MINISTRY OF ENVIRONMENT AND PARKS
PROVINCE OF BRITISH COLUMBIA

TALKA-NECHAKO AREA
NECHAKO RIVER
WATER QUALITY ASSESSMENT AND OBJECTIVES

TECHNICAL APPENDIX

L.G. Swain, P.Eng.
RESOURCE QUALITY SECTION
WATER MANAGEMENT BRANCH

R. Girard
WASTE MANAGEMENT BRANCH
NORTHERN REGION

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1. INTRODUCTION

1.1 BACKGROUND

The Ministry of Environment and Parks is preparing water quality assessments and objectives in priority water basins. This technical appendix describes the water quality within the Nechako River watershed, based upon data collected to about December 1983.

Some of the data are summarized as mean values, or often as median values. The reason for this apparent inconsistency is that many data were collected over long time periods during which many detection limits have existed. The authors have used whichever of these two statistics appeared more relevant. Median values are always reported for coliforms and pH.

1.2 ORGANIZATION

The Nechako River flows west to east across the watershed before merging with the Fraser River at Prince George (Figure 1). It has been divided into four major sections, for purposes of data presentation in this report, according to areas where water quality data had been collected. These are shown in Figure 2.

1.2.1 NECHAKO RIVER FROM THE KENNEY DAM TO THE NAUTLEY RIVER CONFLUENCE

The Nechako River currently flows northward to Fort Fraser after originating just upstream from the outlet from Murray Lake. It has a drainage area at Fort Fraser of approximately 20 380 km^2, with nearly 14 000 km^2 of the drainage area being behind the Kenney Dam. Fort Fraser is located adjacent to the Nechako River just upstream from the Nautley River. Major lakes in this section include Ootsa, Whitesail, Eutsuk, Tahtsa, Natalkuz and Cheslatta Lakes.

1.2.2 NECHAKO RIVER FROM THE NAUTLEY RIVER TO ISLE PIERRE

At about Fort Fraser, the Nechako River flows easterly or southeasterly to Vanderhoof and then to Isle Pierre. The drainage area of the watershed at Vanderhoof is about 27 700 km^2, nearly half of which is behind the Kenney Dam. The major tributaries to Isle Pierre are the Nautley River (6 030 km^2) and the Stuart River (over 14 600 km^2). Major lakes in this section include Francois and Fraser Lakes.

1.2.3 STUART RIVER

This is the largest tributary to the Nechako River which it joins between Vanderhoof and Isle Pierre. It has a drainage area of over 14 600 km^2 (at Fort St. James), and includes the town of Fort St. James. Major lakes include Stuart, Tezzeron, Pinchi, Trembleur and Takla Lakes.

1.2.4 NECHAKO RIVER FROM ISLE PIERRE TO THE FRASER RIVER

The Nechako River has a watershed drainage area of about 51 900 km^2 when it meets the Fraser River at Prince George. The Chilako River (3 390 km^2) is the major tributary in this reach. There are no major lakes in this section.

1.3 PROVISIONAL WATER QUALITY OBJECTIVES - BASIC PHILOSOPHY

Water quality objectives are established in British Columbia for water-bodies on a site-specific basis. An objective can be a physical, chemical or biological characteristic of water, biota or sediment, which will protect the most sensitive designated water use at a specific location with an adequate degree of safety. The objectives are aimed at protecting the most sensitive designated water use with due regard to ambient water quality, aquatic life, waste discharges, and socio-economic factors(1).

Water quality objectives are based upon working water quality criteria which are characteristics of water, biota, or sediment that must not be exceeded to prevent specified detrimental effects from occurring to a water use[1]. The working criteria upon which the proposed objectives are based come from the literature, and are referenced in the following chapters. The B.C. Ministry of Environment and Parks is in the process of developing official criteria for water quality characteristics throughout British Columbia, to form part of the basis for permanent objectives.

As a general rule, objectives are only set in water bodies where man-made influences threaten a designated water use, either now or in the future. Provisional objectives are proposed in this report, and are to be reviewed as more monitoring information becomes available and as the Ministry of Environment and Parks establishes water quality criteria.

The provisional objectives take into account the use of the water to be protected and the existing water quality. They allow for changes from background which the Ministry of Environment and Parks feels can be tolerated, or for upgrading which may be required. Any change from background which is allowed indicates that some waste assimilative capacity can be used while still maintaining a good margin of safety to protect designated water uses. In cases of water quality degradation, objectives will set a goal for corrective measures.

The objectives do not apply to initial dilution zones of effluents. These zones in rivers are defined as extending up to 100 m downstream from a discharge, and occupying no more than 50 percent of the width of the river, from its bed to the surface.

In cases where there are many effluents discharged to the river, there could be some concern about the additive effect of initial dilution zones in which water quality objectives may be exceeded. Permits issued pursuant to the Waste Management Act control effluent quality which in turn determines the extent of initial dilution zones and the severity of conditions within them. In practice, small volume discharges or discharges with low levels of contaminants will require initial dilution zones much smaller than the maximum allowed. The concentrations of contaminants permitted in effluents are such that levels in the initial dilution zones will not be acutely toxic to aquatic life or create objectionable or nuisance conditions. Processes such as chemical changes, precipitation, adsorption and microbiological action, as well as dilution, take place in these zones to ensure that water quality objectives will be met at their border.

When dealing with limited data bases, natural variability can be noted, and comments made on whether extremes exceed published working water quality criteria. This doesn't necessarily mean that there is a problem since these extremes may be inherent in the drainage in question. These are factors which must be understood before specific objectives can be finalized.

1.4 HYDROLOGY

The Nechako River is one of the major tributaries to the Fraser River which it joins at Prince George. It originates from a chain of lakes, known as the Nechako Reservoir, which drain an area of about 14 000 km², west of Prince George.

Before 1950, the Nechako River was formed by water draining eastwards from two sets of lakes (Figure 3). One set comprised Skims Lake which flowed into Cheslatta Lake, then into Murray Lake, and finally into the Nechako River at Cheslatta Falls. The second set originated from Knewstubb Lake as the combined flow from Ootsa, Entiako and Eutsuk Lake drainages, and after passing through the Grand Canyon of the Nechako was joined at Cheslatta Falls by waters from the first set of lakes.

Since 1950, the larger lakes have been used as a storage reservoir for hydroelectric power. The power is generated at Kemano, about 240 km west from Cheslatta Falls, and is transmitted to Alcan's aluminum plant at Kitimat. To form the reservoir, the Kenney Dam was completed in 1952 at what became the outlet to Knewstubb Lake. The dam eliminated previous flows into the Nechako River at this point and backed water westward via Knewstubb and Natalkuz Lakes into Ootsa Lake. Excess water, not required for power generation, is released from Ootsa Lake into Skins Lake via the Skins Lake Spillway. The overflow then travels via Cheslatta and Murray Lakes to the Nechako River.

Downstream from Cheslatta Falls, the Nechako River flows in a north-easterly direction to Fort Fraser. Here it is joined by the Nautley River, a short river draining Francois Lake and Fraser Lake, from the West