan are as follows:

1. There appears to be sufficient water resources in the Nicola basin to supply both fishing and agricultural requirements for the foreseeable future (20 years). However, they will have to be managed more carefully than at present through a combination of additional storage and more efficient use of water already licenced for irrigation purposes. There will also have to be additional monitoring of stream flows in a number of tributaries in order to design efficient levels of storage and control water releases to meet the multiple needs of water and agriculture.
2. The present institutional arrangements for financing, building and operating additional storages to support fishery and irrigation water requirements are inadequate. Immediate analysis is required to arrange cost-sharing agreements between the Ministries involved in fishery management and those financing agricultural development. In addition, new procedures must be developed to include the Regional District of Thompson-Nicola and the benefitting ranchers in the financing and operating of new storage works.
3. Deteriorating water quality is a growing problem, especially in the mainstem Nicola River and Nicola Lake and in Guichon Creek. The main sources of pollution are the Merritt Sewage Treatment Plant, runoff from agricultural operations along the streambanks and surface flows off the open-pit mining areas in the Guichon watershed. At present, there is no evidence that declining water quality has had a direct impact on fisheries, but if fishery resources are to be increased in the future, levels of water quality must be improved for security.

4. Current production of anadromous fish is well below historical levels, largely due to poor recruitment as a result of over-harvesting on the coast and in some watersheds, low summer flows. If in-stream flows can be guaranteed, enhancement opportunities exist largely through stocking streams with fry, to double present levels of production.
5. Success rates of sport fishing in the basin's lakes have declined over the past decade from over 2 fish per day to around 1.1-1.3 fish per day. This decline is largely the result of increased angling activity. The potential exists in the basin to double current levels of sport fish productivity, but budget constraints will limit the levels of enhancement that can be undertaken.
6. Opportunities exist to increase populations of mule deer by protecting key winter habitats and through co-operative forest and range programmes with the Ministries of Forests and Lands, Parks and Housing respectively. More attention must be paid to the inventory and protection of a range of habitats supporting a diversity of dry-land, non-game species, especially endangered species such as the burrowing owl. Waterfowl habitats, scattered throughout the basin can also be protected and enhanced through the combined efforts of the Ministry of Environment and Ducks Unlimited.

RECOMMENDED MANAGEMENT STRATEGY

The dominant aspect of an environmental management strategy for the Nicola basin is improved water supply and water quality controls. In all watersheds of the Nicola basin, all presently controlled flows of water are fully allocated to either irrigation licenced users or to fisheries. This means that no further licencing for water in any stream can be permitted without the support of additional storage. Alternatively, current licences might extend their irrigated acreage a little, through more efficient use of their licenced water. However, this will restrict future irrigation expansion to a few areas in the basin.

Thus the major facets of a water supply management approach for the Nicola basin are:

- devise institutional arrangements to finance, construct and operate new storages
- increase hydrometric monitoring in selected tributary streams to improve water yield estimates for future storage development and resulting water allocation
- monitor licenced users to encourage more efficient use of water.

STORAGE DEVELOPMENT

It is recommended that storage development in Nicola Lake be given first priority. The present dam structure must be repaired or replaced in a few years; hydrologic data are adequate to design the storage and the water will supply the multiple needs of fisheries, stream water improvement and irrigation. Consequently, if institutional arrangements can be developed to construct and operate this storage unit, they will provide the basis for development of additional storages on tributary streams in the future.

To meet long-term needs for irrigation and fisheries, Nicola Lake storage should be increased. This means replacing the present structure with a new dam at a capital cost of approximately $2 million. Thus over the next couple of years, the following activities are required:

- cost-sharing agreement between B.C. Ministry of Environment and the Department of Fisheries and Oceans on the financing of the new dam between fishery and non-fishery interests
- cost-sharing agreement under ARDSA to fund the proportion of costs for agricultural purposes between the Federal and Provincial governments and the local beneficiaries
- cost-sharing agreement between the Regional District and benefitting ranchers on the local share of costs

- arrangements with the Regional District to take on the responsibility of owning and operating the new storage under an agreement with B.C. Ministry of Environment and Federal Fisheries
- detailed design of dam plus lake level operation to ensure no impacts on shoreline developments around the lake due to changes in present operating levels
- assessment of the impact a new dam may have on Nicola Lake water quality.
- full discussions with all affected parties over this design period to inform them of progress, opportunities, costs and consequences

STREAMFLOW MONITORING AND TRIBUTARY STORAGE

To prepare for additional storage development in the tributary watersheds over the next 10 years, hydrologic stream gauges should be installed on the Upper Nicola, Guichon and Moore-Stump Creeks. In addition, detailed storage reconnaissance should be undertaken by the Ministry on Upper Nicola, Quilchena, Coldwater, Guichon and Moore-Stump Creeks in the next couple of years with flooding reserves placed on potential sites. These reserves will restrict further development on lake shores, thus reducing costs of development.

MONITORING WATER USE

To protect current stocks of anadromous fish, minimum in-stream flows for fish in the Coldwater (1.42 cms), Spius (2.22 cms), and Nicola Rivers (N1 5.66 cms, N2 3.12 cms, N3 1.70 cms) should be protected. The Ministry of Environment should monitor selected licences in the basin to ensure compliance with existing water licence conditions and design a detailed contingency plan for allocating water between licenced users and fishery interests in the event of a major drought. This analysis should also examine the opportunities for switching diversion points from the lower reaches of some tributaries (Guichon, Clapperton for example) to the main-stem Nicola.

WATER MANAGEMENT IN TRIBUTARIES

Once the Nicola Lake dam is replaced, or failing an agreement between governments on cost-sharing, repaired, selected tributary watersheds should be subject to detailed operational-level planning. Based on information acquired through hydrologic monitoring, storage reconnaissance, any water use effiencies, a hydrologic analysis of supply and demand can be undertaken at a detailed level. This will lead to specific management measures, such as construction of additional storages, and regulation to meet fishery and irrigation requirements. Cost-sharing and operating responsibilities would follow the same institutional arrangements as established for the Nicola Lake dam. The priority watersheds for such a detailed level of analysis include Upper Nicola, Guichon and Moore-Stump. The second level priorities should include Coldwater, Quilchena and Clapperton Creeks.

ANADROMOUS FISHERIES MANAGEMENT

Assuming that fishery flows are provided with an adequate frequency in the key watersheds of the mainstem Nicola, Coldwater, Spius and Guichon Creeks, both the Federal Department of Fisheries and Oceans and the Fish and Wildlife Branch of the B.C. Ministry of Environment should jointly undertake stock enhancement as indicated in this plan. Funding for the programme should be sought under the Salmonid Enhancement Programme.

WATER QUALITY IMPROVEMENTS

The quality of effluent from the Merritt STP must be upgraded to ensure that ambient water quality objectives for the Lower Coldwater and Nicola Rivers remain well above thresholds for fishery production. Operational planning must continue to determine the most cost-effective means of sewage treatment, through rapid infiltration to ground, spray irrigation or tertiary treatment at the plant. A major aspect of this program will be the development of an agreement on cost-sharing involving the senior governments and the City of Merritt. At present, technical studies on infiltration to ground are underway.

To ensure water quality in the Nicola basin is maintained at levels required to support designated uses, ambient objectives must be developed for priority streams - Nicola River, Guichon Creek and Upper Nicola. Additional in-stream water quality monitoring will be required to support this analysis and should be incorporated into Ministry budgets over the next few years.

Over the next five years the Ministry must develop effective means for reducing nutrient loadings to the tributaries to Nicola Lake and in the mainstem Nicola. Nicola Lake will continue to be eutrophic for the foreseeable future, but controls on the major sources of nutrient loading should prevent the lake water quality from further deterioration. This would be a benefit for water-based recreation and the sport-fishery. In conjunction with the water quality monitoring noted above, specific controls on identified major nutrient loadings sources from agricultural operations could be undertaken through a co-operative agricultural control program involving government and the ranchers involved.

The other major water quality management priority is to reduce contamination of Guichon Creek by heavy metals leached from mining operations. A co-operative water quality monitoring program involving the mining industry and the Ministry should be established to identify major sources, develop effective controls and establish appropriate ambient water quality objectives of the watershed to protect public health and the sport and anadromous fishery.

SPORT FISHERY MANAGEMENT

The Nicola basin contains potentially one of the most productive small lake sport fisheries in the province. With its easy access to major population centres in the Lower Mainland and Kamloops, the Ministry places a high priority on providing an adequate sport fish harvest potential to satisfy this demand.

The public who responded to the three fishery management objectives set out in Table 10 generally preferred option three - a high increase in production. However, given current budget constraints and competing demands for increasing fish production in other parts of the Region, the Ministry has established option 2 (medium increase in fish production) as its management objective. This will involve an increase of between 130,000 and 150,000 harvestable sport fish in the basin over the next five years. The total costs of such a programme are estimated at between $480,000 and $530,000 in 1982 dollars.

The main components of this programme will be increased rainbow trout production in selected headwater lakes through stocking, rehabilitation and aeration, stocking Stump Lake with kokanee on a trial basis and improving public access to lakes that are currently underutilized. Towards the end of the five-year period, emphasis will shift to improving the sport fishery on Nicola Lake through increased flows on the Nicola River as a result of storage development on Douglas or other headwater lakes and improvements to Nicola Lake water quality. Nicola Lake could provide an increased harvest of around 57,000 fish or approximately one-third of the production target for sport fishery in the Nicola.

WILDLIFE MANAGEMENT

The key management objective for wildlife resources is to protect and manage dry-land habitats for both game and non-game species. Over the next five years, the Ministry should undertake an inventory of dry-land habitats essential for the protection of the diversity of wildlife species in the dry-interior, with particular emphasis on endangered species such as the Burrowing Owl. Once these habitats have been identified, specific agreements should be negotiated with the Ministry of Lands, Parks and Housing and the Ministry of Forests to manage these habitats for wildlife.

The management target for mule deer in the basin is set at 5600-6000 ± 1000 with a hunter success rate of no less than 35 days per kill. This target will be used to negotiate future land use decisions with other Ministries.

Because the Nicola basin contains the highest waterfowl production potential of the strategic planning units in the basin, populations should be increased through entering into management agreements with Ducks Unlimited on the lakes and marshes.

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APPENDICES

APPENDIX 1

MONTHLY RESIDUAL BASIN OUTLET FLOWS AT SELECTED LOW FLOW RETURN PERIODS (m^3s^{-1})

(Using Entire Available Record)

COLDWATER WATERSHED[1]

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1:2	1.78	2.11	3.08	9.31	29.7	30.9	9.15	1.49	1.14	2.12	3.00	2.79
1:5	0.975	1.17	1.85	5.50	22.0	20.2	4.57	0.800	0.628	1.26	1.75	1.34
1:10	0.781	0.929	1.50	3.91	18.9	15.1	2.77	0.591	0.457	0.974	1.29	0.870
1:20	0.678	0.801	1.28	2.77	16.6	11.1	1.51	0.468	0.350	0.785	0.979	0.592

UPPER NICOLA WATERSHED[2]

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1:2	0.502	0.786	0.769	1.35	15.4	14.2	4.23	0.747	0.365	0.221	0.390	0.312
1:5	0.365	0.597	0.594	0.858	10.3	8.22	2.62	0.307	0.119	0.064	0.144	0.116
1:10	0.320	0.497	0.481	0.661	8.25	5.90	2.01	0.219	0.067	0.034	0.086	0.074
1:20	0.291	0.415	0.374	0.523	6.76	4.28	1.61	0.178	0.041	0.020	0.057	0.053

MIDDLE NICOLA[3]

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1.2	3.83	4.40	5.06	11.91	42.0	48.0	14.9 (1)	4.67	3.08	4.04	4.70	4.06
1:5	2.48	3.05	3.78	8.28	32.3	32.7	9.41	3.20	2.12	2.80	2.67	2.24
1:10	1.97	2.60	3.34	6.83	28.6	26.8	7.55	2.71	1.85	2.28	1.87	1.68
1:20	1.64	2.32	3.05	5.83	26.1	22.9	6.37	2.40	1.70	1.89	1.33	1.35

1 Using W.S.C. gauge 08LG010, Coldwater River at Merritt.

2 Using W.S.C. gauge 08LG049, Nicola River above Nicola Lake, which is above some irrigation diversions.

3 Using W.S.C. gauge 08LG007, Nicola River above Merritt.

APPENDIX 1 (Continued)

GUICHON CREEK[1]

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1:2	0.252	0.289	0.328	0.732	4.15	1.89	0.626	0.171	0.125	0.164	0.217	0.236
1:5	0.158	0.195	0.187	0.336	1.33	0.475	0.164	0.034	0.044	0.062	0.102	0.131
1:10	0.119	0.157	0.141	0.203	0.365	(-0.008) 0	0.021	0.007	0.026	0.036	0.064	0.080
1:20	0.091	0.131	0.113	0.117	(-0.245) 0	(-0.327) 0	(-0.058) 0	(-0.004) 0	0.017	0.021	0.041	0.039

QUILCHENA CREEK[2]

	APRIL	MAY	JUNE	JULY	AUG.	SEPT.
1:2	0.315	2.65	4.63	0.529	0.160	0.176
1:5	0.511	1.46	2.04	0.239	0.042	0.072
1:10	0.417	1.04	0.716	0.116	(-0.009) 0	0.018
1:20	0.360	0.770	(-0.359) 0	0.044	(-0.046) 0	(-0.026) 0

MOORE CREEK[3]

	APRIL	MAY	JUNE	JULY	AUG.	SEPT.
1:2	0.232	1.90	0.648	0.157	0.083	0.073
1:5	0.127	0.793	0.374	0.071	0.049	0.046
1:10	0.094	0.247	0.283	0.047	0.037	0.039
1:20	0.073	(-0.203) 0	0.226	0.034	0.029	0.026

1 Using W.S.C. gauge 08LG004. Guichon Creek near Lower Nicola.

2 Using W.S.C. gauge 08LG017. Quilchena Creek at Quilchena.

3 Using W.S.C. gauge 08LG011. Moore Creek near Quilchena (natural flow).

APPENDIX 1 (Continued)

LOWER NICOLA[1]

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1:2	6.79	8.79	10.14	27.0	89.1	95.0	27.3	8.57	5.64	7.21	9.08	7.84
1:5	4.86	5.68	7.58	17.4	68.7	60.9	16.4	5.61	4.03	5.12	5.62	4.51
1:10	4.26	4.79	6.80	12.8	60.9	45.5	12.7	4.35	3.52	4.33	4.41	3.40
1:20	3.91	4.28	6.35	9.13	55.6	34.4	10.4	3.43	3.21	3.79	3.63	2.87

SPIUS[2]

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1:2	2.00	2.38	3.12	11.9	36.4	30.0	8.55	2.38	1.55	1.94	2.73	3.05
1:5	1.22	1.44	1.80	6.60	25.7	15.8	4.31	1.38	1.02	1.19	1.29	1.29
1:10	0.955	1.11	1.21	4.40	21.1	10.7	3.01	1.05	0.875	0.947	0.925	0.829
1:20	0.793	0.892	0.763	2.84	17.8	7.58	2.24	0.836	0.795	0.798	0.730	0.580

1 Using W.S.C. gauge 08LG006, Nicola River near Spences Bridge.

2 Using W.S.C. gauge 08LG008, Spius Creek near Canford.

APPENDIX II
WATER MANAGEMENT

METHOD OF ANALYSIS

The method of analysis for each month period includes:

1. For each basin mouth station, the average flow in the month period was determined for each year in the period 1961-79. All missing data from this nineteen year period was estimated using a multiple regression model (refer to UBC trip). Data from nearby hydrometric stations and snow courses were used as independent variables. Thus a standardized nineteen year data set was constructed for each station.
2. Each standardized data set was input to a frequency analysis program which fits the data to each of four extreme value frequency distributions (Gumbel, log-normal, Pearson Type III, and log-Pearson Type III), computes several statistical parameters of the data set, graphs the data for each distribution and provides flow estimates at selected probabilities.
3. The best fitting distribution was chose, or an averaged distribution was determined, based on the Kolmogorov-Smirnov goodness-of-fit test, and the best estimates for 2, 5, 10 and 20 year low flows were derived.

Since the resulting flow estimates are provided by hydrometric stations which are downstream of the storage and diversion works in each major watershed, they are estimates of residual flows. Estimates of the natural supply (the yield which would occur in the absence of the upstream water use) were made by adding upstream water use to the estimates. Thus, present water use could be compared to estimated natural supply.

SUPPLY/DEMAND ASSUMPTIONS

The assumptions employed in developing this supply/demand analysis were as follows:

1. Actual water use is assumed equal to licenced amounts; specifically, all storages are completely filled every year and all diversion licences are fully utilized.

2. The storages are filled in the April-June period: April - 7%, May - 44%, July - 49%.

3. No interannual regulation of storage occurs.

4. All water released from storage in the entire April-September period is diverted for use downstream.

5. The breakdown of demand for irrigation water unsupported by storage is as follows: May - 20%, June - 12%, July - 36%, August - 20%, September - 12%. this breakdown is assumed not to vary between years.

6. The non-agricultural water demand is assumed to be divided into twelve equal monthly increments.

7. In all but the Guichon, Coldwater and Lower Nicola watersheds, it is assumed that all licenced use is for irrigation.

8. It is assumed that the surplus storage on Nicola Lake is released in the July-September period.

9. It is assumed that water demands were constant in each major watershed throughout the nineteen year analysis period.

PROBLEMS

General Problems

Some of the general problems with, and limitations of, the supply/demand analysis are as follows:

1. The monthly breakdown of agricultural demand is an estimated average breakdown at an "average" location in the Nicola watershed in an "average" year (it was determined through discussions with the Ministry of Agriculture). The actual breakdown depends on location, the number of crops grown, the amount of rain during the growing season, and other factors.

2. Flows are measured at the basin mouth but demands are spread out over the entire basin. Thus critical streams or reaches will be overloaded in comparing basin outlet supplies to basin-wide demands.

3. Average monthly flow do not indicate the severity of water shortages on shorter time scales; for example, weekly. In several major watersheds, the residual flow estimates at low probabilities (10 and 20 year recurrence intervals) are very small relative to the upstream demands. In these watersheds in low flow years, shortages almost certainly occur at smaller spatial scales (on the tributaries to the mainstream) and over shorter temporal scales (weeks).

Specific Problems

Some of the major watersheds presented special problems which are acknowledged and explained below:

1. Moore, Stumplake, and Clapperton Creeks have very little hydrological information which prevented standarization of their records to the common period 1961-79. It is known that Stump Lake has no outlet and it was assumed that whatever water that flows in Stumplake Creek below the lake (mostly from Peter Hope Creek) is used by Guichon Ranch; and that there is therefore no contribution from the Stumplake Creek drainage of the Moore/Stump watershed. Clapperton Creek has only two years of data covering the April-June period and one year covering the July-September period, and therefore the July-September estimates provided by a regionalization of Quenville Creek unit runoff (analysis by P. Doyle, Ministry

of Environment, Kamloops) are used, since a frequency analysis on one year of data can only provide a 1:2 year estimate (the one measure flow). The hydrometric stations on Moore and Clapperton Creeks both recorded natural flow. Therefore demands were not added to measured yields to estimate natural supply.

2. It is believed that the assumptions on the amount and temporal distribution of water use in the Guichon Creek watershed are among the least reliable in the Nicola watershed. However, since actual patterns of use are not known, the assumptions that actual use equals licenced use and that the seasonal distribution of water use is the same as in other major watersheds were maintained.

3. Flow estimates for the Upper Nicola watershed were made using data from Water Survey of Canada station 08LG049, which is situated upstream of irrigation diversions at Quilchena Home Ranch. Thus the "natural" supply estimates should be higher by the amount of the use at this ranch.

4. The problem of estimating "natural" basin yields on the two major watersheds which lie downstream of other watersheds was addressed. The Quilchena, Upper Nicola, Moore/Stump, Clapperton and Coldwater watersheds are tributary to the Middle Nicola, which along with the Guichon and Spius watersheds is tributary to the Lower Nicola watershed. It is of little value to attempt to estimate "natural" yields in the absence of all upstream water use in these two watersheds since the use is of such a complex nature. For the Middle Nicola watershed, the addition of residual Coldwater flows to Nicola River flows just above the end-point of the Middle Nicola watershed creates the impression that supply greatly exceeds demand in this watershed. However, analyzing the reach of the Nicola River between Nicola Lake and the Coldwater confluence presents a better view of supply/demand. Residual coldwater flows were subtracted from residual Middle Nicola flows, to obtain estimates of flows in this reach. They are thus residuals, after the effects of the

Nicola Lake dam, Middle Nicola diversions, and all upstream storage and diversion. Note that storage on Nicola Lake amounts to 22 800 dam^3 and total diversions in the Middle Nicola watershed total only 13 300 dam^3. Thus the flows are augmented by 9500 dam^3 over the irrigation season (from what they should be if neither the dam nor the irrigation was operational). For the Lower Nicola watershed, the residual flows (which represent the effects of <u>all</u> upstream use, including the operation of the Nicola Lake dam) were added to the water withdrawals for the Lower Nicola watershed only, to estimate the flows that would result in the Nicola River in the absence of Lower Nicola water use.

APPENDIX III

STORAGE WATER RIGHTS IN THE NICOLA WATER DISTRICT

Licences (dam³)

Watershed	Irrigation		Other Uses		Totals
	Licences	Applications	Licences	Applications	
Upper Nicola	12(10,497.9)	0	0	0	12(10,479.9)
Middle/Lower Nicola	7(24,177.8)	2(160.3)	0	0	9(24,338.1)
Quilchena	13(5,004.8)	0	0	0	13(5,004.8)
Moore-Stump	15(5,457.9)	3(388.5)	0	0	18(5,846.5)
Clapperton	1(3,083.7)	0	0	0	1(3,083.7)
Guichon	46(6,858)	11(3,638)	5(943)	4(1,904)	66(13,344.8)
Coldwater	17(1,285.9)	3(333)	1(9.8)	0	21(1,628.8)
Spius	2(74)	1(98.6)	0	0	3(172.6)
Totals	113(56,440.3)	20(4,619)	6(953.2)	4(1,906.5)	143(63,917.6)

LICENCED DIVERSIONS IN THE NICOLA WATER DISTRICT (dam³)

	Irrigation	Other	Total
Upper Nicola	9,650	0	9,650
Middle/Lower Nicola	5,582	2,400	7,982
Quilchena	570	0	570
Moore-Stump	1,925	0	1,925
Clapperton	6,258	0	6,258
Guichon	6,820	2,820	9,640
Coldwater	6,960	4,140	11,100
Spius	1,625	0	1,625
Totals	39,390	9,360	48,750

STORAGE LICENCES FOR IRRIGATION PURPOSES, UPPER NICOLA TRIBUTARY SUB-BASIN

1.	F.L. 10196	Glimpse Lake	159 acre-feet
2.	F.L. 10195	Glimpse Lake	200 acre-feet
3.	F.L. 10852	Sucker Lake	383.2 acre-feet
4.	F.L. 19037	Frank Woods Lake	237 acre-feet
5.	C.L. 31912	Brenda Creek	107.5 acre-feet
6.	C.L. 9246	Hatheume Lake	750 acre-feet
7.	F.L. 9834	Glimpse Lake	100 acre-feet
8.	C.L. 33810	Chapperon Creek	1120 acre-feet
9.	C.L. 35030	Spahomin Creek	1500 acre-feet
10.	C.L. 43042	Chapperon Lake	2484 acre-feet
11.	C.L. 46591	Mellin and Berry Creeks	1030 acre-feet
12.	C.L. 43857	Chapperon Lake	440 acre-feet
			8510.7 acre-feet

STORAGE LICENCES FOR IRRIGATION PURPOSES

SPIUS DRAINAGE

1. C.L. 22168 August Creek G. Capp Storage for C.L. 21927, 50 acre-feet, Y^{Y}P, 6050, reservoir on pt. Sec. 22, Tp. 13, R. 23.

2. C.L. 48918 Richardson Creek L. A. Swoboda 10 acre-feet D, ?

1. Application 0365794 Pond by G. Capp for 80 acre-feet of storage on 20 acres of NE¼ of Sec. 22, Tp. 13, R. 23 N^{4}, 6050, storage to back up irrigation diversion licence.

There are no other storage licences in the Spius drainage.

<u>Summary</u>:

Two storage licences authorizing the storage of 60 acre-feet; one application for 80 acre-feet, all for irrigation.

STORAGE LICENCES FOR OTHER THAN IRRIGATION PURPOSES

COLDWATER DRAINAGE

1. C.L. 28274 — Oluk Creek, tributary to Coldwater River, held by the B. C. Forest Service, Range Div. for domestic purposes on L. 4289 for 8 acre-feet; E^E, F^F, 6053.

Summary:

17 water licences, authorizing the storage of 1042.5 acre-feet and 4 applications for storage totalling 570 acre-feet, all for irrigation purposes.

There is one other water licence for storage purposes in the Coldwater drainage for non-irrigation purposes for 8 acre-feet.

STORAGE LICENCES FOR IRRIGATION PURPOSES, COLDWATER DRAINAGE

1 C.L. 28276 on Gillis Creek, held by J. M. Anderson, storage for C.L. 28275 for 2 acre-feet, L^L, 6061.

2 C.L. 47634 on Salem Creek, held by H. S. Strande, to back up diversion licence C.L. 47633, for 100 acre-feet, V^V, 6054; storage is in Dry Lake.

3 C.L. 46821 on Castillion Creek, held by Glenwalker Cattle Co. for 10 acre-feet to back up irrigation diversion licence F.L.'s 5666 and 7464, X^X, W^W, 6054.

4 F.L. 4238 on Marquart Lake, held by A. Collett to back up irrigation diversion licence F.L. 4237, for 22 acre-feet; A, 6055.

5 C.L. 13102 on Pye creek, held by Dept. of Indian Affairs for the Joeyaska I. R. No. 2, for 30 acre-feet to back up irrigation diversion licence F.L. 9072, P, 6055; storage is on creek.

6 C.L. 19624 on Godey Creek, held by A. Collett for 80 acre feet to back up irrigation diversion licence C.L. 19623, S, 6055; storage is in Garcia Lake.

7 C.L. 44653 on Godey Creek, held by A. Collett for 60 acre-feet to back up irrigation diversion licence F.L. 4308, X, 6055; storage is on Gray Lake.

8 F.L. 5662 on Howarth Creek, held by D. F. Chambers, for 62 acre-feet to back up irrigation diversion licence F.L. 5661, H(G), 6059; storage is on Edna Lake.

9 F.L. 5733 on Menzies Lake, held by J. A. Menzies, storage for F.L. 5732, for 17.5 acre-feet, J. 6059.

10 F.L. 14668 on Kane Creek (also called Kaneville Creek), held by J. A. Menzies, storage for F.L. 14667, for 54 acre-feet, Q^Q, R^R, 6059; storage on Kane Lake.

11 C.L. 51361 on Kaneville Creek, held by Nicola Ranch Ltd., storage for C.L. 15177 and F.L. 10514, for 300 acre-feet, M, 6060; storage in Harrison Reservoir.

12 C.L. 15181 on Howarth Creek, held by Balco Industries Ltd., storage for C.L. 15180, for 100 acre-feet, storage on Sampson Reservoir, S, Q, R, 6060.

13 C.L. 20670 on Freshet Creek and Easterly Slough, held by J.A. Menzies, storage for C.L. 20669, for 80 acre-feet, W, 6059, K^K, L^L, and M^M, N^N, 6059.

14 C.L. 41107 on Brown Creek, held by P. F. Chambers, storage for C.L. 41106 for 25 acre-feet, R^R, S^S, 6053.

15 C.L. 37563 on Howarth Creek, held by S. G. & V. L. Stewart, storage for C.L. 37562, for 60 acre-feet, storage in Edna Lake, H, 6059.

16 C.L. 37571 on Edna Lake, held by S. G. & V. L. Stewart, storage for C.L. 37570, for 90 acre-feet, reservoir is Roth Lake X, C^C, 6059.

17 C.L. 11781 on Nilsson (Mosquito or Neilson) Creek, held by G. Parker, storage of 150 acre-feet, to irrigate 75 acres of D.L.s 304, 779, and 1858, C^C, 6061; reservoir is on Seymour Lake, diversion to storage to take place from May 15 to June 15.

GUICHON CREEK STORAGES

STORAGE LICENCES:

1. Irrigation Purpose:

C.L. 46582	Blanchet Brook	7.4 acre-feet
C.L. 49280	Blanchet Brook	24.7 acre-feet
C.L. 46580	Blanchet Brook	11.8 acre-feet
F.L. 7437	Tunkwa Lake	282 acre-feet
C.L. 37199	Cougar Lake	60 acre-feet
F.L. 5716	Danish Lake	6 acre-feet
C.L. 46587	Danish Creek	6 acre-feet
C.L. 48264	Danish Creek	39 acre-feet
C.L. 48261	Danish Creek	39 acre-feet
C.L. 16090	Billy Lake	100 acre-feet
C.L. 28272	Billy Lake	80 acre-feet
F.L. 6349	Tunkwa and Leighton Lakes	270 acre-feet
F.L. 6351	Tunkwa and Leighton Lakes	130 acre-feet
F.L. 6346	Tunkwa and Leighton Lakes	93 acre-feet
F.L. 6338	Tunkwa and Leighton Lakes	175 acre-feet
F.L. 6343	Tunkwa and Leighton Lakes	100 acre-feet
F.L. 6340	Tunkwa and Leighton Lakes	51 acre-feet
F.L. 6334	Tunkwa and Leighton Lakes	45 acre-feet
F.L. 7628	Tunkwa and Leighton Lakes	282 acre-feet
F.L. 6336	Tunkwa and Leighton Lakes	47 acre-feet
	Sub total	1,848.9 acre-feet

Irrigation Purpose con't:		Balance forwarded	1,848.9 acre-feet
F.L. 8936	Mamit Lake		377 acre-feet
F.L. 8937	Mamit Lake		115.4 acre-feet
F.L. 8938	Mamit Lake		50 acre-feet
F.L. 8939	Mamit Lake		26.8 acre-feet
F.L. 8935	Mamit Lake		948 acre-feet
F.L. 7910	Mamit Lake		84 acre-feet
F.L. 8230	Mamit Lake		30 acre-feet
F.L. 45454	Leighton Lake		105 acre-feet
F.L. 13814	Leighton Lake		51.3 acre-feet
F.L. 13816	Leighton Lake		49 acre-feet
C.L. 27726	Mamit Lake		213 acre-feet
F.L. 6073	Walloper Lake		40 acre-feet
C.L. 14833	Walloper Lake		160 acre-feet
C.L. 45259	Rey Lake		350 acre-feet
F.L. 8216	Eve Lake		34.5 acre-feet
F.L. 8219	Phelps Lake		86 acre-feet
C.L. 11137	Tom Peter Lake		55 acre-feet
C.L. 30674	Saxon Lake		80 acre-feet
F.L. 5629	Sophia Lake		180 acre-feet
F.L. 6150	Saxon Lake		48 acre-feet
F.L. 7426	Revelle Lake		100 acre-feet
		Sub total	5,031.9 acre-feet

Irrigation Purpose con't:	Balance forwarded	5,031.9 acre-feet
F.L. 11802	Samson Creek	8 acre-feet
C.L. 30676	Saxon Lake and Hector Creek	320 acre-feet
C.L. 30678	Pooley Creek	50 acre-feet
C.L. 20728	Quenville Creek	100 acre-feet
C.L. 23261	Hazlehurst Lake	50 acre-feet
	Total storage (Irrigation)	5,559.9 acre-feet

STORAGE LICENCES:

2. Any Other Purpose:

C.L. 39932	Ware Lake	100 acre-feet
F.L. 9672	Mamit Lake	50.8 acre-feet
C.L. 53705	Gnawed Lake	230 acre-feet
C.L. 53707	Fourier Creek	134 acre-feet
C.L. 27822	No Loon and One Loon Lake	250 acre-feet
	Total storage (Other)	764.8 acre-feet

Total storage in Guichon Drainage (all purposes) = 6,324.7 acre-feet

46 Irrigation licences

5 Other purpose

51 Total storage licences

Number of reservoirs involved = 24

STORAGE LICENCES FOR IRRIGATION PURPOSES, MOORE - STUMP TRIBUTARY SUB-BASIN

1.	F.L. 6193	Frogmoore Lakes	1000	acre-feet
2.	F.L. 6251	Rossmoore Lake	400	acre-feet
3.	C.L. 32468	Frogmoore Lake	24	acre-feet
4.	F.L. 10101	Mildred and Frogmoore Lakes	163	acre-feet
5.	C.L. 12745	Frogmoore Lake	100	acre-feet
6.	C.L. 25184	Moore Creek	160	acre-feet
7.	C.L. 26166	Mildred Lake	300	acre-feet
8.	F.L. 9548	Kullagh Lake	55	acre-feet
9.	C.L. 20500	Palmers Lower Meadow	400	acre-feet
10.	C.L. 20499	Palmers Lower Meadow	800	acre-feet
11.	F.L. 10824	Peterhope Lake	212.75	acre-feet
12.	C.L. 20781	Frisken Creek	160	acre-feet
13.	C.L. 26287	Palmers Lower Meadow	150	acre-feet
14.	C.L. 26254	Palmers Lower Meadow	300	acre-feet
15.	C.L. 43408	Frisken Creek Reservoir, Fraser Lake	200	acre-feet
			4424.75	acre-feet

STORAGE LICENCES FOR IRRIGATION PURPOSES, QUILCHENA TRIBUTARY SUB-BASIN

1.	F.L. 5659	Corbett Lake	100 acre-feet
2.	F.L. 9550	Paradise Lake	337.4 acre-feet
3.	C.L. 44731	Minnie Lake	739.6 acre-feet
4.	F.L. 44641	Reservoir Lake	160.4 acre-feet
5.	C.L. 10253	Reservoir Lake	880 acre-feet
6.	F.L. 44075	Pot Hole Lake	84 acre-feet
7.	F.L. 44074	Pot Hole Lake	16 acre-feet
8.	C.L. 12788	Reservoir and Paradise Lakes	500 acre-feet
9.	C.L. 44686	Minnie Lake	616.5 acre-feet
10.	C.L. 44642	Minnie Lake	133.5 acre-feet
11.	C.L. 33809	Hill Lake	30 acre-feet
12.	C.L. 33296	Tinmilsh	60 acre-feet
13.	C.L. 46593	Minnie Lake	400 acre-feet
			4057.4 acre-feet

STORAGE LICENCES FOR IRRIGATION PURPOSES, LOWER NICOLA PRECINCT

EXCLUDING GUICHON CREEK DRAINAGE

1. C.L. 13195 on the Clapperton Creek watershed held by Nicola Ranch Ltd. for 2500 acre-feet to back up diversion licence C.L. 13194, B, C, D, 6004; A, C, D, E, F, H, 6003, J, N, P, 6001, B, C, D, E, G, 6000. Supercedes C.L. 8776. Reservoirs are Anderson & Kirby Meadows, Fox, Conant, Dry, Mab, Helmer, Bob, Kent, Sussex and Surrey Lakes.

STORAGE LICENCES IN LOWER NICOLA PRECINCT, NICOLA WATER DISTRICT

EXCLUDING GUICHON CREEK DRAINAGE AND

FOR PURPOSES OTHER THAN IRRIGATION

1. C.L. 13594 on the Nicola River, held by Nicola Ranch Ltd., for 28,000 acre-feet to back up power diversion licence C.L. 13593 (which was abandoned on April 4, 1979 by the way); N, 6000; storage on Nicola Lake; Regional Water Manager's order restricts maximum operating level of Nicola Lake to 3.0 feet (approximately 18,450 acre-feet of storage).

STORAGE LICENCES FOR IRRIGATION PURPOSES

MIDDLE/LOWER NICOLA

1. F.L. 14930 — Hamilton Creek, tributary to the Nicola River held by Chutter Ranch Ltd. for 188 acre-feet to back up irrigation diversion licence F.L. 9485 F(C.G) 6055 (storage is on Hamilton Lake)

2. C.L. 30475 — Chapman Slough, tributary to Nicola River, held by Neale Bros. Ranch, to back up irrigation diversion licence C.L. 30474, for 63 acre-feet; H^{H}, 6052^{A}.

3. C.L. 53225 — Hamilton Creek, tributary to Nicola River held by Chutter Ranch Ltd. for 300 acre-feet to back up C.L. 53224; F, 6056 (storage in Hamilton Lake).

APPENDIX IV

POTENTIAL STORAGE SITES IN NICOLA BASIN[1]

Lake or Site	Inflow Estimates	Existing Storage	Storage Capability and Constraints	Cost	Priority and Purpose
Nicola Lake Middle Nicola					Current fishery shortages, Potential irrigation demands
Douglas Lake Upper Nicola					
Mamit Lake Guichon					
Lac Le Juene Guichon					
Walloper Lake Guichon					
Face Lake Guichon					

1 Bajard, Y. 1980. "An Approximate Hydrologic Model of the Nicola Basin". Report to Water Management Branch, Ministry of Environment, Victoria.

PRIORITY STORAGE SITES IN NICOLA BASIN

Lake or Site	Inflow Estimates	Existing Storage	Storage Capability and Constraints	Cost	Priority and Purpose
Paska Lake Guichon					
Lower Palmer Meadows					

UPPER NICOLA

STORAGE POTENTIAL

Lake or Site	Inflow Estimates	Existing Storage	Storage Capability and Constraints	Cost	Priority and Purpose
Douglas Lake	60' - high		moderate 2[1] topography limiting; flooding nsks up-stream Surface are 1610 acres = 4000 dam^3, buildings to be flooded	250,000 capital operating	High-to provide flows for fisheries and potential irrigation
Chapperon	15-20'-high	4988 dam^3	poor, evaporation tops limiting		low-regulation
Spahomin Cr.		1850 dam^3	?		irrigation to meadows, some benefit to fisheries
Glimps Lake	check on inflow estimates to see H_2O is available, ARDSA	3 storage licences 566 dam^3	potential-poor to moderate		
Barton Lake			?		
Old Dave Lake			?		
Range Creek					improve supply to irrigated lands
Frank Ward Cr.		1 storage licence 292 dam^3			
Mellin Creek		1 storage licence 1270 dam^3			
Sucker Lake					

COLDWATER

STORAGE POTENTIAL

Lake or Site	Inflow Estimates	Existing Storage	Potential Storage Capability and Constraints	Cost	Priority and Purpose
Upper Coldwater R. Site 61-1 (Bajard's re-commendation)			Coquihalla Hwy. (see map)		High-to accomodate current fishery shortages and limited potential irrigation demands -to regulate flows
Falls Lake Creek					
Coquihalla Lakes					
Gillis Creek		1 licence 2.4 dam^3			
Satem Creek		1 licence 123 dam^3			
Castillion Cr.		1 licence 12 dam^3			
Marquart Lakes		1 licence 27 dam^3			
Pye Creek		1 licence 37 dam^3			
Godey Creek		2 licence 172 dam^3			
Menzies Lake		1 licence 21 dam^3			
Kane Creek		1 licence 66 dam^3			
Kaneville Cr.		1 licence 197 dam^3			

COLDWATER

STORAGE POTENTIAL

Lake or Site	Inflow Estimates	Existing Storage	Potential Storage Capability and Constraints	Cost	Priority and Purpose
Howarth Creek		2 licence 123 dam^3			
Freshet Creek		1 licence 98 dam^3			
Brown Creek		1 licence 30 dam^3			
Edna Lake		1 licence 111 dam^3			

GUICHON

STORAGE POTENTIAL

Lake or Site	Inflow Estimates	Existing Storage	Potential Storage Capability and Constraints	Cost	Priority and Purpose
Mamit Lake					
Upper Guichon Creek					
Tunkwa Lake					
Upper Meadow Creek					
Middle Hector Creek					
Walloper Lake					
Rey Lake					
Paska Lake					
Upper Lac Le Jeune					
Quenville Creek					
Anther Lake					
Lyner Creek					
Face Lake					
Lower Morgan Creek					

GUICHON

STORAGE POTENTIAL

Lake or Site	Inflow Estimates	Existing Storage	Potential Storage Capability and Constraints	Cost	Priority and Purpose
Logan Lake					
Desmond Lake					
Le Roy Lake					
Billy Lake					
Sophia Lake					
Revelle Lake					
Gump Lake					
Hazelhurt Cr.					
Tom Peter Lake					

MOORE-STUMP
STORAGE POTENTIAL

Lake or Site	Inflow Estimates	Existing Storage	Potential Storage Capability and Constraints	Cost	Priority and Purpose
Lower Palmer meadows		4 licences 2035 dam^3			improvement & expansion
Peterhope Lake		1 licence 262 dam^3	Recreation		
Lower Frogmore Lake		2 licences 152 dam^3			
Kullagh Lake					
Middle Stump Lake					
Plateau Lake			Recreation		
Fraser Lake					
Mildred Lake		2 licences 571 dam^3			
Salt Lake					
Frisken		1 licence 197 dam^3			
Dardonelles Lake			Lake Fishery		
Upper Frogmore		3 licences 1386 dam^3			increase height

APPENDIX V

SCHEDULE OF WELLS

GROUNDWATER SECTION WELL REFERENCE NUMBERS	LOCATION AND WELL NUMBER	WELL[1] NUMBER	USE[2]	YIELD (Igpm/ls^{-1})	DEPTH (ft/m)	COMMENTS
Z8,X12,Y19 #1	Along Nicola R.	87	D	N.A.	16/5	Supplies 1 unit
Z8,X12,Y19 #2	between Merritt	88	D	N.A.	10/3	Supplies 1 unit
Z8,X11,Y24 #1	and Lower Nicola	89	D	N.A.	10/3	
Z8,X11,Y25 #1	(87-92)	90	D	N.A.	8/2.4	8 or 9 units supplied
Z8,X11,Y25 #2		91	D	10/0.8	92/28	
Z8,X11,Y25 #3		92	N	0	60/	Dry hole
Z8,X12,Y3 #1	East side Cold-	36	D	N.A.	44/	
Z8,X12,Y4 #1	water R. just	37	D	N.A.	105/	Flowing, rate unknown
#2	above mouth, 2-4	38	D	N.A.	20/	
#3	km. south east of	39	D	N.A.	16/	
#4	Merritt	40	D	4/	315/	
#5	(36-73)	41	D	N.A.	45/	
#6		42	D	N.A.	394/	
#7		43	D	3/	198/	
#8		44	D	3/	370/	
#9		45	D	3/	239/	
#10		46	D	55-60/	70/	Bedrock aquifer
#11		47	D	3/	415/	
#12		48	D	6/	170/	pH-7.96, $CaCO^3$-115 mg/l Total Fe - .14
#13 (+13a)		49	D	N.A.	70/	
Z8,X12,Y10 #1		50	N.A.	N.A.	95/	
Z8,X12,Y16 #2		51	D	N.A.	18/	Supplies 6 units
Z8,X12,Y9 #1		52	D	4-6/	200/	
#2		53	N.A.	N.A.	N.A.	No information
#3		54	D	N.A.	30/	Sufficient water except in dry years
#4		55	D	N.A.	25/	Poor quality. Often dry
#5		56	D	N.A.	20/	
#6		57	D	N.A.	100/	Reliable flow
#7		58	D	20/	210/	Flowing well @ 20 G.P.M.
#8		59	D	N.A.	14/	
#9		60	N.A.	N.A.	96/	Very good well
#10		61	D	N.A.	45/	
#11		62	D	N.A.	70/	
#12		63	D	N.A.	60/	
#13		64	N.A.	6/	160/	
#14		65	N.A.	N.A.	187/	
#15		66	N.A.	12/	160/	
#16		67	D	N.A.	60/	
#17		68	N.A.	12/	160/	
#18		69	N.A.	8-10/	215/	
#19		70	D	N.A.	160/	Flowing, rate unknown
#20		71	D	N.A.	27/	Flowing, rate unknown
#21		72	N.A.	N.A.	96/	
#22		73	N.A.	N.A.	N.A.	No well log

(1) Numbers are the same as on fig. 4.331.
(2) D: domestic; N: not in use
I: industrial; Irr: irrigation
M: municipal; N.A.: not available

Groundwater Well Reference Number - refers to the Groundwater Section, Well Location Mapping reference number system.
Well Number - refers to reference numbers used for reference on the Strategic Planning Map (1:250 000).

APPENDIX V

SCHEDULE OF WELLS (cont'd)

GROUNDWATER SECTION WELL REFERENCE NUMBERS	LOCATION AND WELL NUMBER	WELL[1] NUMBER	USE[2]	YIELD (Igpm/ls-1)	DEPTH (ft/m)	COMMENTS
Z8,X12,Y8 #1	Merritt (74-86)	74	N.A.	N.A.	N.A.	No well log
Z8,X12,Y16 #3		75	M	60/	83/	Merritt municipal supply
Z8,X11,Y16 #4		76	M	400/	35/	" " "
Z8,X11,Y16 #5		77	M	60/	42/	" " "
Z8,X11,Y20 #1		78	N	-	99/	Hole filled in
Z8,X11,Y17 #1		79	M	217/	90/	Fills 50,000 gal. storage tank which supplies 170 units. Test pumped at 217 Igpm
#2		80	N.A.	20-25/	16/	
#3		81	N.A.	N.A.	55/	Poor will
#4		82	N.A.	N.A.	152/	
#5		83	M	300/	89/	Used for waterworks & fire protection
#6		84	M	1000/	98/	Yield is a rough estimate by driller
		85	N	-	-	Test hole filled in
#7		86	M	900/	148/	Aquifer from 123-148' depth (25)
Z7,X13,Y29 #1	Near junction of Iron Mtn. Rd. and Merritt/Princeton Highway (6,7)	6	D	51/	18/	Located in D.C. 714
Z7,X13,Y21 #1		7	N	-	45/	Located in D.C. 715 - sealed - not enough water - hard water - high iron content
Z7,X11,Y23 #1	Coldwater R. Valley, in IR 1 (34,35)	34	N.A.	40/	221/	
Z7,X11,Y23 #2		35	N.A.	4/	365/	
Z9,X10,Y8 #1	Nicola R. Valley, downstream of Spius Ck. conflu-ence, in IR 10	147	N.A.	N.A.	N.A.	No well log
Z9,X10,Y4 #1		148	N.A.	20/	54/	Probably domestic use
Z9,X10,Y9 #1		202	N.A.	10/	85/	
Z8,X10,Y34 #1	Spius Ck. Valley at Mouth (150,151)	150	N.A.	20/	175/	
Z8,X10,Y34 #2		151	N.A.	8/	93/	
Z8,X10,Y25 #2	Nicola R. Valley, at and just up-stream of, Canford (29-33,149)	29	N.A.	N.A.	N.A.	Water level 6-8' below surface
Z8,X10,Y25 #1A		30	N.A.	N.A.	N.A.	Dry in spring; water level 15' below surface; water quality inadequate
Z8,X10,Y25 #1B		31	N.A.	N.A.	N.A.	
Z8,X10,Y26 #1		32	N.A.	N.A.	16/	
Z8,X10,Y26 #2		33	N.A.	N.A.	30/	
Z8,X10,Y26 #3		149	N.A.	N.A.	N.A.	No well log
Z8,X11,Y33 #1	Nicola R. Valley, between Canford and Lower Nicola (24-28,201)	201	D	71/	110/	Hard:272 ppm; Iron:2.8 ppm; Cond:650 mhos-cm^{-1}
Z8,X11,Y27 #1		24	N.A.	N.A.	42/	Little water
Z8,X11,Y28 #1		25	D	N.A.	25/	Good quality and flow for domestic use
Z8,X11,Y29 #1		26	N.A.	N.A.	10/	Good quality
Z8,X11,Y30 #1		27	D	N.A.	6/	
Z8,X10,Y25 #3		28	N.A.	10/	65/	

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APPENDIX V

SCHEDULE OF WELLS (cont'd)

GROUNDWATER SECTION WELL REFERENCE NUMBERS	LOCATION AND WELL NUMBER	WELL[1] NUMBER	USE[2]	YIELD (Igpm/ls-1)	DEPTH (ft/m)	COMMENTS
Z9,X11,Y10 #1 Z9,X11,Y10 #2	Craigmont Mine-Guichon Ck. Valley west side (10,11)	10 11	I I	1/ 10/	282/ 188/	Flowing. Abandoned. Flowing. Estimated yield 25 Igpm
Z9,X11,Y3 #1 Z9,X11,Y3 #1 Z9,X11,Y3 #2 Z8,X11,Y34 #1 Z8,X11,Y34 #2 Z8,X11,Y34 #3	West side of Guichon Ck. Valley near mouth (12-23, 96-99)	12 13 14 15 16 17	D N.A. D N.A. D D	N.A. N.A. N.A. 13/ N.A. N.A.	27/ N.A. 15/ 191/ 16/ 13/	 No well log Supplies 3 units Supplies 3 units
Z8,Z11,Y34 #4 #5 #6 #7 #8 #9 Z9,X11,Y2 #1 #2 #3 #4	West side of Guichon Ck. Valley near the mouth (12-23, 96-99)	18 19 20 21 22 23 96 97 98 99	D D D D M D N.A. N.A. N.A. N.A.	N.A. N.A. N.A. N.A. 500/38 N.A. N.A. 4/ 3/ 20/	12/ 10/ 15 12/ 354/108 12/ N.A. 40/ 40/ 216/	Supplies 4 trailers and 7 houses Supplies 6 units Lower Nicola municipal supply Good quality No well log Flowing. Very good aquifer
Z8,X11,Y26 #1 Z8,X11,Y35 #2 Z8,X10,Y35 #1	East side of Guichon Ck. Valley near the mouth (93-95)	93 94 95	D D D	N.A. N.A. N.A.	N.A. 12/ 10/	Supplies 10-15 units. Spring Supplies 9 units
Z8,X13,Y30 #1 Z8,X13,Y31 #1 Z8,X13,Y32 #1	South side Nicola R. between Merritt and Nicola Lake (100-102)	100 101 102	D N.A. D	N.A. N.A. N.A.	20/ N.A. 12/	Supplies 2 units, and stock watering No well log Supplies 1 unit
Z8,X12,Y36 #1	North side Nicola R. between Merritt and Nicola Lake (103)	103	N.A.	6/0.5	179/54	
Z9,X13,Y8 #1 Z9,X13,Y5 #1 Z9,X13,Y6 #1 Z9,X13,Y6 #2 Z9,X13,Y6 #3	Clapperton Creek Valley near mouth (104-108)	104 105 106 107 108	D D D N.A. N.A.	N.A. 17/ N.A. N.A. N.A.	N.A. 47 1/2/ 6/ N.A. 45/	Supplies 3 units Supplies 100 people; flowing spring No well log

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APPENDIX V.

SCHEDULE OF WELLS (cont'd)

GROUNDWATER SECTION WELL REFERENCE NUMBERS	LOCATION AND WELL NUMBER	WELL[1] NUMBER	USE[2]	YIELD (Igpm/ls-1)	DEPTH (ft/m)	COMMENTS
Z9,X13,Y2 #1	Along north shore of Nicola Lake (109-113)	109	N.A.	8/	38/	
" " " #2		110	N.A.	5/	42/	
Z9,X14,Y6 #1		111	Camp	93/	65/	Monck park campsite
Z9,X14,Y8 #1		112	N	-	400/122	Monch Park campsite;
Z9,X14,Y8 #2		113	N	-	234/71	Abandoned - no water
Z9,X14,Y4 #1	Guilchena Ck. near mouth (114-117, 203)	114	D	N.A.	15/	Supplies 2 units
Z8,X14,Y32 #1		115	D	N.A.	12/	" " "
Z8,X14,Y33 #1		116	D	N.A.	13/	Supplies hotel and lawn watering
Z8,X14,Y33 #2		117	D	N.A.	15/	Suplies 3 units
Z9,X14,Y4 #2		203	D	N.A.	16/	
Tp97,IR1 #2	East side of Nicola Lake, north of Nicola R. inflow (121-123)	121	N.A.	25/	66/	
#3		122	N.A.	N.A.	25/	
#4		123	N.A.	20/	40/	
Z6,X17,Y15 #1	Pennask Lake (134-137)	134	I?	355/	77/	
#2		135	I?	280/	130/	
#3		136	I?	25/	33/	
#4		137	I?	-	135/	
Tp98,S7 #3	Moore Creek Valley near mouth (217-220,127-129)	217	N.A.	25/	70/	
Tp99,S7 #1		218	D	400/	N.A.	Pumped at 400 Igpm - no drawdown
Tp99,S7 #2		219	D	N.A.	12/	Supplies 4 units
Tp99,S21 #1		220	N.A.	100/	208/	
Tp99,S7 #2		127	N.A.	N.A.	N.A.	No well log
Tp99,S7 #3		128	N.A.	N.A.	N.A.	No well log
Tp99 pr 98 L104 #2		129	N.A.	N.A.	N.A.	No well log; non-flowing artesian
Tp99,L101 #1	Stumplake Cr. Valley between Nicola and Stump Lake (126)	126	N.A.	N.A.	N.A.	No well log
Tp96,S19 #1	Upper Nicola R. Valley, just upstream of point of inflow to Nicola Lake (213-216, 118-120)	213	D	N.A.	N.A.	Supplies 2 units
Tp96,IR1 #1		214	D	N.A.	6/	" " "
Tp96,IR1 #2		215	N.A.	20/	20/	
Tp97,S3 #1		216	Irr.	N.A.	300/	Irrigation for 40ac (16 ha)
Tp99,S7 #1		118	N.A.	N.A.	N.A.	No well log
Tp99,S7 #2		119	N.A.	N.A.	N.A.	" " "
Tp99,S21 #1		120	N.A.	N.A.	N.A.	" " "

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APPENDIX V

SCHEDULE OF WELLS (cont'd)

GROUNDWATER SECTION WELL REFERENCE NUMBERS	LOCATION AND WELL NUMBER	WELL[1] NUMBER	USE[2]	YIELD (Igpm/ls-1)	DEPTH (ft/m)	COMMENTS
Z9,X15,? #1	Lauder Creek near mouth (125)	125	N.A.	N.A.	N.A.	No well log
Tp96,S10 #1	Junction of Douglas Lk. and Lauder Cr. roads - BCHPA substation (124)	Z12	I	20-30/	124/	
Z9,X16,? #1	Outlet of Douglas Lake (124)	124	N.A.	N.A.	10/3	Poor quality
Map A921/1g#1 Map A921/1g#2	Douglas Lake Ranch east end of Douglas Lake (8,9)	8 9	D D	N.A. 104/8	30/ 50/	Suplies 3 units
WR-38-67 L229 Tp16,R18,S31 #1	Northend of Stump Lake (132,133)	132 133	Obs N.A.	5/0.4 N.A.	80/24 N.A.	Bail test:5 Igpm Government Observation Well Artesian flowing
?	Brookmere (L 659)	145	N.A.	N.A.	N.A.	No well log
Z12,X7,Y1 #1	Coldwater R. Valley, between Voght and Hidday Creeks (146)	146	N.A.	N.A.	N.A.	No well log
	Logan Lake		M M M	 800/ 200-250/		Municipal supply wells
Tp18,R22,S14 #3-#7	Witches Brook Valley (tributary to Guichon Creek) (1-5, 138-144) 204-220	Well developed for mill water supply and open pit dewatering for 3 mines and 1 future mine. Yields range from 100-1000 Igpm.				

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APPENDIX VI

GROUNDWATER QUALITY AT SELECTED SITES

		STUMP LAKE OBSERVATION WELL WR-18-67 - 1975	BETHLEHEM[1] BW5 - 1977	LOGAN LAKE[1] WELL - 1970
Physical Tests				
pH		9.3	7.7	8.00
Conductivity (mhos/cm)		431	346	N/A
Turbidity (JTU)		N/A	0.3	2.0
Colour (Pt-Co)		N/A	<5	1.0
Total Dissolved Solids (mg/L)		250	320	416
Dissolved Anions (mg/L)				
Alkalinity				
Bicarbonate	HCO_3	109	241	282
Carbonate	CO_3	45	-	-
Chloride	Cl	10.5	0.5	4.0
Sulfate	SO_4	56.1	2.0	12.8
Nitrate & Nitrite	N	N/A	<0.01	N/A
Nitrogen (Kjeldahl)		0.02	N/A	N/A
Phosphorous (Total)		<0.003	N/A	N/A
Phosphate	PO_4	N/A	0.09	N/A
Fluoride	F	N/A	0.11	N/A
Silica	SiO_2	N/A	N/A	21.2
Dissolved Cations (mg/L)				
Total Hardness	$CaCO_3$	96.5	146.7	208
Calcium	Ca	1.9	43.6	49.5
Magnesium	Mg	22.3	9.2	20.4
Sodium	Na	44.6	16.4	21.5
Potassium	K	22.7	1.9	3.4
Iron	Fe	N/A	<0.03	0.05
Manganese	Mn	N/A	0.079	Trace
Cadmium	Cd	N/A	N/A	N/A
Copper	Cu	N/A	0.002	0.02
Lead	Pb	N/A	<0.001	<0.01
Zinc	Zn	N/A	0.012	0.02
Others (mg/L)				
Total Iron	Fe	N/A	0.073	0.22
Total Manganese	Mn	N/A	0.084	N/A

mg/L = milligrams per litre; N/A = not analyzed for.

[1] From Brown, Erdman and Associates Ltd. (1980).

APPENDIX VII

CURRENT AND OPTIMUM SALMONID CATCH AND ANNUAL VALUE FOR NICOLA, COLDWATER AND SPIUS SYSTEM

	TOTAL CATCH[4] PIECES		NET WHOLESALE VALUE[6] $1982	
NICOLA RIVER	CURRENT	POTENTIAL	CURRENT	POTENTIAL
Canadian Commercial[1]	8,283	11,346	161,357	226,534
Sport Tidal[2]	6,288	9,008	182,969	241,727
Sport Fresh[2]	597	840	64,489	90,741
Native Food[5]	627	897	24,375	34,525
U.S. Commercial[7]	2,064	2,716	31,366	46,780
Sport[7]	39	76	1,133	2,208
	17,898	24,883	$465,416	$642,515
COLDWATER SYSTEM				
Canadian Commercial[1]	1,708	4,560	32,535	75,517
Sport Tidal[2]	1,455	3,720	42,274	108,085
Sport Fresh[2]	103	180	11,126	19,444
Native Food[5]	143	360	4,744	9,992
U.S. Commercial[7]	446	1,440	7,319	21,128
Sport[7]	54	240	1,569	6,973
	3,909	10,500	$99,567	$241,139
SPIUS SYSTEM				
Canadian Commercial[1]	567	1,506	9,635	28,551
Sport Tidal[2]	466	1,284	13,539	37,306
Sport Fresh[2]	25	90	2,701	9,722
Native Food[5]	46	126	1,326	4,161
U.S. Commercial[7]	173	396	2,586	6,494
Sport[7]	28	48	813	1,395
	1,305	3,450	$30,600	$87,629

APPENDIX VII

ESTIMATE OF THE CURRENT AND POTENTIAL SALMON CATCH AND VALUE ASSOCIATED WITH THE NICOLA RIVER

CHINOOK

Average Escapement (1976-80)	3,320	Current C/E Ratio	4.5:1
Potential Escapement	7,000	Potential C/E Ratio	3:1
Estimated Current Catch	14,940		
Estimated Potential Catch	21,000		

	ESTIMATED CATCH[4] PIECES		NET WHOLESALE VALUE[6] $1982	
	CURRENT	POTENTIAL	CURRENT	POTENTIAL
Canadian				
Commercial[1]	6,575	9,240	149,118	209,574
Sport Tidal[2]	5,976	8,400	173,632	244,062
Sport Fresh[2]	597	840	64,489	90,741
Native[5]	597	840	23,911	33,643
U.S.				
Commercial[7]	1,195	1,680	25,044	35,211
	14,940	21,000	$436,194	$613,231

COHO

Average Escapement (1976-80)	325	Current C/E Ratio	3:1
Potential Escapement	950	Potential C/E Ratio	2:1
Estimated Current Catch	975		
Estimated Potential Catch	1,900		

Canadian				
Commerical[1]	419	817	4,971	9,692
Sport Tidal[2]	312	608	9,064	17,665
Native[5]	30	57	464	882
U.S.				
Commercial[7]	175	342	2,201	4,301
Sport[7]	39	76	1,133	2,208
	975	1,900	$17,833	$34,748

PINK

Average Escapement (1976-80)	708	Current C/E Ratio	2:8
Potential same as average			
Estimated Current Catch	1,983		

Canadian		
Commercial[1]	1,289	7,268
U.S.		
Commercial[7]	694	4,121
	1,983	$11,389

APPENDIX VII

ESTIMATE OF THE CURRENT AND POTENTIAL SALMON CATCH AND VALUE ASSOCIATED WITH THE COLDWATER SYSTEM

CHINOOK

Average Escapement (1976-80)	572	Current C/E Ratio	4.5:1
Potential Escapement	1,500	Potential C/E Ratio	3:1
Estimated Current Catch	2,574		
Estimated Potential Catch	4,500		

	ESTIMATED CATCH[4] PIECES		NET WHOLESALE VALUE[6] $1982	
	CURRENT	POTENTIAL	CURRENT	POTENTIAL
Canadian				
Commercial[1]	1,134	1,980	25,726	44,909
Sport Tidal[2]	1,029	1,800	29,897	52,299
Sport Fresh[2]	103	180	11,126	19,444
Native[5]	103	180	4,125	7,209
U.S.				
Commercial[7]	205	360	4,289	7,545
	2,574	4,500	$75,163	$131,406

COHO

Average Escapement (1976-80)	445	Current C/E Ratio	3:1
Potential Escapement	1,000	Potential C/E Ratio	2:1
Estimated Current Catch	1,335		
Estimated Potential Catch	6,000		

	CURRENT	POTENTIAL	CURRENT	POTENTIAL
Canadian				
Commercial[1]	574	2,580	6,809	30,608
Sport Tidal[2]	426	1,920	12,377	55,786
Native[5]	40	180	619	2,783
U.S.				
Commercial[7]	241	1,080	3,030	13,583
Sport[7]	54	240	1,569	6,973
	1,335	6,000	$24,404	$109,733

APPENDIX VII

ESTIMATE OF THE CURRENT AND POTENTIAL SALMON CATCH AND VALUE ASSOCIATED WITH THE SPIUS SYSTEM

CHINOOK

Average Escapement (1976-80)	136	Current C/E Ratio	4.5:1
Potential Escapement	750	Potential C/E Ratio	3:1
Estimated Current Catch	612		
Estimated Potential Catch	1,250		

	ESTIMATED CATCH[4] PIECES		NET WHOLESALE VALUE[6] $1982	
	CURRENT	POTENTIAL	CURRENT	POTENTIAL
Canadian				
Commercial[1]	269	990	6,101	22,430
Sport Tidal[2]	244	900	7,089	26,149
Sport Fresh[2]	25	90	2,701	9,722
Native[5]	25	90	1,001	3,604
U.S.				
Commercial[7]	49	180	1,027	3,776
	612	2,250	$17,919	$65,681

COHO

Average Escapement (1976-80)	231	Current C/E Ratio	3:1
Potential Escapement	600	Potential C/E Ratio	2:1
Estimated Current Catch	693		
Estimated Potential Catch	1,200		

	CURRENT	POTENTIAL	CURRENT	POTENTIAL
Canadian				
Commercial[1]	124	516	3,534	6,121
Sport Tidal[2]	222	384	6,450	1,157
Native[5]	21	36	325	557
U.S.				
Commercial[7]	124	216	1,559	2,718
Sport[7]	28	48	813	1,395
	693	1,200	$12,681	$21,948

FOOTNOTES FOR APPENDIX VII

1. Commercial methodology outlined in The Economic Rationale for the Salmonid Enhancement Program and Appendices. Appendix 2. Estimation of Commercial Fishery Benefits and Associated Costs for the National Income Account. J. Barclay and R. Morley.

2. Recreational methodology outlined in Appendix 6 of the same report. Appendix 6. Evaluation of Incremental Recreational Benefits from Salmonid Enhancement. A day of salt water sport fishing was valued at $15.00 (1976$) while a day of freshwater chinook fishing was valued at $25.00/day (1976$). One freshwater chinook is estimated to generate 2.5 angler days of effort.

3. The Consumer Price Index was used to adjust values to reflect current dollars.

   1978-79 = 9.1 1979-80 = 10.1 1980-81 = 12.5 1981-82 = 10.5 (unexpected)

4. Salmonid Catch was allocated to the various fisheries using Production Distribution Tables developed for S.E.P.

5. Salmon caught in the native food fishery have been valued at the highest price associated with "net caught salmon".

6. Net wholesale values are reported for commercially caught species. Harvesting and processing costs have been subtracted from the wholesale value of the salmon.

7. Salmon caught in U.S. are valued at Canadian prices.

APPENDIX VII

ESTIMATES OF EMPLOYMENT IN THE HARVESTING AND PROCESSING SECTORS GENERATED AS A RESULT OF COMMERCIAL CATCH FROM THE NICOLA, COLDWATER AND SPIUS SYSTEMS[1]

	Person Years of Work at Current Production Levels	Person Years of Work at Optimum Production Levels
Harvesting Sector[2]		
Direct Employment	.28 person years	.52
Indirect Employment	5.83 " "	10.69
Total Employment	6.11	11.21
Processing Sector[3]		
Direct Employment	1.49	2.74
Indirect Employment	2.15	3.97
Total Employment	3.64	6.71
Combined Processing & Harvesting Sectors		
Direct Employment	1.77	3.26
Indirect Employment	7.98	14.66
Total Employment	9.75	17.92

1. Methodology outlined in The Economic Rationale for Salmonid Enhancement Program and Appendices. Appendix 15. Economic Impacts Associated with the Salmon Industry in B.C. Acres Consulting Services.

2. It is assumed that 630 person days of harvesting employment are generated for every million lbs. of salmon commercially caught. The multiplier is 21.5. It is also assumed that there are 232 working days in a person year.

3. It is assumed that 3,300 person days of processing employment are generated for every million pounds of salmon commercially caught. The multiplier is 2.45.

APPENDIX VIII

LAKE DATA FOR NICOLA PLANNING UNIT RESIDENT FISHERIES

1. Developed Environment

LAKE NAME	STOCKED	ANGLER DAYS	HARVEST OF FISH	PRODUCTION CAPABILITY	CONSTRAINTS TO PRODUCTION
Nicola		30,000	33,000 - 39,000	198,000	Spawning Habitat
Big Divide		1,000	1,100 - 1,300	2,700	Slough, Mine
Chapperon		500	550 - 650	15,000	Coarse Fish; Spawning Area Depth
Corbett	S	3,000	3,300 - 3,900	4,300	
Edna		1,000	1,100 - 1,300	4,100	Winter-Kill
Face		2,500	2,750 - 3,250	2,000	Elevation
Glimpse	S	6,000	6,600 - 7,800	15,000	Spawning Area
Lac le Jeune	S	20,000	22,000 - 26,000	22,000	
Mamit		2,000	2,200 - 2,600	21,000	Coarse Fish
Murray	S	3,000	3,300 - 3,900	6,300	Water Quality
Paska		2,500	2,750 - 3,250	8,200	Facilities, Access
Peter Hope	S	15,000	16,500 - 19,500	14,000	
Quiltanton		3,100	3,400 - 4,000	5,500	Mine
Stump	S	10,000	11,000 - 13,000	77,000	Spawning Area
Surrey		2,000	2,200 - 2,600	8,000	Access
Sussex		2,000	2,200 - 2,600	8,000	
Twenty Four Mile		500	550 - 650	3,800	Mine
Walloper	S	6,000	6,600 - 7,800	7,600	Winter-Kill
Garcia		-	-	3,000	Access, Private
Logan		-	-	5,000	Winter-Kill
Menzies		-	-	800	Access, Private
Minnie		-	-	10,000	Private Fish Farm

APPENDIX VIII

LAKE DATA FOR NICOLA PLANNING UNIT RESIDENT FISHERIES

2. Natural Environment Lakes

LAKE NAME	STOCKED	ANGLER DAYS	HARVEST OF FISH	PRODUCTION CAPABILITY	CONSTRAINTS TO PRODUCTION
Abbot	S	2,000	2,200 - 2,600	5,200	
Blue	S	1,500	1,650 - 1,950	3,800	
Brook Lakes		1,000	1,100 - 1,300	3,600	
Cameo		100	110 - 130	3,100	Coarse Fish
Chataway		3,000	3,300 - 3,900	3,400	
Courtney	S	12,000	13,200 - 15,600	18,000	
Dot	S	700	770 - 900	6,000	Spawning Habitat
Douglas		2,000	2,200 - 2,600	33,400	Spawning Habitat; Dams
Englishman		500	550 - 650	5,200	Coarse Fish
Frogmoore		1,000	1,100 - 1,300		Access
Gillis	S	1,000	1,100 - 1,300	9,400	
Gwen		2,000	2,200 - 2,600	3,900	
Gypsum	S	100	110 - 130	2,200	Spawning Habitat
Mamen	S	5,000	5,500 - 6,500	7,500	
Kane (left)	S	1,500	1,650 - 1,950	1,900	Coarse Fish
Kane (right)	S	1,500	1,650 - 1,950	2,100	Coarse Fish
Lily	S	1,000	1,100 - 1,300	2,800	
Lodgepole	S	2,000	2,200 - 2,600	1,700	Winter-Kill
Lundbom	S	8,000	8,800 - 10,400	8,000	Predation
Marquart	S	1,500	1,650 - 1,950	8,400	
Neltahan		50	55 - 65	1,200	
Paradise		2,000	2,200 - 2,600	20,000	Fish Size
Pattinson		500	550 - 650	2,700	
Pinacle	S	200	220 - 260	1,600	
Plateau	S	7,000	7,700 - 9,100	4,900	
Porcupine	S	200	220 - 260	1,000	Winter-Kill
Pothole		1,000	1,100 - 1,300	1,200	Coarse Fish
Ridge Lake Ease	S	1,000	1,100 - 1,300		Spawning; Access
Roscoe		1,000	1,100 - 1,300	4,400	Access
Ross Moore	S	2,000	2,200 - 2,600	6,500	Access; Irrigation
Sucker		200	220 - 260	2,700	Irrigation
Tyner	S	500	550 - 650	3,600	
Wyse		500	550 - 650	4,000	Access
Beautiful		-		2,100	Winter-Kill
Boat				1,200	Winter-Kill
Bob				5,800	Winter-Kill, Depth
Chicken Ranch				1,600	
Conant				2,700	

APPENDIX VIII

LAKE DATA FOR NICOLA PLANNING UNIT RESIDENT FISHERIES

2. Natural Environment Lakes (Continued)

LAKE NAME	STOCKED	ANGLER DAYS	HARVEST OF FISH	PRODUCTION CAPABILITY	CONSTRAINTS TO PRODUCTION
Dardenelles				6,310	Winter-Kill, Depth
Dartt				1,500	Slough
Desmond				3,900	Slough
Ere				1,700	
Fred				1,900	
Hamilton				2,900	
Matheume				10,300	Coarse Fish
Melmer				3,600	
Nomfray				4,200	
Index				3,100	
Kent				1,900	Slough
Kullagh				4,200	
Lauder				3,600	
Larigure				3,300	Winter-Kill
Leon				2,700	
Mab				6,300	
Mabel				5,600	
Marquette				900	Access, Private
Mildred				5,800	Unknown
Neven				3,300	Depth
Quenville				2,100	Slough
Rvelle				2,300	Slough
Rey				4,200	
Ridge Lake West					Spawning; Access
Rush				6,000	Winter-Kill
Upper Lundbom				1,900	Winter-Kill; Depth
Walker				2,900	Access; Winter-Kill
Wasley				2,700	

APPENDIX VIII

LAKE DATA FOR NICOLA PLANNING UNIT RESIDENT FISHERIES

3. Wilderness Lakes

LAKE NAME	STOCKED	ANGLER DAYS	HARVEST OF FISH	PRODUCTION CAPABILITY	CONSTRAINTS TO PRODUCTION
Andy		500	550 - 650	2,900	Access
Anther		500	550 - 650	2,400	Access
Boot	S	1,000	1,100 - 1,300	3,700	
Boulder	S	300	330 - 390	3,900	
Farr		100	110 - 130	2,500	
Fox		200	220 - 260	3,200	
Gordon	S	1,000	1,100 - 1,300	4,000	Access
Island	S	1,500	1,650 - 1,950	10,000	
Jackson	S	3,000	3,300 - 3,900	8,800	Access; Winter-Kill
Little Pennask	S	1,500	1,650 - 1,950	2,000	Winter-Kill
Mellin		500	550 - 650	4,500	Access
Pefferle		200	220 - 260	2,900	
Pennask		30,000	33,000 - 39,000	40,000	
Pikehead		500	550 - 650	3,500	Access
Rat		1,000	1,100 - 1,300	2,700	Access, Private
Reservoir		1,000	1,100 - 1,300	4,800	Access; Spawning
Rock		500	550 - 650	5,900	Access; Spawning
Sunset		250	275 - 325	2,700	
Andersen		-		1,500	
Anischeldt				600	
Bob's				1,900	
Conolly				1,500	
Cousineau				1,800	Slough
Danish				1,900	Slough
Dorothy				1,400	
Dupont				1,700	
Ellen				3,500	Access
Eureka				1,600	
Fig				2,700	Slough
Harold				1,600	
Hansell				1,700	Slough
Hidden				1,600	
Jacks					Access
John's				1,400	Access
Kukismous				400	Slough
Lake of the Woods				1,900	
Marsh		-			

APPENDIX VIII

LAKE DATA FOR NICOLA PLANNING UNIT RESIDENT FISHERIES

3. Wilderness Lakes (Continued)

LAKE NAME	STOCKED	ANGLER DAYS	HARVEST OF FISH	PRODUCTION CAPABILITY	CONSTRAINTS TO PRODUCTION
Morgan				1,400	
Mystery				3,800	Access
Naughachapt				2,300	
Nsatiscou				1,700	Slough
Peterson				3,100	
Prospect Lakes				900	Access
Raymer				1,900	Access
Rouse				3,100	Access
Salt				4,300	Access
Saxen				2,400	
Skunk				4,600	Water Levels
Sophia				2,700	
Spahomin				2,700	Coarse Fish
Steer					
Tolman				1,900	
Tom Peter				1,400	
Whiterock				3,600	
Whiterock (1)				1,800	

APPENDIX VIII

ENHANCEMENT OPPORTUNITIES

LAKE	POTENTIAL INCREASE IN ANGLER-DAYS
Lakes With Current Production Capability to Support Increased Angling Activity	
Abbott	2,000 - 2,700
Andy	1,700 - 2,100
Antler	1,400 - 1,600
Boot	1,800 - 2,400
Boulder	2,700 - 3,300
Brook Lakes	1,800 - 2,300
Farr	1,800 - 2,200
Fox	2,300 - 2,700
Gillis	6,200 - 7,500
Gordon	2,100 - 2,600
Gwen	1,000 - 1,500
Mellin	2,900 - 3,500
Neltahan	900 - 1,100
Pattinson	1,600 - 2,000
Pefferle	2,100 - 2,500
Rock	4,100 - 4,900
Roscoe	2,400 - 3,000
Sunset	1,800 - 2,300
Surrey	4,200 - 5,300
Sussex	4,200 - 5,300
Tyner	2,300 - 2,800
Wyse	2,500 - 3,100
Stocking	
Beautiful	2,300 - 2,700
Dot	5,500 - 6,500
Gypsum	2,200 - 2,600
Harmon	1,100 - 1,300
Lac le Jeune	Near Capacity
Lake of the Woods	2,200 - 2,600
Lavigure	3,300 - 3,900
Lily	1,650 - 1,950
Lundbom	Near Capacity
Marquart	7,150 - 8,450
Murray	2,750 - 3,250
Pinnacle	1,650 - 1,950
Reservoir	3,850 - 4,550
Ross Moore	4,400 - 5,200
Risk	6,600 - 7,800
Stump	20,000
Englishman	4,950 - 5,850
Courtney	3,300 - 3,900

APPENDIX VIII (Continued)

ENHANCEMENT OPPORTUNITIES

LAKE		POTENTIAL INCREASE IN ANGLER-DAYS
Rehabilitation		
Mamit		19,800 - 23,400
Pothole		Near Capacity
Aeration		
Beautiful		
Porcupine		770 - 900
Rush		2,200 - 2,600
Access Management		
Ellen	5,000	5,500 - 6,500
Frogmore		
Garcia	3,000	3,300 - 3,900
Marquette	900	1,000 - 1,200
Menzies	800	880 - 1,000
Mildred	6,000	6,600 - 7,800
Pikehead	3,000	3,300 - 3,900
Rat	1,500	1,650 - 1,950

LAKE	ACTIVITY	POTENTIAL INCREASE IN ANGLER-DAYS
Other Opportunities		
Nicola	Kokanee spawning area	50,000
Douglas	Kokanee spawning; dams	
Frogmoore	Improve natural spawning	
Glimpse	Improve natural spawning and water quality	18,000 - 13,000
Ridge Lake E.	Spawning improvement	
Ridge Lake W.	Spawning improvement	
Skunk	Direct water; water levels	5,500 - 6,500

Lakes With Potential for Trophy Fishery Development

Reservoir	Peter Hope
Pinnacle	Frogmoore
Matheume	Lundbom
Chataway	Corbett

APPENDIX IX

PERMITTED POINT SOURCES DISCHARGES INDIRECTLY TO WATER NICOLA BASIN

POINT SOURCES DISCHARGED TO THE GROUND

a) PERMITTED

i) Guichon

SOURCE	TYPE	WORKS	QUANTITY OF DISCHARGE	IMPACT OF DISCHARGE
Village of Logan Lake	Domestic Sewage	Infiltration Basins Spray Irrigation	5500 m^3/d 300 m^3/d	Ground disposal 650 meters west of Guichon Creek and potential impact of nitrates on groundwater and Guichon Creek.
Highmont Mines	Mine Tailings	Tailings Pond	74200 m^3/d	Discharge to tailings pond where solids (25 000+/d) are deposited and water recycled to process. No positive discharge. Potential impact from tailings pond groundater flows with concerns for mill reagents and heavy metals (Cu, Mo). Potential impact of suspended solids in runoff and open pit and waste rock piles. Domestic sewage is treated and put in tailings pond with no impact.
Highmont Mines	Domestic Sewage	Evaporation Lagoon	127 m^3/d	Emergency domestic sewage treatment pond. Disposal by evaporation as soil is too imper ious for infiltration. No impact on environment.
Lornex Mining	Domestic Sewage	Infiltration Pond Tailings Line Spray Irrigation	57 m^3/d	Treated sewage either infiltrates to the ground, evaporates or is deposited in tailings pond. Company has sprayed treated effluent over old tailings areas and property in the

APPENDIX IX

PERMITTED POINT SOURCES DISCHARGES INDIRECTLY TO WATER NICOLA BASIN (CONTINUED)

a) PERMITTED

i) Guichon

SOURCE	TYPE	WORKS	QUANTITY OF DISCHARGE	IMPACT OF DISCHARGE
				months of June to September inclusive. No impact on the environment
Bethlehem Copper	Mine Tailings	Tailings Pond	50 000 m^3/d	Discharge to a tailings pond when solids (17 500+/d) are deposited and water recycled to process. No positive discharge. Potential impact from tailings pond groundwater flows with concerns from mill reagents and heavy metals (Cu, Mo). Potential impact from suspended solids in runoff from open pit, mine roads and waste rock piles.
Highmont Mines	Domestic Refuse	Waste Rock Pile	4.0 m^3/d	No impact.
Lornex Mines	Domestic Refuse	Waste Rock Pile	6.0 m^3/d	No impact.
TNRD - Logan Lake	Domestic Refuse	Trench	26 m^3/d	Potential problems of bears attracted to garbage. Burning garbage can be offensive to surrounding neighbours.
Lac Le Jeune	Domestic Refuse	Trench + Septic Tanks, Pits	1 m^3/d	Potential leachate although determined to be minor in this case.

APPENDIX IX

PERMITTED POINT SOURCE DISCHARGES INDIRECTLY TO WATER

ii) Lower Nicola

SOURCE	TYPE	WORKS	QUANTITY OF DISCHARGE	IMPACT OF DISCHARGE
Craigmont Mines	Mine Tailings	Tailings Pond	6000 m^3/d	Mine closed in Spring 1982. Tailings pond remains and there is potential for groundwater surface water contamination from mill reagents and heavy metals.
TNRD Lower Nicola	Domestic Refuse	Trench	0.75 m^3/d	Potential problems of bears attracted to garbage. Burning garbage can be offensive to surrounding neighbours. Potential leachate although determined to be minor in this case.

iii) Coldwater

SOURCE	TYPE	WORKS	QUANTITY OF DISCHARGE	IMPACT OF DISCHARGE
City of Merritt	Domestic Refuse STP Solids	Trench Lagoon	29 m^3/d 250 m^3/Month	Relatively large landfill. Potential groundwater contamination from refuse decaying leachate (high BOD, color). Burning garbage could be offensive.
City of Merritt	Domestic Refuse	Area Filling	24 m^3/d	Covered and filled landfill. Not in use. Potential leachate into groundwater. Not identified as a problem to date.
City of Merritt	Domestic Refuse	Area Filling	24 m^3/d	Covered and filled landfill. Not in use. Potential leachate into groundwater. Not identified as a problem to date.

APPENDIX IX

PERMITTED POINT SOURCE DISCHARGES INDIRECTLY TO WATER (CONTINUED)

SOURCE	TYPE	WORKS	QUANTITY OF DISCHARGE	IMPACT OF DISCHARGE
Aspen Planers	Logyard Refuse	Area Filling	760 m^3/Year	Potential fires from spontaneous combustion due to poor operation and leachate. Dry area, therefore leachate should not be a problem.
Balco Industries	Logyard Refuse	Area Filling	240 m^3/d	
Weyerhauser Canada	Logyard Refuse	Area Filling	100 m^3/d	

iv) Middle Nicola

J. Steffans	Vet Clinic	Tile Field	0.9 m^3/d	Small discharges with minor impact.
Hullcar Farms	Abattoir	Tile Field Trench	0.9 m^3/d 180 kg/d	
Grasslands	Meat Abattoir	Tile Field	5.5 m^3/d 0.91 m^3/d	

v) Quilchena

SOURCE	TYPE	WORKS	QUANTITY OF DISCHARGE	IMPACT OF DISCHARGE
Paradise Lake Resort	Domestic Refuse	Trench	0.7 m^3/d	Small discharges with minor impact.

APPENDIX X

RESULTS OF THE WATER QUALITY PROGRAM IN THE NICOLA BASIN 1979-1982

TABLE 1 : Maximum, minimum and mean concentration values (mg/L) for selected chemical parameters at stations on the Nicola and Coldwater Rivers during freshet (1978/79).

Parameter		Station: Nicola River						Coldwater River		
		68	116	115	534	179	7	500	502	543
Phosphorus:Total	-max.	0.34	.044	.079	.086	.386	.065	.615	.519	.007
	-min.	.023	.038	.050	.052	.027	.012	.007	.062	.007
	-mean	.027	.040	.065	.068	.128	.032	.160	.231	.007
Phosphorus:Tot.diss.	-max.	.012	.028	.039	.036	.021	.010	.019	.103	.003
	-min.	.011	.020	.023	.020	.013	.003	.003	.030	.003
	-mean	.011	.024	.031	.029	.017	.007	.008	.065	.003
Nitrogen:Total	-max.	.42	.54	.48	.50	.51	.34	.75	1.00	.10
	-min.	.35	.36	.38	.39	.30	.16	.06	.32	.10
	-mean	.39	.45	.43	[illegible]	.37	.26	.28	.65	.10
Nitrogen:Organic	-max.	.40	.52	.46	.46	.49	.34	.72	.68	.10
	-min.	.33	.36	.37	.38	.29	.15	.06	.09	.10
	-mean	.37	.44	.41	.43	.35	.26	26	.34	.10
Nitrogen:NH_3	-max.	.018	.019	.027	.038	.022	.011	.012	.580	.005
	-min.	.008	.005	.008	.008	.010	.005	.005	.056	.005
	-mean	.014	.014	.015	.017	.015	.008	.008	.295	.005
Nitrogen:NO_3	-max.	.02	.02	.02	.02	.02	-	.02	.02	.02
	-min.	.02	.02	.02	.02	.02	-	.02	.02	.02
	-mean	.02	.02	.02	.02	.02	-	.02	.02	.02
Nitrogen:Kjeldahl	-max.	.418	.539	.474	.498	.512	346	.731	1.000	.105
	-min.	.346	.365	.378	.388	.302	.159	.065	.316	.105
	-mean	.383	.452	.425	.445	.367	.267	.264	.627	.105

TABLE 2 : Maximum, minimum and mean concentrations (mg/L) for selected chemical parameters on the Nicola and Coldwater Rivers during freshet (1980/81)

Parameter		Station: Nicola River			Coldwater River	
		115	534	179	500	502
Phosphorus:total	- max.	.096	.077	.053	.029	.046
	- min.	.053	.035	.033	.007	.020
	- mean	.069	.056	.045	.016	.031
Phosphorus:total diss.	- max.	.036	.025	.020	.010	.028
	- min.	.027	.01	.009	.003	.009
	- mean	.032	.017	.014	.007	.019
Nitrogen:total	- max.	.47	.86	.80	.26	2.0
	- min.	.33	.17	.27	.15	.37
	- mean	.40	.46	.45	.21	1.05
Nitrogen:organic	- max.	.44	.78	.75	.25	1.0
	- min.	.26	.06	.20	.14	.19
	- mean	.36	.40	.43	.20	.46
Nitrogen:NH_3	- max.	.046	.108	.035	.020	1.06
	- min.	.026	.035	.023	.008	.18
	- mean	.033	.064	.030	.012	.61
Nitrogen:NO_3 (NO_2 + NO_3)	- max.	.02	.02	.04	L.02	.02
	- min.	L.02	L.02	L.02	L.02	L.02
	- mean	L.02	L.02	.03	L.02	L.02
Nitrogen:Kjeldahl	- max.	.43	.84	.78	.26	2.06
	- min.	.31	.17	.23	.15	.78
	- mean	.38	.46	.43	.21	1.07

TABLE 3 : Maximum, minimum and mean loads (kg/day) for selected chemical parameters at stations on the Nicola and Coldwater Rivers during freshet (1978/79)

Parameter		Station								
		Nicola River						Coldwater River		
		68	116	115	534	179	7	500	502	543
Phosphorus:Total	-max.	68.5	93.5	189.4	653.3	2932.2	1164	3197.3	2698.2	2.7
	-min.	7.9	18.0	23.7	54.1	23.2	17.5	2.7	51.9	2.7
	-mean	31.03	49.15	90.65	280.13	800.78	410.27	662.98	608.42	2.7
Phosphorus:tot.diss.	-max.	24.2	59.9	93.5	273.5	159.5	161.2	57.2	171.6	1.16
	-min.	3.6	12.4	14.3	21.5	11.2	4.4	1.2	36.3	1.16
	-mean	11.57	38.31	51.67	107.25	63.87	63.82	14.59	67.84	1.16
Nitrogen:Total	-max.	846.7	863.1	935.1	2960	3874.3	1917.9	3899.1	3951.1	38.5
	-min.	115.2	255.6	227.2	395	283.4	232.7	38.9	265.8	38.5
	-mean	415.0	500.5	508.2	1362.3	1387.8	1010.7	857.7	1088.6	38.5
Nitrogen:Organic	-max.	806.4	839.2	911.1	2890.0	3722.3	1851.8	3743.2	3535.2	38.5
	-min.	108.6	246.2	203.6	395.0	274.8	218.2	38.9	58.3	38.5
	-mean	398.8	489.1	490.9	1324.7	1336.2	821.6	797.9	841.2	38.5
Nitrogen:NH_3	-max.	36.3	36.0	26.4	60.8	1671.1	197.0	57.2	291.1	1.93
	-min.	4.6	7.6	8.7	17.8	8.6	13.1	1.9	139.2	1.93
	-mean	14.32	15.97	15.03	34.38	58.55	64.70	15.44	216.8	1.93
Nitrogen:NO_3	-max.	40.32	47.95	47.95	151.93	151.93	-	103.98	103.98	7.71
	-min.	6.58	9.47	9.47	17.17	17.17	-	7.71	7.71	7.71
	-mean	20.60	25.07	25.07	65.08	65.08	-	40.01	40.01	7.71
Nitrogen:Kjeldahl-m	-max.	842.7	875.2	937.5	2950.8	3889.3	1884.9	3800.4	3826.3	40.4
	-min.	113.9	254.7	216.4	429.6	283.4	231.3	42.1	253.7	40.4
	-mean	413.1	505.1	505.9	1354.1	1394.8	794.4	893.23	1058.1	40.4

TABLE 4: Maximum, minimum and mean loads (kg/day) for selected chemical parameters on the Nicola and Coldwater Rivers during freshet (1980/81)

Parameter		Station				
		Nicola River			Coldwater River	
		115	534	179	500	502
Phosphorus:total	- max.	277	344	237	25	32
	- min.	41	46	47	3	12
	- mean	106	82.6	113	12.5	19
Phosphorus:total diss.	- max.	98	112	89	9	14
	- min.	9	11	10	2	7
	- mean	39.5	42.5	38.7	4.8	10.3
Nitrogen:total	- max.	1183	1988	1251	284.6	585
	- min.	254	245	389	65.6	355
	- mean	634.7	920.3	840.3	148.1	481.7
Nitrogen:organic	- max.	1096.6	1831.4	1161.4	268.8	300.4
	- mix.	200.4	86.4	287.7	63.1	91.1
	- mean	585.0	803.1	758.4	138.9	214.6
Nitrogen:NH_3	- max.	78	156.3	102.7	15.8	280
	- min.	22	63	36.4	2.5	264
	- mean	41.7	111.7	63.1	8.8	270.3
Nitrogen:NO_3 (NO_2^- - NO_3)	- max.	58	89	89	32	32
	- min.	15	22	22	.5	5
	- mean	26.7	41.5	56	14.7	15.3
Nitrogen:Kjeldahl	- max.	1174.6	1987.7	1264.1	284.6	580.4
	- min.	235.8	241.4	337.8	65.6	355.1
	- mean	626.6	914.8	821.5	147.7	484.9

TABLE 5 : Maximum, minimum and mean concentration values (mg/L) for selected chemical parameters at stations on the Nicola and Coldwater Rivers during non-freshet (1978/79)

Parameter		Station								
		Nicola River						Coldwater River		
		68	116	115	534	179	7	500	502	543
Phosphorus: Total	-max.	.036	.110	.155	.162	.154	.030	.072	1.560	.440
	-min.	.016	.027	.036	.031	.024	.009	.003	.052	.005
	-mean	.024	.050	.066	.089	.062	.015	.016	.543	.018
Phosphorus: Tot.diss	-max.	.032	.089	.128	.114	.130	.017	.058	.512	.030
	-min.	.005	.008	.007	.006	.006	.003	.003	.039	.003
	-mean	.015	.031	.038	.044	.037	.007	.012	.240	.008
Nitrogen: Total	-max.	.55	1.00	2.00	1.01	1.00	.35	.78	8.052	1.00
	-min.	.25	.45	.38	.38	.27	.16	.08	.695	.07
	-mean	.40	.62	.66	.67	.45	.24	.18	3.661	.15
Nitrogen: Organic	-max.	.53	.96	2.00	1.00	1.00	.32	.12	5.34	1.00
	-min.	.20	.42	.30	.21	.05	.15	.05	.21	.07
	-mean	.34	.56	.56	.50	.35	.22	.09	1.93	.11
Nitrogen: NH_3	-max.	.036	.148	.355	.392	.330	.013	.011	2.68	.045
	-min.	.009	.005	.015	.040	.011	.005	.005	.53	.005
	-mean	.019	.045	.060	.172	.084	.089	.007	1.629	.015
Nitrogen: NO_3	-max.	.14	.12	.15	.16	.17	-	.08	1.00	.09
	-min.	.02	.02	.02	.02	.02	-	.02	.02	.02
	-mean	.055	.036	.062	.061	.074	-	.038	.14	.03
Nitrogen: Kjeldahl	-max.	.547	.997	2.355	1.392	1.330	.333	.135	5.34	.191
	-min.	.247	.469	.296	.379	.190	.158	.016	.21	.075
	-mean	.366	.608	.426	.665	.311	.230	.091	1.93	.123

TABLE 6 - Maximum, minimum and mean concentrations (mg/l) for selected chemical parameters on the Nicola and Coldwater Rivers during non-freshet (1980/81).

PARAMETER		STATIONS				
		NICOLA RIVER			COLDWATER RIVER	
		115	534	179	500	502
Phosphorus: total	- max.	.068	.144	.061	.032	1.38
	- min.	.025	.023	.015	.004	.026
	- mean	.042	.051	.029	.013	.360
Phosphorus: Tot. diss.	- max.	.034	.056	.023	.009	.128
	- min.	.010	.009	.011	L.003	.008
	- mean	.022	.022	.016	.005	.04
Nitrogen: total	- max.	.82	.69	.63	.32	5.0
	- min.	.33	.27	.15	.03	.66
	- mean	.47	.49	.36	.13	2.43
Nitrogen: organic	- max.	.78	.59	.59	.32	3.0
	- min.	.26	.10	.03	L.01	L.01
	- mean	.44	.28	.25	.11	1.05
Nitrogen: NH_3	- max.	.058	.327	.140	.022	2.96
	- min.	.023	.076	.023	L.005	1.49
	- mean	.035	.178	.061	.010	1.43
Nitrogen: NO_3 (NO_2 + NO_3)	- max.	.10	.06	.13	.06	.35
	- min.	L.02	L.02	.02	L.02	L.02
	- mean	L.04	L.04	.05	L.028	.08
Nitrogen: Kjeldahl	- max.	.817	.666	.613	.325	.486
	- min.	.305	.233	.058	.006	.66
	- mean	.444	.453	.295	.108	2.41

TABLE 7 : Maximum, minimum and mean loads (kg/day) for selected chemical parameters at stations on Nicola and Coldwater Rivers during non-freshet (1978/79)

Parameter		Station: Nicola River						Coldwater River		
		68	116	115	534	179	7	500	502	543
Phosphorus:Total	-max.	3.3	20.5	28.8	88.6	78.2	17.6	11.3	129.3	62.4
	-min.	.8	3.3	3.0	10.5	7.2	2.9	.2	6.7	.6
	-mean	2.23	10.67	14.16	37.24	26.25	8.78	3.03	71.41	3.9
Phosphorus:Tot.diss.	-max.	2.2	17.1	23.8	57.9	66.0	7.6	10.6	54.7	9.7
	-min.	.4	1.7	1.9	2.8	2.8	1.0	.2	5.3	.3
	-mean	1.12	6.08	7.60	18.42	15.73	3.70	2.32	35.33	2.0
Nitrogen:Total	-max.	85.6	321.4	372.0	508.0	508.0	228.2	104.0	965.8	141.
	-min.	14.9	30.6	31.3	41.7	64 4	59.8	7.1	98.5	6.7
	-mean	39.65	143.2	140.2	275.1	191.0	131.6	30.71	533.9	30.5
Nitrogen:organic	-max.	83.3	308.6	372.0	508.0	508.0	208.6	38.6	643.9	141.
	-min.	13.6	86.4	48.7	41.7	9.9	56.0	6.4	60.9	6.7
	-mean	38.23	140.8	126.3	208.8	151.7	127.0	16.45	273.38	22.7
Nitrogen:NH_3	-max.	2.4	27.5	66.0	199.1	167.6	8.5	3.5	459.6	7.7
	-min.	.8	1.1	2.9	18.8	3.9	3.0	.4	36.3	0.4
	-mean	1.75	10.00	11.75	68.46	34.84	4.67	1.29	[illegible]	2.69
Nitrogen:NO_3	-max.	9.55	24.70	28.81	76.19	86.35	-	25.75	133.3	28.9
	-min.	1.15	1.36	4.18	5.98	5.98	-	1 42	2.83	1.42
	-mean	4.29	7.68	10.97	25.07	28.20	-	8.25	23.65	6.93
Nitrogen:Kjeldahl	-max.	76.3	320.5	438.0	707.1	675.6	217.1	47.14	1062.4	56.2
	-min.	14.72	106.2	55.4	96.7	38.3	54.0	7.05	257.3	7.39
	-mean	40.02	150.8	138.03	277.2	197.3	131.7	17.74	564.1	25.4

TABLE 8 : Maximum, minimum and mean loads (kg/day) for selected chemical parametors on the Nicola and Coldwater Rivers during non-freshet (1980/81)

Parameter		Station: Nicola River			Coldwater River	
		115	534	179	500	502
Phosphorus:total	- max.	44	63	89	16	246
	- min.	7	16	8	1	10
	- mean	21.2	35.2	27.5	4.9	83.2
Phosphorus:total diss.	- max.	22	32	34	4.3	73
	- min.	4	7	5	.4	3
	- mean	11.8	17.2	14.0	1.9	14.5
Nitrogen:total	- max.	466	791	500	116.6	1205
	- min.	105	212	114	5.3	242
	- mean	222.1	385.8	313.8	39.7	614.7
Nitrogen:organic	- max.	368.1	349.7	349.7	76.9	751.7
	- min.	91.7	64.5	101.6	2.9	3.2
	- mean	189.6	197.1	189.1	29.6	278.3
Nitrogen:NH_3	- max.	33.7	219	137.4	14.3	568.5
	- min.	6.5	45	13.6	.7	179
	- mean	17.8	141.0	52.3	3.8	346.4
Nitrogen:NO_3	- max.	65	88	162	39	62
	- min.	8	9	11	3	4
	- mean	21.8	17.0	48	10	18.6
Nitrogen:Kjeldahl	- max.	398.3	[illegible]	363.3	85.6	1166.7
	- min.	98.2	201.5	63.1	5.0	241.4
	- mean	195.4	[illegible]	241.5	33.4	624.5

TABLE 4 : N:P Ratio ($NH_3 + NO_3 + NO_2$/Total Diss. Phosphorus) at stations on the Nicola and Coldwater Rivers (1978/79)

Date	Station								
	Nicola River						Coldwater River		
	68	116	115	534	179	7	500	502	543
February 1979	5.4	2.8	3.9	4.7	3.9	-	2.8	8.8	7.1
January 1979	5.9	2.6	3.2	5.3	4.4	-	18.0	7.2	-
December 6, 1978	-	-	2.2	4.9	4.8	-	11.5	8.5	9.0
Oct. 23-24, 1978	4.8	1.2	1.0	4.9	1.5	-	-	7.1	2.3
Oct. 10-11, 1978	-	-	1.0	4.5	2.2	1.3	1.7	28.5	14.0
Sept. 25-26, 1978	1.9	1.8	1.3	4.5	1.5	.8	1.3	9.5	13.6
Sept. 11-12, 1978	1.4	-	1.6	5.8	.7	1.4	1.7	10.1	2.4
Aug. 28-29, 1978	2.1	3.4	1.2	2.6	.6	2.7	1.7	5.7	11.4
Aug. 14-15, 1978	2.1	1.9	1.1	5.1	1.9	3.3	3.0	5.3	17.3
July 31, 1978	3.4	4.6	2.7	6.7	9.2	2.5	1.7	5.6	-
July 17, 1978*	1.5	-	-	1.5	.8	3.0	1.7	5.9	14.3
July 10, 1978*	1.0	.9	.6	.7	1.0	.6	1.3	5.2	-
June 20, 1978*	.8	.2	.3	.2	.6	-	2.0	4.2	-
June 5, 1978*	1.5	.6	.3	.2	1.1	1.2	2.8	2.3	-
March 20, 1978	-	-	2.2	4.4	5.3	-	3.8	4.4	-
March 1, 1978	-	-	6.2	8.9	11.5	5.9	1.0	7.8	8.1
Mean:Freshet	1.2	.6	.4	.7	.9	1.6	2.0	4.4	14.3
Mean:Non-Freshet	3.4	2.6	2.3	5.2	3.9	2.6	4.4	9.0	3.1

TABLE 10: N:P Ratio (NH_3 + NO_3 + NO_2/Total Diss. Phosphorus) at stations on the Nicola and Coldwater Rivers (1980/81)

Date	Station 115	179	500	502	534
April 22, 1981*	1.8	6.3	5.0	-	8
April 8, 1981	2.0	4.1	4.7	25.0	11.1
March 12, 1981	2.4	6.8	4.3	-	12.1
February 24, 1981	3.3	7.1	4.4	-	10.9
February 11, 1981	2.7	10.1	5.4	65.0	14.4
January 28, 1981	3.6	5.2	6.3	5.5	5.6
January 13, 1981	5.9	7.1	11.7	6.2	7.0
December 9, 1980	5.5	15.0	19.0	92.0	23
November 26, 1980	4.7	14.8	9.8	68.7	19
November 13, 1980	4.9	11.2	9.6	84.2	23.8
October 30, 1980	4.1	8.2	8.3	156.0	21.7
October 8, 1980	2.3	4.6	6.3	44.0	4.4
October 1, 1980	2.3	3.8	5.0	63.5	11.1
September 24, 1980	2.5	6.5	5.0	30.7	9.7
September 10, 1980	2.9	3.9	8.7	88.0	7.0
September 4, 1980	4.5	3.3	8.3	45.0	4.2
August 19, 1980	-	-	-	-	-
August 6, 1980	3.8	2.8	8.7	26.9	5.8
July 22, 1980*	5.2	5.9	3.0	38.6	7.7
July 8, 1980*	1.7	-	9.3	28.6	4.2
June 19, 1980*	1.4	2.1	5.0	21.9	2.2
Mean: Freshet	1.6	4.8	5.6	29.7	5.5
Mean: Non-Freshet	3.7	7.2	7.8	57.2	10.1

TABLE 11: N:P Ratio in Algal Cells (Total Kjeldahl Nitrogen compared to Total Phosphorus on two plates at each station)(1980)

Date	Station 115	Station 179	Station 500	Station 502	Station 534
October 1 - 30	4.2 3.5	- -	2.8 -	4.3 5.5	11.1 5.6
October 1 - 21 (Oct. 8 - 30 for 179)	6.5 7.6	8.7 8.0	1.1 4.6	8.8 4.1	8.9 -
October 1 - 15 (October 8 - 21 for 179)	10.0 31.0	4.8 3.9	24.4 50.0	8.5 80.0	7.9 10.0
October 1 - 8 (October 8 - 15 for 179)	30.4 36.9	3.7 20.0	L10 26.0	170.0 -	80.0 53.0
September 4 - October 1 (Sept. 4 - Oct. 8 for 179)	2.6 2.6	11.8 8.6	5.0 3.6	4.9 5.3	8.5 11.4
September 4 - 24	5.7 7.9	12.4 10.5	7.1 10.0	- -	11.0 8.6
September 4 - 17	4.8 7.8	6.6 6.5	20.0 -	1.4 3.2	10.9 7.9
September 4 - 10	3.7 10.0	L10 11.7	10.0 -	5.0 4.7	6.7 6.7
August 6 - September 4	7.4 13.2	8.4 -	2.0 2.7	5.8 6.5	8.8 -
August 6 - 26	5.9 13.2	7.7 -	4.5 2.7	2.0 3.8	7.1 13.6
August 6 - 19	6.9 6.1	7.9 9.6	6.0 6.2	4.4 5.9	5.9 11.0
August 6 - 12	5.0 7.5	7.3 12.0	L2.5 L3.3	3.7 4.1	8.0 10.0
July 9 - August 6	7.6 8.6	18.3 10.0	2.6 4.0	4.7 6.7	8.3 5.7
July 9 - 29	13.3	28.7 12.7 10.0	6.0 15.0	2.3 -	6.3 10.0
July 9 - 22	L10.0 -	- -	[illegible] -	3.3 15.0	6.0 8.6
July 9 - 15	L3 10.0	12.5 15.0	7.5 [illegible]	20.0 10.0	10.0 10.0

TABLE 12: Range of non-filterable residue concentrations (mg/L) in the Nicola River during freshet and non-freshet periods (1978/79 and 1980/81)

Station			Period			
			Freshet 1978	Non-freshet 1978/79	Freshet 1980	Non-freshet 1980/81
Nicola River	68	max.	20	14		
		min.	2	4		
		mean	8	7.5		
	116	max.	4	14		
		min.	4	2		
		mean	4	7		
	115	max.	32	32	8	14
		min.	4	4	8	4
		mean	17	12.2	8	9
	534	max.	68	68	18	30
		min.	6	2	18	2
		mean	25	16.7	18	13.6
	179	max.	418	36	8 [illegible]	28
		min.	6	2	8	3
		mean	124	10	8 [illegible]	8.4
	7	max.	38	12		
		min.	4	4		
		mean	11.5	6.4		

TABLE 13: Range of non-filterable residue loads (kg/day) measured in the Nicola River during freshet and non-freshet periods (1978/79 and 1980/81)

Station			Period			
			Freshet 1978	Non-freshet 1978/79	Freshet 1980	Non-freshet 1980/81
Nicola River	68	max.	40,318	3,240.2		
		min.	765.8	185.9		
		mean	12,155	808.1		
	116	max.	9,590.3	3,517.6		
		min.	1,893.5	272.0		
		mean	5,009.6	1,583.5		
	115	max.	76,723	6,221	6,169	9,780
		min.	1,894	750	2,972	1,080
		mean	29,571	2,429	4,722	4,804
	534	max.	516,547	36,096	25,894	36,637
		min.	5,153	783	4,182	847
		mean	147,774	7,667	10,260	11,655
	179	max.	3,174,526	19,689	11,508	41,031
		min.	5,153	783	2,618	1,270
		mean	834,908	4,717	6,169	9,133
	7	max.	251,312	11,723		
		min.	5,818	1,311		
		mean	89,168	3,981		

TABLE 14: Numbers of total coliforms (MPN) measured in the Nicola and Coldwater Rivers during freshet and non-freshet periods (1978/79 and 1980/81)

Period		Stations								
		Nicola River						Coldwater River		
		68	116	115	534	179	7	500	502	543
Freshet:1978	-max.	130	240	140	2400	1600	300	110	G240,000	-
	-min.	4	22	33	540	350	183	49	G 2,400	-
	-mean	68	95	101	1513	1183	244	69	92,500	240
Freshet: 1980	-max.	-	-	170	9200	288	-	920	G 24,000	-
	-min.	-	-	13	100	130	-	22	1,400	-
	-mean	-	-	87	2950	205	-	255	10,400	-
Non-freshet:1978/79	-max.	220	350	540	3500	2400	79	540	G240,000	1600
	-min.	8	L.2	8	920	130	8	L2	G2,400	2
	-mean	77	51	150	2460	977	36	152	51,700	504
Non-freshet:1980/81	-max.	-	-	790	16000	G2400	-	170	G240,000	-
	-min.	-	-	5	110	33	-	7	790	-
	-mean	-	-	87	3770	1108	-	48	69,000	-

TABLE 15: Numbers of fecal coliforms (MPN) measured in the Nicola and Coldwater Rivers during freshet and non-freshet periods (1978/79 and 1980/81)

Period		Stations								
		Nicola River						Coldwater River		
		68	116	115	534	179	7	500	502	543
Freshet 1978	- max.	13	240	70	3500	920	74	110	540,000	-
	- min.	2	8	13	49	79	28	13	5,400	-
	- mean	9	85	33	1209	370	42	47	31,500	49
Freshet 1980	- max.	-	-	70	1700	80	-	540	G 24,000	-
	- min.	-	-	13	20	L20	-	8	200	-
	- mean	-	-	38.7	530	50	-	147	6,630	-
Non-freshet 78/79	- max.	31	17	79	G2400	G2400	33	540	17,000	920
	- min.	2	L2	L2	33	17	L2	2	L2	2
	- mean	11	6	27	981	425	15	68	4,161	177
Non-freshet 1980/81	- max.	-	-	80	9200	790	-	49	54,000	-
	- min.	-	-	2	49	33	-	L2	60	-
	- mean	-	-	20	1146	212	-	16	9,533	-

TABLE 16: Range of non-filterable residue concentrations (mg/l) in the Coldwater River during freshet and non-freshet periods (1978/79 and 1980/81)

Station			Period			
			Freshet 1978	Non-freshet 1978/79	Freshet 1980	Non-freshet 1980/81
Coldwater River	500	max.	724	14	16	22
		min.	6	2	16	2
		mean	176.4	4	16	7.7
	502	max.	658	56	10	49
		min.	4	2	10	5
		mean	162.8	19.4	10	14

TABLE 17: Range of non-filterable residue loads (kg/day) measured in the Coldwater River during freshet and non-freshet periods (1978/79 and 1980/81)

			Period			
			Freshet 1978	Non-freshet 1978/79	Freshet 1980	Non-freshet 1980/81
Coldwater River	500	max.	3,763,050	5,213	10,688	10,368
		min.	2,313	168	294	449
		mean	762,047	1,040	3,145	4,067
	502	max.	3,420,736	3,967	6,679	11,664
		min.	1,541	257	1,037	769
		mean	704,142	2,695	3,128	5,383

TABLE 18 : Maximum, minimum, and mean concentrations (mg/L) for selected chemical parameters on Quilchena Creek during freshet and non-freshet periods (1978/79)

Parameter		Concentration		Load	
		Freshet	Non-Freshet	Freshet	Non-Freshet
Phosphorus:Total	-max.	.354	.044	152.93	1.87
	-min.	.035	.027	2.08	.50
	-mean	.141	.035	46.87	.95
Phosphorus:tot.diss.	-max.	.040	.028	17.28	1.36
	-min.	.024	.018	1.43	.194
	-mean	.033	.023	7.33	.643
Nitrogen:total	-max.	.999	.378	431.69	13.83
	-min.	.364	.211	21.61	1.16
	-mean	.613	.299	155.84	6.78
Nitrogen:Kjeldahl	-max.	.999	.378	431.69	13.83
	-min	.364	.211	21.61	1.16
	-mean	.613	.299	155.84	6.78
Nitrogen:NH_3	-max.	.014	.028	3.89	1.19
	-min.	.009	.007	.63	.22
	-mean	.011	.018	1.98	.47
Nitrogen:NO_3	-max.	L.02	L.02		
	-min.	L.02	L.02	nil	nil
	-mean	L.02	L.02		
Nitrogen:Organic	-max.	.99	.35	427.7	13.12
	-min.	.35	.20	20.78	.94
	-mean	.60	.28	153.89	6.30

Figures for the freshet and non-freshet periods are based on data for June to mid-July and mid-July to November 1978 respectively. No further data were available for 1978.

TABLE 19 - Maximum, minimum and mean concentrations (mg/l) for selected chemical parameters on Moore Creek during freshet and non-freshet periods (1980/81).

PARAMETER		CONCENTRATION		LOAD	
		FRESHET	NON-FRESHET	FRESHET	NON-FRESHET
Phosphorus: total	- max.	.051	.051	3.024	.346
	- min.	.032	.019	.259	.043
	- mean	.040	.031	1.380	.142
Phosphorus: tot. diss.	- max.	.037	.037	2.246	.259
	- min.	.024	.015	.259	.026
	- mean	.031	.024	[illegible]	.113
Nitrogen: total	- max.	.44	.27	21.96	1.47
	- min.	.20	.12	4.06	.35
	- mean	.33	.20	10.05	.83
Nitrogen: organic	- max.	.36	.25	21.69	1.47
	- min.	.15	.08	1.38	.35
	- mean	.24	.18	9.16	.80
Nitrogen: NH_3	- max.	.117	.028	1.123	1.467
	- min.	L.005	L.005	.086	.026
	- mean	.042	.017	.489	.526
Nitrogen: NO_3	- max.	.17	.02	1.55	.17
	- min.	L.02	L.02	.43	.03
	- mean	L.07	L.02	L 1.06	L .08
Nitrogen: Kjeldahl	- max.	.36	.27	21.71	1.43
	- min.	.20	.16	2.50	.38
	- mean	.28	.21	9.55	.83

TABLE 20 : Range of non-filterable residue concentrations (mg/L) and loads (kg/day) measured in Quilchena Creek (1978/79) and Moore Creek (1980/81).

Location	Period		Non-filterable residue Concentration (mg/L)	load (kg/day)
Quilchena Creek	Freshet (1978)	- max.	334	144,288
		- min.	4	356
		- mean	99	39,275
		- N	4	4
	Non-freshet	-max.	20	619.3
		-min.	2	61.2
		-mean	10	267.8
		-N	6	6
Moore Creek	Freshet (1980)	-max.	6	361.8
		-min.	2	18.5
		-mean	4	156.4
		-N	3	3
	Non-freshet (1980/81)	-max.	9	54.6
		-min.	2	3.3
		-mean	5	24.5
		-N	7	7

TABLE - Numbers of total and fecal coliforms measured in Quilchena Creek (1978/79) and Moore Creek (1980/81) during freshet and non-freshet periods.

LOCATION	PERIOD		TOTAL COLIFORM	FECAL COLIFORM
Quilchena Creek	freshet 1978	-max.	540	170
		-min.	540	49
		-mean	540	109.5
		-N	2	2
	non-freshet 1978/79	-max.	1,600	330
		-min.	23	23
		-mean	346	87.4
		-N	9	9
Moore Creek	freshet 1980	-max.	540	540
		-min.	540	540
		-mean	540	540
		-N	1	1
	non-freshet 1980/81	-max.	G2,400	G2,400
		-min.	63	63
		-mean	G1,068	F1,068
		-N	7	7

TABLE 7.7 - Range of concentration values (mg/l) for selected chemical parameters at stations on Guichon Creek during freshet (1979)

PARAMETER		STATION						
		128	26	96	44	345	351	3
Phosphorus: total	- max.	115	44	92	71	40	54	770
	- min.	84	36	84	44	27	32	36
	- mean	100	40	88	57	33	40	222
	- N	4	4	2	4	4	4	4
Phosphorus: total diss.	- max.	67	32	71	56	13	21	47
	- min.	31	31	65	34	7	11	16
	- mean	48	32	68	43	10	16	31
	- N	4	3	2	4	3	4	4
Nitrogen: total	- max.	480	470	430	590	510	620	2,000
	- min.	300	300	380	340	460	330	360
	- mean	400	390	410	420	470	460	820
	- N	4	4	2	4	4	4	4
Nitrogen: Kjeldahl	- max.	480	410	430	570	510	620	2,000
	- min.	300	300	350	320	460	330	330
	- mean	400	360	390	410	470	460	810
	- N	4	4	2	4	4	4	4
Nitrogen: $NO_3 + NO_2$	- max.	L20	60	30	20	L20	L20	30
	- min.	L20	L20	L20	L20	L20	L20	L20
	- mean*	L20	30	25	20	L20	L20	25
	- N	4	4	2	4	4	4	4

* In order to calculate a mean value for concentration of $NO_3 + NO_2$ concentration values below the detectable limit of .02 mg/l (20 ug/l) were taken as 20 ug/l. When all samples had concentrations less than 20 ug/l the mean is indicated as L20 ug/l.

TABLE _ Range of loading rates (kg/day) for selected chemical parameters at stations on Guichon Creek during freshet (1979)

PARAMETER		STATION						
		128	26	96	44	345	351	3
Phosphorus: total	- max.	.67	.38	.74	4.36	1.51	5.42	67.86
	- min.	.31	.05	.41	1.09	.15	1.01	.02
	- mean	.47	.21	.58	2.65	.74	2.76	17.30
	- N	4	4	2	4	3	3	4
Phosphorus: total diss.	- max.	.56	.24	.57	2.96	.38	1.53	4.14
	- min.	.24	.04	.32	.86	.04	.67	.02
	- mean	.40	.12	.45	1.96	.23	1.01	1.20
	- N	4	4	2	4	3	3	4
Nitrogen: total	- max.	2.78	3.86	3.45	43.60	17.70	65.38	176.26
	- min.	1.31	.61	1.87	5.20	2.47	10.46	.22
	- mean	1.87	1.91	2.66	22.48	9.88	32.50	48.43
	- N	4	4	2	4	3	3	4
Nitrogen: Kjeldahl	- max.	2.78	3.68	3.45	42.12	17.70	65.38	176.26
	- min.	1.31	.53	1.72	4.90	2.47	10.46	.22
	- mean	1.87	1.82	2.59	21.70	9.88	32.50	48.40
	- N	4	4	2	4	3	3	4
Nitrogen: $NO_3 + NO_2$	- max.	.11*	.18	.15	1.48	.75*	2.78*	2.64
	- min.*	.07	.08	.16	.31	.11	.63	.01
	- mean*	.09	.13	.15	.98	.42	1.49	.86
	- N	4	4	2	4	3	3	4

* Values indicated by an asterisk were computed from concentration values of L.02 mg/1 (minimum detectable limit for NO_c) using .02 mg/1 as the concentration. Consequently, the values listed are maximum values with the actual loading being less than that shown. All minimum loading values for NO_3 nitrogen were calculated this way. Mean values were determined using values calculated as above where necessary (usually only one or two values).

TABLE - Range of loading rates (kg/day) for selected chemical parameters at stations on Guichon Creek during non-freshet (1979/80)**

Parameter		STATION						
		128	26	96	44	345	351	3
Phosphorus: total	- max.	.79	.17 (.34)	.50	.74 (36.2)	8.26 (14.98)	2.23 (7.89)	.31 (23.53)
	- min.	.07	.01	.04	.12	.01	.03	.02
	- mean	.22	.04 (.06)	.23	.43 (3.18)	1.65 (2.76)	.59 (1.15)	.07 (2.03)
	- N	13	13 (14)	10	12 (13)	11 (12)	12 (13)	11 (12)
Phosphorus: total diss.	- max.	.59	.11 (.19)	.61	.58 (27.41)	1.67 (13.88)	1.48 (6.74)	.27 (5.66)
	- min.	.05	.01	.04	.09	.01	.01	.02
	- mean	.16	.03 (.04)	.15	.31 (2.39)	.28 (1.52)	.39 (.87)	.06 (.53)
	- N	13	13 (14)	10	12 (13)	10 (11)	12 (13)	11 (12)
Nitrogen: total	- max.	2.34	1.23 (1.23)	3.03	3.54 (186.8)	75.77 (190.97)	28.69 (132.18)	2.97 (66.10)
	- min.	.20	.04	.16	.45	.10	.35	.20
	- mean	.76	.32 (.37)	.87	2.02 (16.23)	20.9 (35.10	7.16 (17.57)	1.10 (7.71)
	- N	12	13 (14)	10	12 (13)	11 (12)	11 (12)	11 (12)
Nitrogen: Kjeldahl	- max.	2.07	.76 (.76)	2.35	3.3 (186.8)	75.77 (190.97)	28.69 (132.18)	2.97 (66.10)
	- min.	.20	.04	.16	.5	.10	.22	.20
	- mean	.68	.19 (.21)	.71	1.71 (15.95)	14.8 (30.9)	6.03 (16.54)	.83 (6.27)
	- N	12	13 (14)	10	12 (13)	10 (11)	11 (12)	11 (12)
Nitrogen: NO_3	- max.	.27	.54 (.54)	.68	1.18 (8.87)	1.51*	1.43 (11.90)	2.56
	- min.*	.01	.01	.02	.03	.01	.03	.01
	- mean*	.09	.14 (.16)	.17	.35 (1.00)	.36 (.63)	.68 (1.61)	.39 (.91)
	- N	12	13 (14)	10	12 (13)	10 (11)	11 (12)	11 (12)

** Loading values for non-freshet were computed using data for all dates except February 28, 1980, which was an anomaly, being a sudden thaw and high flow run-off period of about two days. Figures in brackets were computed using all available data including February 28, 1980.

The flows at station 26 were taken from the federal gauging station there (08LG009). The flow for February 28 was an estimate only, based on other flows at that station, so the peak flow observed at stations downstream was not apparent in the data based on this estimate. Since flow data at stations 128 and 96 were calculated from the related flows at station 26, no peak flow on February 28 was apparent at these stations either. From the estimated data, stations 26 and 128 had high flows February 28 and March 12, 1980. No sample was obtained at station 96 on February 28, so only the figure calculated without February 28 data is given.

* Values indicated by an asterisk were computed from concentration values of L.02 mg/l (20 ug/l), the minimum detectable limit for NO_3, using .02 mg/l as the actual concentration. All minimum figures for nitrate loading at each station were estimates calculated this way. Mean figures were determined using values calculated as above where necessary.

TABLE - Range of concentration values (ug/l) for selected chemical parameters at stations on Guichon Creek during non-freshet (1979/80).*

PARAMETER		STATION						
		128	26	96	44	345	351	3
Phosphorus: total	- max.	184	78 (187)	136	89 (776)	216	51 (179)	73 (1,780)
	- min.	72	29	33	37	32	14	11
	- mean	123	44 (54)	71	65 (119)	86 (164)	27 (39)	26 (172)
	- N	13	13 (14)	10	12 (13)	11 (12)	12 (13)	11 (12)
Phosphorus: total diss.	- max.	114	50 (102)	124	65 (587)	122 (945)	42 (153)	60 (428)
	- min.	39	23	28	24	8	10	10
	- mean	89	35 (40)	55	47 (88)	34 (110)	21 (31)	20 (54)
	- N	13	13 (14)	10	12 (13)	10 (11)	12 (13)	11 (12)
Nitrogen: total	- max.	520	570 (570)	910	480 (4,000)	2,000 (13,000)	550 (3,000)	630 (6,000)
	- min.	300	130	160	180	530	140	120
	- mean	397	326 (340)	329	326 (608)	980 (1,980)	341 (563)	311 (785)
	- N	12	13 (14)	10	12 (13)	11 (12)	11 (12)	11 (12)
Nitrogen: Kjeldahl	- max.	460	350 (350)	540	350 (4,000)	2,000 (13,000)	490 (3,000)	610 (5,000)
	- min.	200	100	120	150	530	100	120
	- mean	365	211 (215)	264	257 (545)	951 (,2,251)	253 (482)	260 (655)
	- N	12	13 (14)	10	12 (13)	10 (11)	11 (12)	11 (12)
Nitrogen: $NO_3 + NO_2$	- max.	100	260 (260)	370	160 (190)	150 (230)	270 (290)	190 (510)
	- min.	L20	L20	L20	L20	L20	L20	L20
	- mean**	60	119 (126)	78	54 (65)	45 (62)	94 (110)	59 (96)
	- N	12	13 (14)	10	12 (13)	10 (11)	11 (12)	11 (12)

* Concentration values given above for non-freshet were computed using data for all dates except February 28, 1980, which was an anomaly, being a sudden thaw and high flow run-off period of about two days. Concentrations were also abnormally high at this time. Figures in brackets were computed using all available data, including February 28, 1980.

The flows at station 26 were taken from the federal gauging station there (08LG009). The flow for February 28, 1980, was an estimate only, based on other flows at that station so the peak flow observed at stations downstream was not apparent in the data based on this estimate. Since flow data for stations 96 and 128 were calculated from the related flows at station 26, no peak flows were apparent at these stations either. From the estimated data, stations 26 and 128 had high flows February 28 and March 12, 1980. To be consistent with the other stations, the first figure given was calculated without February 28 data while the figure in brackets includes all data. Since no sample was obtained at station 96 on February 28, only the figure computed without February 28 data is given.

** In order to calculate a mean value for concentration of NO_3, concentration values below the detectable limit of 0.2 mg/l (20 ug/l) were taken as 20 ug/l.

TABLE 26 - Arsenic (total) (mg/l)

	STATION						
DATE	128	26	96	44	345	351	3
July 3, 1979	L.005	L.005	L.005	L.005	L.005		
July 10, 1979							
July 24/25, 1979	L.005	L.005	L.005	L.005	L.005		
August 7, 1979							
August 21, 1979	L.005	L.005	---	.007	.014		
September 12/13	L.005	L.005	L.005	L.005	L.005	L.005	
October 17, 1979							
October 22, 1979	L.005	L.005	L.005	L.005	L.005		
November 14, 1979	L.05	L.05	L.05	L.05	L.05	L.05	L.05
January 8, 1980							
February 5, 1980							
February 28, 1980	.006	L.005			.010	.009	.019
March 12, 1980	.005	L.005	.005	L.005	.006	L.005	L.005
April 9, 1980							
April 24, 1980							
April 30, 1980	L.001	L.001	.002	L.001	.002		

TABLE 27- Cadmium (total and dissolved) (mg/l)

	STATION									
	128		26		96		44		345	
DATE	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.
July 3, 1979	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001
July 25, 1979	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001
August 21, 1979	L.001	L.001	L.001	L.001	---	---	L.001	L.001	L.001	L.001
September 12, 1979	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001
October 22, 1979	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001
November 14, 1979	L.01	---	L.01	---	L.01	---	L.01	---	L.01	---
April 30, 1980	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001

TABLE 28 - Copper (total and dissolved) (mg/1)

DATE	STATION 128 TOTAL	128 DISS.	26 TOTAL	26 DISS.	96 TOTAL	96 DISS.	44 TOTAL	44 DISS.	345 TOTAL	345 DISS.	351 TOTAL	351 DISS.	3 TOTAL	3 DISS.
May 15, 1979	.001		.004				.002							
May 29, 1979													.003	
June 12, 1979											L.001		.002	
June 27, 1979											.004		.005	
July 3, 1979	.013	.003	.012	.003	.017	.006	.009	.002	.009	.004				
July 10, 1979											.002		.005	
July 24/25, 1979	.006	.006	.006	.006	.012	.007	.009	.004	.003	.003	L.001		.002	
August 7, 1979											.002		.002	
August 21, 1979	.006	.005	.014	.004			.010	.002	.010	.001	L.001		.003	
September 12/13	.005	.003	.013	.004	.029	.003	.007	.002	.006	L.001	L.001		L.001	
October 17, 1979	.001		.002		L.001		.002		L.001		.001		.001	
October 22, 1979		L.002		.004		.004		L.002		L.002				
November 14, 1979	L.01		L.01		L.01		L.01		L.01		L.01		L.01	
January 8, 1980	.002		.003				.001		L.001		.001		.004	
February 5, 1980	.001		L.001				L.001		L.001		L.001		L.001	
February 28, 1980	.003		.013				.007		.005		.003		.23	
March 12, 1980	.002		.005		.002		.001		.001		.001		.006	
April 9, 1980	.002		.003		.002		L.001		.001		L.001		.001	
April 24, 1980	L.001		.002		.001		.001		L.001		L.001		.002	
April 30, 1980	.027	.005	.024	.007	.009	.004	.014	.005	.004	.006				

TABLE 29 - Lead (total and dissolved) (mg/l)

DATE	STATION 128 TOTAL	128 DISS.	26 TOTAL	26 DISS.	96 TOTAL	96 DISS.	44 TOTAL	44 DISS.	345 TOTAL	345 DISS.
uly 3, 1979	.003	.002	.004	L.002	.002	.002	.002	L.002	.004	.002
July 25, 1979	L.001	L.001	L.001	L.001	L.001	L.001	.001	.001	.002	L.001
August 21, 1979	L.001	L.001	.002	L.001	---	---	L.001	L.001	L.001	L.001
September 12, 1979	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001	.004	.001
October 22, 1979	L.012	.002	L.001	L.001	.003	L.001	.020	L.001	.010	.002
November 14, 1979	L.1	---	L.1	---	L.1	---	L.1	---	L.1	---
April 30, 1980	.001	L.001	.002	L.001	L.001	L.001	.002	L.001	L.001	L.001

TABLE 30 - Manganese (total and dissolved) (mg/1)

	STATION													
	128		26		96		44		345		351		3	
DATE	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.
June 27, 1979													.02	
July 3, 1979	.036	.018	.047	.012	.074	.053	.093	.056	.063	.030				
July 10, 1979														
July 24, 1979	.086	.035	.021	.015	.071	.055	.141	.117	.055	.005			.02	
August 7, 1979														
August 21, 1979	.108	.070	.006	.007	—	—	.120	.071	.055	.013				
September 12/13	.042	.041	.008	.005	.023	.023	.049	.049	.160	.041				
October 17, 1979														
October 22, 1979	.018	—	.010	L.002	.044	.042	.068	.060	.080	.028				
November 14, 1979	.10		.53		.03		.10		.13		.01		L.01	
January 8, 1980	.08		.23				.06		.05		L.02		.21	
February 5, 1980	.10		.19				.07		.08		L.01		.01	
February 28, 1980	.12		.17				.23		.11		.05		1.35	
March 12, 1980	.07		.14		.02		.08		.14		L.02		.04	
April 9, 1980	.08		.13		.02		.08		.04		.01		.02	
April 24, 1980	.05				L.02		.06		.07		L.02		.02	
April 30, 1980	.048	.048	.009	.005	.068	.055	.077	.063	.052	.031				

TABLE 31 - Mercury (total) (ug/1)

	STATION				
DATE	128	26	96	44	345
July 3, 1979	L.05	L.05	L.05	L.05	L.05
July 25, 1979	L.05	L.05	L.05	L.05	L.05
August 21, 1979	L.05	L.05	----	L.05	L.05
September 12, 1979	L.05	L.05	L.05	L.05	L.05
October 22, 1979	L.05	L.05	L.05	L.05	L.05
April 30, 1980	L.2	L.2	L.2	L.2	L.2

TABLE 32 - Molybdenum (total and dissolved) (mg/l)

	STATION													
	128		26		96		44		345		351		3	
DATE	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.
May 15, 1979	.0017		.0183				.0027							
May 29													.0025	
June 12											.0038		.0043	
June 27											.0033		.0051	
July 3	.002	.002	.014	.014	---	.006	.004	.004	.004	.003				
July 10											.0030		.0055	
July 24	.001	.001	.024	.018	.008	.008	.002	.002	.002	.002	.0022		.0027	
August 7											.004		.0056	
August 21	.003	.002	.019	.019	---	---	.002	.002	.003	.002	.0041		.0047	
September 12	.002	.002	.021	.020	.011	.011	.002	.002	.005	.003	.0032		.005	
October 17	.0016		.01				.0018		.003		.0026		.0043	
October 22	.001	.001	.019	.014	.014	.010	.002	.002	.003	.002				
November 14, 1979	L.01		.02		L.01		L.01		L.01		L.01		L.01	
January 8, 1980	.0011		.018				.0026		.0033		.0033		.0037	
February 5	.0019		.02				.0019		.0043		.0035		.0035	
February 28	.0019		.0127				.0013		.0029		.0025		.0043	
March 12	.0017		.03		.0046		.0042		.0048		.0032		.0037	
April 9	.02		.06		.04		.04		.04		.02		.04	
April 24	.0023		.05		.0065		.0037		.004		.0035		.0046	
April 30, 1980	.009	.006	.024	.026	.013	.011	.011	.009	.008	.006				

TABLE 33 - Zinc (total and dissolved) (mg/l)

	STATION													
	128		26		96		44		345		351		3	
DATE	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.
May 15, 1979	.05		L.005				.023							
May 29													L.005	
June 12											L.005		L.005	
June 27											L.005			
July 3	L.001	L.001	.002	L.001	.006	.013	.004	.002	.002	.001				
July 10											.038			
July 24/25	.002	.002	.001	.001	.003	.003	.005	.001	.001	.001	L.005		L.005	
August 7											L.005		L.005	
August 21	L.001	L.001	L.001	L.001	---	---	L.001	L.001	.001	.001	L.005			
September 12/13	.002	.002	L.001	L.001	.007	.007	.005	.005	.003	.002	L.005		L.005	
October 17	L.005		L.005				.007		L.005		L.005		L.005	
October 22	.002	.001	L.001	L.001	L.001	L.001	.001	.001	.001	L.001				
November 14, 1979	.01		.02		L.01		L.01		L.01		L.01		L.01	
January 8, 1980	L.005		L.005		---		L.005		L.005		L.005		L.005	
February 5	L.005		L.005		---		.008		L.005		L.005		L.005	
February 28	L.005		.04						.008		L.005		.16	
March 12	L.005		L.005		L.005		L.005		L.005		L.005		L.005	
April 9	L.005		.007		L.005		L.005		L.005		L.005		L.005	
April 24	L.005		L.005		L.005		L.005		L.005		L.005		L.005	
April 30, 1980	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001				

TABLE 34 - Iron (total and dissolved((mg/1)

	STATION													
	128		26		96		44		345		351		3	
DATE	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.
July 3, 1979	.18	.080	.062	.011	.46	.13	.26	.039	.022	.014				
July 10														
July 25	.29	.086	.099	.006	.61	.10	.251	.028	.050	.002				
August 7														
August 21	.10	.01	.08	.005			.02	.019	.02	.002			.1	
September 12	.16	.08	.07	.01	.17	.04	.17	.05	.12	.002				
October 17	.3		.1		L.1		.3		.2		L.1		L.1	
October 22	.03	.03	.05	L.01	.26	.08	.24	.06	.11	L.01				
November 14	.32		.48		.14		.33		.1		.04		.02	
January 8, 1980	.6		.2				.2		.1		.1		L.01	
February 5	.4		.11				.15		.02		.02		.03	
February 28	1.24		2.31				3.9		1.5		.32		43.6	
March 12	.69		.59		.5		.5		.2		.1		.03	
April 9														
April 24														
April 30, 1980	.52	.23	.068	L.03	.51	.23	.24	.086	.066	L.03				

TABLE 35 - Other metal concentrations (mg/1)

	STATION													
	128		26		96		44		345		351		3	
DATE	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.	TOTAL	DISS.
NICKEL														
July 3	L.001	L.001	L.001	L.001	.001	L.001	.001	L.001	L.001	L.001				
July 25	.001	.001	L.001	L.001	.002	.001	.001	.001	L.001	L.001				
August 21	L.001	L.001	L.001	L.001			L.001	L.001	L.001	L.001				
September 12	.001	.001	.001	L.001	.001	.001	.001	L.001	L.001	L.001				
October 22	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001	L.001				
November 14	L.05		L.05		L.05		L.05		L.05		L.05		L.05	
April 30	L.005	L.005	L.005	L.005	L.005	L.005	L.005	L.005	L.005	L.005				
CHROMIUM														
July 3	L.002	L.002	L.002	L.002	L.002	L.002	L.002	L.002	L.002	L.002				
July 25														
August 21														
September 12														
October 22														
November 14	.04		.03		.03		.03		.04		.04		.03	
April 30	L.001	L.001	L.001	L.001	L.001	L.001			L.001	L.001				
VANADIUM														
July 3	.003	L.002	L.002	L.002	L.002	L.002	L.002	L.002						
July 25	L.005		L.005		L.005		L.005		L.005					
August 21	L.005	L.005	L.005	L.005			L.005	L.005	L.005	L.005				
September 12	L.005		L.005		L.005		L.005		L.005					
October 22	L.005		L.005		L.005		L.005		L.005					
April 30	.012	L.005	.005	L.005	.005	L.005	L.001	L.005	L.005	L.005				
ALUMINUM														
April 30	.024	.035	.49	.024	.19	.005	.15	.015	.020	.007				

APPENDIX X (b)

AIR MONITORING DATA (FROM MERRITT TOWN HALL:
STATION #0605040) AS MEANS FOR YEARS 1974 TO 1981

PARAMETER*	UNITS	YEAR 1974	1975	1976	1977	1978	1979	1980	1981
Part: tot Dust. tot	$mg/dm^2/d$	2.87	2.36	4.33	3.18	2.94	3.18	2.63	2.48
Part: tot S. Part. TL	g/m^3	103.63	84.24	89.85	99.76	78.41	85.94	77.63	61.19
	mg		149.62	280.25	163.0	142.0			
Part: sol Dust. sol	$mg/dm^2/d$	.169	.241	.155	.256	.258	.770	.431	.726
Part: sol Dust: sol	$mg/dm^2/d$	2.71	2.13	4.19	2.93	2.69	2.41	2.20	1.75
Sol ash Dust. sol	$mg/dm^2/d$	.107	.139	.807	.113	.170	.454	.239	.436
Insl ash Dust. insl	$mg/dm^2/d$	2.15	1.52	2.99	2.02	1.84	1.71	1.79	1.37
Part: com Dust. tot	$mg/dm^2/d$					.704	1.01	.729	.715
Sulfate S. Part. TL	g/m^3					2.85	2.27	1.79	2.10
Sulfate Dust. sol	$mg/dm^2/d$					.044	.111	.078	.080
Sodium S. Part TL	g/m^3				.78	.69	.51	.51	.5
Sodium Dust. sol	$mg/dm^2/d$				.003	.023	.035	.029	.023
Chloride S. Part. TL	g/m^3				.5	.61	.59	.55	.52
Chloride Dust. sol	$mg/dm^2/d$				.006	.023	.064	.030	.023
Sul. inde	$mg/dm^2/d$		.107	.069	.054	.036	.024	.026	.02

* Records for 1977 only for S. Part TL for arsenic, copper, zinc, cadmium and mercury so these parameters were not included in the above table.

APPENDIX X (b)

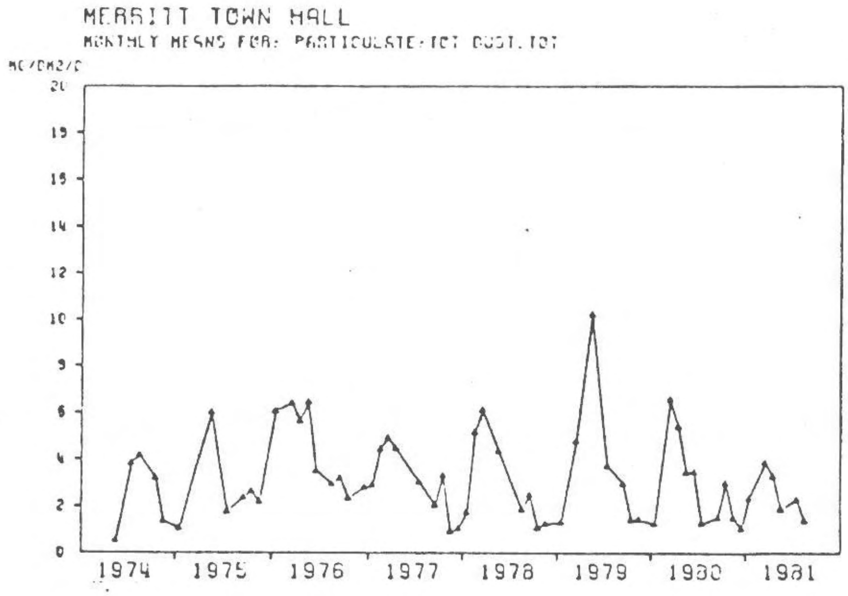
TRENDS IN AIR EMISSIONS DATA

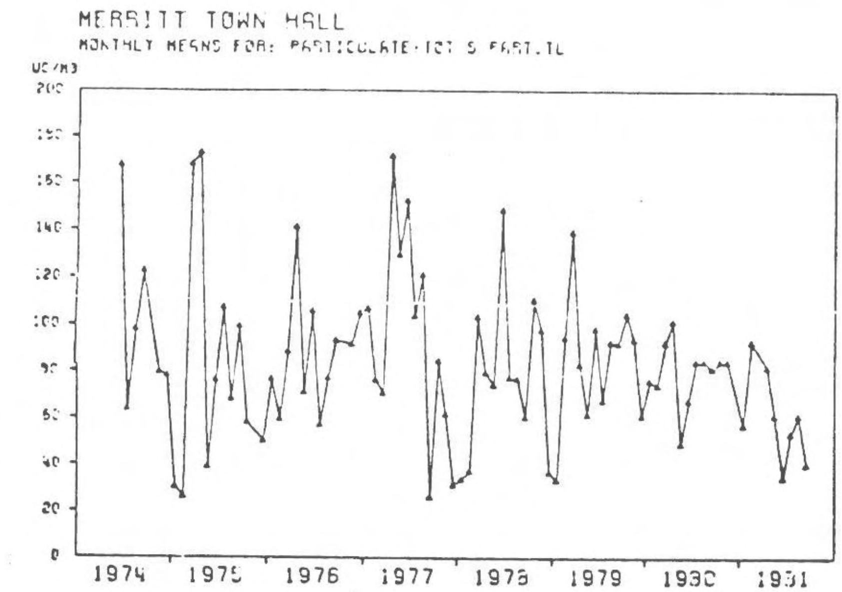
(FROM MERRITT TOWN HALL: STATION #0605040)

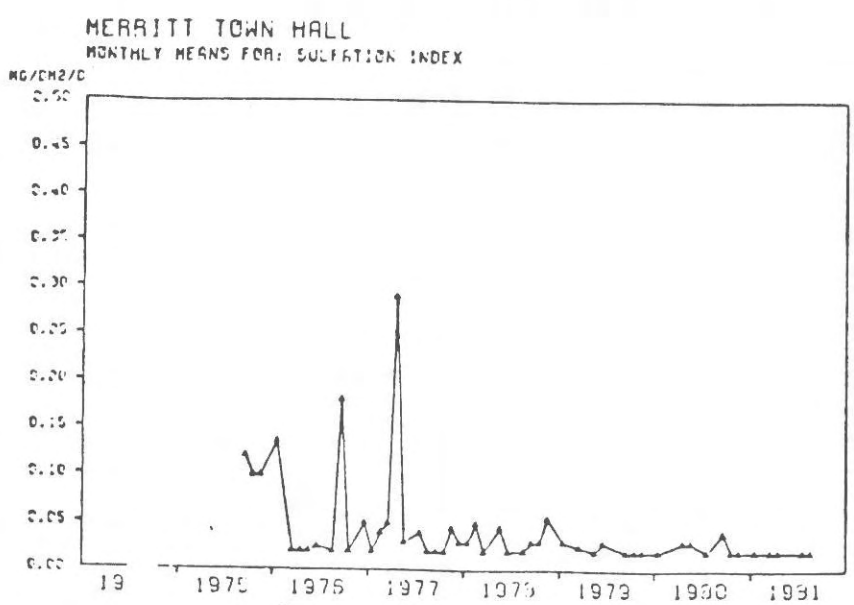
PARAMETER*	RANGE OF VALUES		TRENDS (FROM MEANS FOR 1974-1981)
	max(yr)/min(yr)		
Part: tot Dust. tot	4.33(76)	2.36(75)	- fairly constant (no signif. trend)
Part: tot S. Part. TL g/m^3	103.63(74)	61.19(81)	- slight decrease from 1974-81
(mg)	280.25(76)	142.0(81)	- no signif. trend (constant)
Part: sol Dust. sol	.770(79)	.155(76)	- values .155 to .258 1875-78 (increase) .431 to .770 1979-81
Part: ins Dust: insl	4.19(76)	1.75(81)	- constant
Sol ash Dust. sol	.807(76)	.107(74)	- variable, poss. slight increase
Insl ash Dust. insl	2.99(76)	1.37(81)	- constant (very slight decrease)
Part: com Dust. tot	1.01(79)	.704(78)	- constant (records only 1978-81)
Sulfate S. Part. TL	2.87(78)	1.79(80)	- constant (records only 1978-81)
Sulfate Dust. sol	.111(79)	.044(78)	- very slight increase (records only 1978-81)
Arsenic S. Part TL	one value only		.05(77)
Sodium S. Part TL	.78(77)	.5(81)	- slight decrease (records only 1977-81)
Sodium Dust. sol	.035(79)	.003(77)	- constant (records only 1977-81)
Chloride S. Part. TL	.61(79)	.5(77)	- constant (records only 1977-81)
Chloride Dust. sol	.006(77)	.064(79)	- constant (records only 1977-81)
Sul. inde	.107(75)	.02(81)	- decreasing (records 1975-81)

* Records for 1977 only for S. Part TL for arsenic, copper, zinc, cadmium and mercury so these parameters were not included in the above table.

Table 2. Graphs of monthly means for particulates and sulfation indices (from Merritt Town Hall: station #0605040).







APPENDIX XI
MONTHLY WATER SUPPLY AND DEMAND FOR WATERSHEDS IN THE NICOLA BASIN
SUPPLY AND DEMANDS BY MONTH - UPPER NICOLA
(dam^3)

SUPPLY[1] (Good Hydrologic Records)					DEMAND				SHORTFALL[5]		
MONTH	1:2	1:5	1:10	1:20	WATER STORED[2]	IRRIGATION[3]	FISHERIES[4]	TOTAL	RETURN PERIOD	IRRIGATION SHORTFALL	FISHERY SHORTFALL
JANUARY	1 340	978	857	779			2 055	2 055	<1:2		✓
FEBRUARY	1 900	1 440	1 200	1 000			2 055	2 055	<1:2		✓
MARCH	2 060	1 590	1 290	1 000			2 055	2 055	<1:2		✓
APRIL	3 880	2 600	2 090	1 740	420		2 055	2 475	1:5-1:10		✓
MAY	47 800	34 200	23 700	24 700	5 143	1 930	2 055	9 128	-		
JUNE	42 400	26 900	20 900	16 700	4 934	1 160	2 055	8 149	-		
JULY	14 800	10 500	8 850	7 780		3 470	2 055	5 525	-		
AUGUST	3 930	2 750	2 520	2 410		1 930	2 055	3 985	<1:2		✓
SEPTEMBER	2 110	1 470	1 330	1 270		1 160	2 055	3 215	<1:2		✓
OCTOBER	592	171	91	54			2 055	2 055	<1:2		✓
NOVEMBER	1 010	373	223	148			2 055		<1:2		✓
DECEMBER	836	311	193	142			2 055		<1:2		✓

[1]Estimated Natural Flows
[2]Licenced Storage - Appendix III
[3]Licenced Diversions - Irrigation
[4]Maintenance Flows for Fisheries - derived from 20% of mean annual discharge - (28 cfs)
[5]Return period and amount of water shortfall

APPENDIX XI

APPROXIMATE MONTHLY FLOWS AND FISHERIES REQUIREMENTS FOR THE NICOLA RIVER BETWEEN NICOLA LAKE AND SPENCES BRIDGE (dam^3)

REACH 1: NICOLA LAKE TO COLDWATER RIVER[2] (MIDDLE NICOLA)

MONTH	(RESIDUAL) APPROXIMATE MONTHLY FLOW VOLUME[1] (good hydrologic records) 1:2	1:5	1:10	1:20	FISHERY FLOW REQUIREMENT	COMMENTS
JANUARY	5 530	4 030	3 190	2 570	2 930	Fishery requirements apparently not met between 1:10 & 1:20.
FEBRUARY	5 500	4 550	4 040	3 670	2 930	Fishery requirements apparently met ≥ 19 years in 20.
MARCH	5 350	5 140	4 930	4 740	2 930	Fishery requirements apparently met ≥ 19 years in 20.
APRIL	6 800	7 200	7 600	7 920	2 930	Fishery requirements apparently met ≥ 19 years in 20.
MAY	32 500	27 600	25 000	25 400	2 930	Fishery requirements met ≥ 19 years in 20.
JUNE	43 900	32 400	30 400	30 600	2 930	Fishery requirements met ≥ 19 years in 20.
JULY	15 400	13 000	12 800	13 100	2 930	Fishery requirements met ≥ 19 years in 20.
AUGUST	8 510	6 430	5 680	5 180	4 400	Fishery requirements met ≥ 19 years in 20.
SEPTEMBER	5 000	3 870	3 620	3 500	4 400	Fishery requirements apparently not met between 1:2 & 1:5.
OCTOBER	5 120	4 130	3 500	2 960	4 400	Fishery requirements apparently not met between 1:2 & 1:5.
NOVEMBER	4 420	2 380	1 510	910	4 400	Fishery requirements apparently not met at 1:2.
DECEMBER	3 430	2 410	2 170	2 030	2 930	Fishery requirements apparently not met between 1:2 & 1:5.

[1] The flows are residuals, after the effects of consumptive use (which on the mainstem Nicola River are not very important). 5503 dam^3 is licenced for irrigation. They are only approximate estimates of flows with each reach because unmeasured inflow to the reach is ignored.

[2] Obtained by subtraction of Coldwater River flows (station no. 08LG010) from flows on Nicola River at outlet of Middle Nicola watershed (station no. 08LG007). The backwater effect on this reach when the Coldwater River is high is evident (see April - July flows).

[3] Fishery Flows - Nicola R. above Merritt - Aug. 1-Nov. 30 - 60 cfs; Dec. 1-July 31 - 40 cfs.

APPENDIX XI

APPROXIMATE MONTHLY FLOWS AND FISHERIES REQUIREMENTS FOR THE NICOLA RIVER BETWEEN NICOLA LAKE AND SPENCES BRIDGE (dam^3)

REACH 2: COLDWATER RIVER TO SPIUS CREEK[2]

MONTH	(RESIDUAL) APPROXIMATE MONTHLY FLOW VOLUME[1] (good hydrologic records) 1:2	1:5	1:10	1:20	FISHERY FLOW REQUIREMENT[3]	COMMENTS
JANUARY	10 300	6 640	5 280	4 390	8 070	Fishery requirements apparently not met between 1:2 & 1:5.
FEBRUARY	10 600	7 380	6 290	5 610	8 070	Fishery requirements apparently not met between 1:2 & 1:5.
MARCH	13 600	10 100	8 950	8 170	8 070	Fishery requirements met ≥ 19 years in 20.
APRIL	30 900	21 500	17 700	15 100	8 070	Fishery requirements met ≥ 19 years in 20.
MAY	112 000	86 500	76 600	69 900	8 070	Fishery requirements met ≥ 19 years in 20.
JUNE	124 000	84 800	69 500	59 400	8 070	Fishery requirements met ≥ 19 years in 20.
JULY	39 900	24 200	20 200	17 100	8 070	Fishery requirements met ≥ 19 years in 20.
AUGUST	12 500	8 570	7 260	6 430	8 070	Fishery requirements not met between 1:5 and 1:10.
SEPTEMBER	7 980	5 500	4 800	4 410	8 070	Fishery requirements apparently not met at 1:2.
OCTOBER	10 800	7 500	6 110	5 060	8 070	Fishery requirements apparently not met between 1:2 & 1:5
NOVEMBER	12 200	6 920	4 850	3 450	8 070	Fishery requirements not met between 1:2 and 1:5.
DECEMBER	10 900	6 000	4 500	3 620	8 070	Fishery requirements not met between 1:2 & 1:5.

[1] The flows are residuals, after the effects of consumptive use 3750 dam^3 is licenced for irrigation. They are only approximate estimates of flows within each reach because unmeasured inflow to the reach is ignored.

[2] Using flow record at outlet of Middle Nicola watershed (station no. 08LG007) and ignoring other inflow to the reach (eg. Guichon Creek).

[3] Nicola River below Merritt - Aug. 1-Nov. 30 - 110 cfs; Dec. 1-July 31 - 110 cfs.

APPENDIX XI

WATER SUPPLY AND DEMANDS BY MONTH - LOWWER NICOLA (dam^3)

REACH 3: SPIUS CREEK TO SPENCES BRIDGE

	SUPPLY (GOOD HYDROLOGIC RECORDS)[1]				DEMAND					SHORTFALL[6]		
MONTH	1:2	1:5	1:10	1:20	WATER STORED[2]	OTHER[3]	IRRIGATION[4]	FISHERIES[5]	TOTAL	RETURN PERIOD	IRRIGATION SHORTFALL	FISHERY SHORTFALL
JANUARY	18 400	13 200	11 600	10 700		200		14 600	14 800	1:2-1:5		1 600
FEBRUARY	21 200	13 900	11 800	10 600		200		14 600	14 800	1:2-1:5		900
MARCH	27 400	20 500	18 400	17 200		200		14 600	14 800	>1:20		
APRIL	70 300	45 400	33 500	24 000	110	200		14 600	14 910	>1:20		
MAY	241 000	186 000	165 000	151 000	340	200	1 116	14 600	16 256	>1:20		
JUNE	248 000	160 000	120 000	90 800	290	200	670	14 600	15 760	>1:20		
JULY	76 500	57 300	37 400	31 300		200	2 010	14 600	16 810	>1:20		
AUGUST	25 000	17 000	13 700	11 200		200	1 116	14 600	15 915	1:5-1:10		2 880
SEPTEMBER	15 900	11 700	10 400	9 590		200	670	14 600	15 970	1:2-1:5		900
OCTOBER	19 500	13 900	11 800	10 400		200		14 600	14 800	1:2-1:5		
NOVEMBER	23 700	14 800	11 600	9 610		200		14 600	14 800	1:5-1:10		3 200
DECEMBER	21 200	12 300	9 550	7 890		200		14 600	14 800	1:2-1:5		2 500

[1]Estimated 'Natural Flows' - Using flow record on Nicola River at basin outlet (station no. 08LG006)
[2]Licenced Storage - Appendix III
[3]Domestic, Industrial Use
[4]Licenced Diversions
[5]Fishery Maintenance Flow - Aug. 1 - Nov. 30 - 200 cfs; Dec. 1 - July 31 - 200 cfs.
[6]Greatest Shortfall

APPENDIX XI

GUICHON - MONTHLY CURRENT WATER SUPPLY/DEMAND (1230 km^2)

(dam^3)

	SUPPLY (GOOD HYDROLOGIC RECORDS)[1]				DEMAND					SHORTFALL[6]		
MONTH	1:2	1:5	1:10	1:20	WATER STORED[2]	OTHER[3]	IRRIGATION[4]	FISHERIES[5]	TOTAL	RETURN PERIOD	IRRIGATION SHORTFALL	FISHERY SHORTFALL
ANUARY	910	660	550	480		235		510	750	1:2-1:5		90
EBRUARY	935	705	615	550		235		510	750	1:2-1:5		40
ARCH	1 120	735	615	540		235		510	750	1:2-1:5		10
.PRIL	3 040	2 010	1 670	1 450	900	235		510	750	---		
AY	17 300	9 710	7 130	5 500	4 550	235	1 360	510	6 660	1:10-1:20	650	510
UNE	7 890	4 220	2 970	2 140	1 930	235	820	510	3 500	1:5-1:10	850	510
ULY	4 380	3 140	2 760	2 550		235	2 460	510	3 210	1:2-1:5		55
UGUST	2 060	1 690	1 620	1 590		235	1 360	510	2 110	<1:2		50
.EPTEMBER	1 390	1 180	1 130	1 110		235	820	510	1 570	<1:2		175
CTOBER	675	400	330	290		235		510	750	<1:2		60
OVEMBER	795	500	400	340		235		510	750	1:2-1:5		245
ECEMBER	865	585	450	340		235		510	750	1:2-1:5		160

Estimated 'Natural Flows'
Licensed Storage for irrigation - Appendix III
Domestic Industrial Use
Licensed Diversions - not met by storage
Fishery Maintenance Flows (7 cfs - July 15-Oct. 31) - derived from empirical formula (20% of mean annual discharge)
Greatest Shortfall

APPENDIX XI

QUILCHENA - MONTHLY CURRENT WATER SUPPLY/DEMAND (787 km^2)

(dam^3)

	SUPPLY (FAIR HYDROLOGIC RECORDS)[1]				DEMAND					SHORTFALL[6]		
MONTH	1:2	1:5	1:10	1:20	WATER STORED[2]	OTHER[3]	IRRIGATION[4]	FISHERIES[5]	TOTAL	RETURN PERIOD	IRRIGATION SHORTFALL	FISHERY SHORTFALL
JANUARY												
FEBRUARY												
MARCH												
APRIL	2 460	1 660	1 430	1 280	350			510	860			
MAY	9 420	6 230	5 110	4 380	2 200		120	510	2 830			
JUNE	14 500	7 810	4 380	1 590	2 450		70	510	3 030	1:10-1:20	900	510
JULY	1 630	850	521	328			210	510	720	1:5 -1:10		200
AUGUST	549	232	95.2	3			120	510	630	<1:2		80
SEPTEMBER	526	257	117	2.6			70	510	580	<1:2		50
OCTOBER												
NOVEMBER												
DECEMBER												

1 Estimated 'Natural Flows'
2 Licensed Storage for irrigation - Appendix III
3 Domestic Industrial Use
4 Licensed Diversions
5 Fishery Maintenance Flows (7 cfs - July 15-Oct. 31)
6 Greatest Shortfall

APPENDIX XI

MOORE-STUMP - MONTHLY CURRENT WATER SUPPLY/DEMAND (545 km2)

(dam3)

SUPPLY (POOR HYDROLOGIC RECORDS)[1]					DEMAND					SHORTFALL[6]		
MONTH	1:2	1:5	1:10	1:20	WATER STORED[2]	OTHER[3]	IRRIGATION[4]	FISHERIES[5]	TOTAL	RETURN PERIOD	IRRIGATION SHORTFALL	FISHERY SHORTFALL
JANUARY												
FEBRUARY												
MARCH												
APRIL	601	329	244	189	330			150	480	1:2-1:5		150
MAY	5 000	2 120	662	0	2 890		385	150	3 425	1:2-1:5	1 150	150
JUNE	1 680	969	734	586	2 240		230	150	2 620	1:2	790	150
JULY	421	190	126	91.1			695	150	845	1:2	270	150
AUGUST	222	131	99.1	77.7			385	150	535	1:2	160	150
SEPTEMBER	189	119	88.1	67.4			230	150	380	1:2	41	150
OCTOBER												
NOVEMBER												
DECEMBER												

1 Estimated 'Natural Flows'
2 Licensed Storage for irrigation - Appendix III
3 Domestic Industrial Use
4 Licensed Diversions
5 Fishery Maintenance Flows (2 cfs)
6 Greatest Shortfall

APPENDIX

SPIUS - MONTHLY CURRENT WATER SUPPLY/DEMAND (780 km^2)

(dam^3)

SUPPLY (FAIR HYDROLOGIC RECORDS)[1]					DEMAND					SHORTFALL[6]		
MONTH	1:2	1:5	1:10	1:20	WATER STORED[2]	OTHER[3]	IRRIGATION[4]	FISHERIES[5]	TOTAL	RETURN PERIOD	IRRIGATION SHORTFALL	FISHERY SHORTFALL
JANUARY	5 360	3 270	2 560	2 120				5 720	5 720	<1:2		2 450
FEBRUARY	5 760	3 400	2 690	2 160				5 720	5 720	1:2-1:5		2 320
MARCH	8 360	4 820	3 240	2 040				5 720	5 720	1:2-1:5		900
APRIL	30 800	17 100	11 400	7 370	10			5 720	5 730	>1:20		
MAY	97 900	69 200	56 900	51 100	35	325		5 720	6 080	>1:20		
JUNE	78 000	41 200	27 900	19 800	30	195		5 720	5 945	>1:20		
JULY	23 500	12 100	8 650	6 590		585		5 720	6 300	>1:20		
AUGUST	6 700	4 030	3 140	2 570		325		5 720	6 040	1:2-1:5		2 010
SEPTEMBER	4 220	2 840	2 470	2 260		195		5 720	5 910	<1:2		1 695
OCTOBER	5 200	3 190	2 540	2 140				5 720	5 720	<1:2		520
NOVEMBER	7 080	3 340	2 400	1 890				5 720	5 720	1:2-1:5		2 380
DECEMBER	8 170	3 460	2 220	1 550				5 720	5 720	1:2-1:5		2 260

1 Estimated 'Natural Flows'
2 Licensed Storage for irrigation - Appendix III
3 Domestic Industrial Use
4 Licensed Diversions
5 Fishery Maintenance Flows (78 cfs) - based on 20% of mean annual flow 2.22 m^3s
6 Greatest Shortfall

APPENDIX XI

CLAPPERTON - MONTHLY CURRENT WATER SUPPLY/DEMAND (181 km^2)

(dam^3)

SUPPLY (POOR HYDROLOGIC RECORDS)[1]					DEMAND					SHORTFALL[6]		
MONTH	1:2	1:5	1:10	1:20	WATER STORED[2]	OTHER[3]	IRRIGATION[4]	FISHERIES[5]	TOTAL	RETURN PERIOD	IRRIGATION SHORTFALL	FISHERY SHORTFALL
JANUARY												
FEBRUARY												
MARCH												
APRIL	770	480	540		216			336	522	>1:10		
MAY	6 560	3 130	1 470		1 357		1 252	336	2 945	1:5-1:10		✓
JUNE	2 160	1 430	1 610		1 511		751	336	2 598	1:2-1:5	✓	✓
JULY	25.5	14.9	11.3				2 252	336	2 588		✓	✓
AUGUST	9	4.4	14.6				1 252	336	1 588		✓	✓
SEPTEMBER	5.9	2.7					751	336	1 087		✓	✓
OCTOBER								336	336			
NOVEMBER												
DECEMBER												

1 Estimated 'Natural Flows'
2 Licensed Storage for irrigation - Appendix III
3 Domestic Industrial Use
4 Licensed Diversions
5 Fishery Maintenance Flows (5 cfs)
6 Greatest Shortfall

1) from seasonal flow at mouth Clapperton Creek 1913-17
2) single station frequency analysis + 1920-21 WSC data = revised estimates of natural flow

APPENDIX

COLDWATER - MONTHLY CURRENT WATER SUPPLY/DEMAND (914 km^2)

(dam^3)

SUPPLY (GOOD HYDROLOGIC RECORDS)[1]					DEMAND					SHORTFALL[6]		
MONTH	1:2	1:5	1:10	1:20	WATER STORED[2]	OTHER[3]	IRRIGATION[4]	FISHERIES[5]	TOTAL	RETURN PERIOD	IRRIGATION SHORTFALL	FISHERY SHORTFALL
JANUARY	5 120	2 960	2 440	2 170		345		3 660	4 000	1:2-1:5		1 000
FEBRUARY	5 450	3 180	2 600	2 290		345		3 660	4 000	1:2-1:5		825
MARCH	8 600	5 310	4 370	3 780		345		3 660	4 000	1:10-1:20		
APRIL	24 600	14 800	10 600	7 680	181	345		3 660	4 180	>1:20		
MAY	81 700	61 100	52 800	46 700	557	345	1 390	3 660	5 950	>1:20		
JUNE	81 800	54 100	40 800	30 500	557	345	835	3 660	5 400	>1:20		
JULY	27 400	15 100	10 300	6 900		345	2 510	3 660	6 510	>1:20		
AUGUST	5 730	3 880	3 320	2 990		345	1 390	3 660	5 400	1:2-1:5		1 500
SEPTEMBER	4 130	2 810	2 360	2 090		345	835	3 660	4 840	<1:2		2 000
OCTOBER	6 030	3 720	2 960	2 450		345		3 660	4 000	1:2-1:5		285
NOVEMBER	8 130	4 890	3 690	2 890		345		3 660	4 000	1:5-1:10		
DECEMBER	7 820	3 940	2 680	1 940		345		3 660	4 000	1:2-1:5		65

1 Estimated 'Natural Flows'
2 Licensed Storage - Appendix III
3 Domestic Industrial Use
4 Licensed Diversions
5 Fishery Maintenance Flows (50 cfs - year round)
6 Greatest Shortfall

APPENDIX XII
TEST PRODUCTION WELL COSTS

Estimates of Itemized costs for an 8" Diameter, 100 Feet Deep, Test Well in Overburden Using Cable-Tool Method or Rotary Drilling with a Driven Casing

ITEM	COST
1. Mobilization and Demobilization (lump sum)	$ 500.
2. 10-inch drive shoe (each)	300.
3. 20 feet of 10" cased drilling ($48/ft.)	960.
4. 8-inch drive shoe (each)	185.
5. 20 feet of 8-inch overlap ($16.25/ft.)	325.
6. 80 feet of 8-inch cased drilling ($38/ft.)	3,040.
7. 10 feet of 8-inch screen and fittings (lump sum)	1,000.
8. Hourly work (set screen, bail test, well development, etc., calculated at $80/hour)	1,600.
9. Standby time ($60/hr.)	480.
10. Mobilization and Demobilization of pump and equipment (lump sum)	200.
11. Install and remove pump and discharge pipe (lump sum)	200.
12. 24-hour pumping test ($50/hr.)	1,200.
13. Pumping crew standby ($40/hr.)	120.
Sub-total	$10,110.
+ 10% contingencies	1,011.
Total	$11,127.
Plus	
Cost of 2 laboratory chemical analysis of groundwater samples at $180 each	360.
	$11,487.

APPENDIX XIII

WILDLIFE SPECIES FOR NICOLA BASIN

MAMMAL SPECIES

Cinereus Shrew
Wandering Shrew
Navigator Shrew
Western Big-eared Bat
Big Brown Bat
Silver-haired Bat
California Myotis
Long-eared Myotis
Little Brown Myotis
Rocky Mountain Pika
Snowshoe Hare
Mountain Beaver
Yellow-bellied Marmot
Hoary Marmot
Northwestern Chipmunk
Red Squirrel
Northern Flying Squirrel
Northern Pocket Gopher
American Beaver
White-footed Mouse
Pack Rat
Northern Bog-lemming
Boreal Redback Vole
Mountain Heather Vole
Long-tailed Vole
Muskrat
House Mouse
Western Jumping Mouse
Porcupine
Coyote
Red Fox
American Black Bear
Marten
Short-tailed Weasel
Long-tailed Weasel
Wolverine
Yellow Badger
Striped Skunk
Canadian River Otter
Cougar
Bobcat
Canada Lynx
Rocky Mountain Elk
Mule Deer
Whitetail Deer
Moose
Richardson Vole
Meadow Vole
Mountain Vole

AMPHIBIAN SPECIES

Long-toed Salamander
Western Spadefoot Toad
Northwestern Toad
Pacific Tree Toad
Western Spotten Frog
Northern Wood Frog

REPTILE SPECIES

Rubber Boa
Yellow-bellied Racer
Bull Snake
Common Garter Snake
Pacific Rattle Snake
Western Painted Turtle
Northern Alligator Lizard

BIRD SPECIES

Common Loon
Arctic Loon
Red-throated Loon
Red-necked Grebe
Horned Grebe
Eared Grebe
Western Grebe
Pied-billed Grebe
American White Pelican
Great Blue Heron
American Bittern
Tundra Swan
Canada Goose
White-fronted Goose

BIRD SPECIES (Continued)

Snow Goose
Mallard
Gadwall
Pintail
Green-winged Teal
Blue-winged Teal
Cinnamon Teal
American Wigeon
Erasian Wigeon
Northern Shoveler
Wood Duck
Redhead
Ring-necked Duck
Canvasback
Greater Scanp
Lesser Scanp
Common Goldeneye
Barrow's Goldeneye
Bufflehead
Oldsquaw
Harlequin Duck
White-winged Scoter
Surf Scoter
Ruddy Duck
Hooded Merganser
Common Merganser
Red-breasted Merganser
Turkey Vulture
Northern Goshawk
Northern Harrier
Sharp-shinned Hawk
Cooper's Hawk
Red-tailed Hawk
Swainson's Hawk
Rough-legged Hawk
Ferruginous Hawk
Osprey
Gyrfalcon
Prairie Falcon
Peregrine Falcon
Merlin
American Kestrel
Blue Grouse
Spruce Grouse
Ruffed Grouse
White-tailed Ptarmigan
Sharp-tailed Grouse
Ring-necked Pheasant
Chukar
Gray Partridge
Sandhill Crane
Virginia Rail
Sora
American Coot
Semipalmated Plover
Killdeer
American Golden Plover
Black Bellied Plover
Ruddy Turnstone
Common Snipe
Long-billed Curlew
Spotted Sandpiper
Greater Yellowlegs
Lesser Yellowlegs
Pectoral Sandpiper
Baird's Sandpiper
Least Sandpiper
Dunlin
Long-billed Dowitcher
Stilt Sandpiper
Semipalmated Sandpiper
Western Sandpiper
Hudsonian Godwit
Sanderling
American Avocet
Wilson's Phalarope
Northern Phalarope
Herring Gull
California Gull
Ringbilled Gull
Mew Gull
Bonaparte's Gull
Black Tern
Rock Dove
Band tailed pigeon
Mourning Dove
Screech Owl
Great Horned Owl
Snowy Owl
Northern Pygmy-Owl
Burrowing Owl
Barred Owl
Great Gray Owl
Long-eared Owl
Short-eared Owl
Northern Saw-whet Owl
Poorwill
Common Nighthawk

BIRD SPECIES (Continued)

Black Swift
Vaux's Swift
Black-chinned Hummingbird
Rufous Hummingbird
Calliope Hummingbird
Belted Kingfisher
Common Flicker
Pileated Woodpecker
Lewis' Woodpecker
Yellow-Bellied Sapsucker
Hairy Woodpecker
Downy Woodpecker
Black-backed Three-toed Woodpecker
Northern Three-toed Woodpecker
Eastern Kingbird
Western Kigbird
Say's Phoebe
Alder Flycatcher
Hammond's Flycatcher
Dusky Flycatcher
Western Flycatcher
Western Wood Peewee
Olive-sided Flycatcher
Horned Lark
Violet-green Swallow
Tree Swallow
Bank Swallow
Rough-winged Swallow
Barn Swallow
Cliff Swallow
Gray Jay
Steller's Jay
Black-billed Magpie
Common Raven
Common Crow
Clark's Nutcracker
Black-capped Chickadee
Mountain Chickadee
Boreal Chickadee
White-breasted Nuthatch
Red-breasted Nuthatch
Pygmy Nuthatch
Brown Creeper
American Dipper
House Wren
Winter Wren
Long-billed Marsh Wren
Rock Wren
Gray Catbird
American Robin
Varied Thrush
Hermit Thrush
Swainson's Thrush
Veery
Western Bluebird
Mountain Bluebird
Townsend's Solitaire
Golden-crowned Kinglet
Ruby-crowned Kinglet
Water Pipit
Bohemian Waxwing
Cedar Waxwing
Northern Shrike
Common Starling
Solitary Vireo
Red-eyed Vireo
Warbling Vireo
Orange-crowned Warbler
Nashville Warbler
Yellow Warbler
Yellow-rumped Warbler
Townsend's Warbler
Blackpoll Warbler
Northern Waterthrush
MacGillivray's Warbler
Common Yellowthroat
Wilson's Warbler
House Sparrow
Western Meadowlark
Yellow-headed Blackbird
Red-winged Blackbird
Northern Oriole
Brewer's Blackbird
Brownheaded Cowbird
Western Tanager
Black-headed Grosbeak
Evening Grosbeak
Purple Finch
Cassin's Fich
House Finch
Pine Grosbeak
Gray-crowned Rosy Finch
Hoary Redpoll
Common Redpoll
Pine Siskin
American Goldfinch
Red Crossbill
White-winged Crossbill

BIRD SPECIES (Continued)

Rufous-sided Towhee
Vesper Sparrow
Lark Sparrow
Dark-eyed Junco
Tree Sparrow
Chipping Sparrow
Clay-coloured Sparrow
Brewer's Sparrow
White-crowned Sparrow
Golden-crowned Sparrow
White-throated Sparrow
Fox Sparrow
Lincoln's Sparrow
Song Sparrow
Song Sparrow
Snow Bunting

APPENDIX XIV
DEVELOPMENT OF APPROACH TO PUBLIC INVOLVEMENT IN NICOLA
- INTERVIEWS COMPLETED -

Background:

During the period June 15/16, 1982, Geoff Swannell (Public Information Officer - Kamloops) and Bob Williams (Public Involvement Coordinator - Victoria) conducted a series of interviews with local residents of the Nicola area. These interviews provided guidance in the development of the approach to public involvement employed in the Nicola Strategic Plan.

Contacts:

The following individuals were contacted personally. Each individual was provided with some background on the planning activity and asked to comment on and suggest improvements to a proposed approach to public involvement.

Kamloops:	
Mel Rothenberger	Kamloops News
Ross Phelps	Kamloops Daily
Ken Darvin	Gtr. Kamloops Outdoor Recreation Assn.
Gerry Paull	MOE - Conservation Officer
Wilf Kipp	Kamloops & District Fish & Game Assn.
Logan Lake:	
Mike Nikischer	Highland Valley Outdoor Assn.
Mary Anne Ismay	Logan Lake Copper
Merritt:	
Dan Richardson	Nicola Valley Rod & Gun Club
Bud Ward	MOE - Conservation Officer
Mike Bristol	Merritt Herald
Duane Slawych	'NL' Radio
Reg Moffatt	Merritt Merrittonian
Paul Chutter	Nicola Valley Water Resource Mgmt. Committee
Guy Rose	Nicola Valley Water Resource Mgmt. Committee

Source: Minutes - 'Strategic Unit Visit' (June 20/81)

APPENDIX XV
NICOLA VALLEY WATER RESOURCE MANAGEMENT WORKING COMMITTEE
- CORE MEMBERSHIP -

The NVWRMWC was established to initiate the study of water storage potential throughout the Nicola area. Subsequently, they functioned as a public advisory committee through the development of the plan by the Ministry of Environment. The membership of this committee included a range of interests concerned with water and included the following in its "core group":

Name	Location	
Paul Chutter	Merritt	Rancher
Guy Rose	Quilchena	Rancher
Len Marchand	Merritt	Indian Administrator
Jim Rabbitt	Merritt	Mayor
Joe Gardner	Douglas Lake	Rancher
Gordon Antoine	Vancouver	Manager - Indian Agriculture
John Curnon	Spences Bridge	Rancher
Russ Turnbull	Lower Nicola	Rancher
Gloria Capp	Lower Nicola	Rancher/Chamber of Commerce
Allan Zackodnik	Kamloops	MOE - Water
Howard Henderson	Kamloops	MOE - Waste
John Cartwright	Kamloops	MOE - Fisheries Biologist
Jon O'Riordan	Victoria	MOE - Planning
Rod Bell-Irving	Vancouver	Fisheries & Oceans Canada - Water Use
Ted Moore	Kamloops	Min. of Agriculture & Food - Agriculturist
Keith Berard	Merritt	Min. of Forests - Planning
Brian Clarke	Kamloops	Min. of Lands, Parks & Housing - Land Manager

Source: (May 25/81) letter to P. Chutter from W. Kastelen acknowledging letter of March 27/81.

APPENDIX XVI
TIMETABLE - PUBLIC INVOLVEMENT

Following is a timetable of the major events in the public involvement component of the planning process (during the period from July - December, 1982):

July 14/82	Draft plan forwarded to Nicola Valley Water Resource Management Committee in advance of July 30 meeting.
July 30/82	Meeting - Merritt Town Hall (1:30 - 4:30). Nicola Valley Water Resource Management Committee and others.
Oct. 18/82	Progress report distributed to Working Committee and public interests.
Nov. 8/82	Draft plan to public groups announce meeting (Dec. 7/82).
Nov. 15,16/82	Workshop sessions (3) with local ranchers.
Nov. 28/82	Newspaper insert published in Merritt Herald.
Dec. 7/82	Open-house meeting - Grasslands Hotel, Merritt (7:00 - 11:00 p.m.).

APPENDIX XVII
NICOLA STRATEGIC PLAN
- INFORMATION DEPOTS -

Information depots were established as centres for the distribution and review of plan-related information. The following locations were used:

Kamloops:

Kamloops Public Library

Ministry of Environment - Regional Headquarters

B.C. Government Agent

Logan Lake:

Logan Lake Public Library

Merritt:

Merritt Public Library

Ministry of Environment - Conservation Officer's Office

B.C. Government Agent

APPENDIX XVIII
WRITTEN SUBMISSIONS/LETTERS

During the course of plan preparation, the following submissions were received:

Oct. 6/82	letter to Planning Branch from M.T. McGarry of Bethlehem Copper Corp. (Vancouver)
Oct. 26/82	letter to Planning Branch from E. Livingston of Pacific Hydrology Consultants Ltd. (Vancouver)
Nov. 1/82	letter to Planning Branch from Gerard Guichon (Quilchena)
Nov. 3/82	letter to Paul Chutter (Merritt) from Regional Headquarters
Nov. 8/82	letter to Planning Branch from Outdoor Recreation Council of B.C. (Vancouver)
Nov. 15/82	letter to Planning Branch from J. Barber-Stanley, P. Eng. (Victoria)
Nov. 25/82	letter/questionnaire from A.H. Allen
Nov. 26/82	letter to Planning Branch from L. den Boer of City of Merritt
Nov. 30/82	letter to Regional Headquarters from R. & M. Warren (Merritt)
Dec. /82	letter to Planning Branch from W. Sellers (Princeton)
Dec. 1/82	letter to Regional Headquarters from J. & J. Ansell, C. Tifenbach, M. Juricic, H. Newhouse (Merritt)
Dec. 7/82	letter to Regional Headquarters from C.E. Brown (Burnaby)
	brief from Nicola Valley Water Resource Management Working Committee
Dec. 17/82	letter to Hon. S. Rogers from Nicola Valley Indian Administration
Dec. 28/82	letter to Regional Headquarters from J.A. Carter, Director, B.C. Wildlife Federation and Chairman, Inland Fisheries (Surrey)
	letters to Regional Headquarters from G.R.S. Armstrong and A. Armstrong (Merritt)
Jan. 5/83	letter to Regional Headquarters from E. Senger (Burnaby)

APPENDIX XIX
DIRECT CONTACT WITH PUBLICS

The draft plan and background information was forwarded to a number of publics thought to be interested in the Nicola area environment. These included:

Ansell, James (Merritt)
Bolco Industries Ltd. (Nicola Division)
B.C. and Yukon Chamber of Mines
B.C. Cattlemen's Association
B.C. Environmental Council
B.C. Interior Fishing Camp Operators Association
B.C. Water and Waste Association
B.C. Wildlife Association (Headquarters)
B.C. Wildlife Association (Shuswap Region)
Canadian Forestry Association of B.C. (Kamloops Region)
Community Planning Association of Canada (B.C. Division)
Curnon, Ronald (Spences Bridge)
Ducks Unlimited
Federation of B.C. Naturalists
Fisheries Association of B.C.
Greater Kamloops Outdoor Recreation Committee
Guichon, Gerard (Quilchena)
Highland Valley Outdoor Association
Highmont Mining Corporation
Huber, Eugene (Quilchena)
Kamloops and District Fish and Game Association
Kamloops Flyfishers Association
Kamloops Naturalists
Kamloops Outdoors Club
Lange, Heinz (Merritt)
Larsen, Jens (Nicola Lake)
Logan Lake, Village of

Logan Lake Ranch and Country Club
Lornex Mining Corporation
Merritt, Town of
Nicola Valley Rod and Gun Club
Outdoor Recreation Council of B.C.
Pacific Salmon Society
Placer Development Limited
S.P.E.C.
Sierra Club (Western Canada Chapter)
Steelhead Society of B.C.
Thompson-Nicola Regional District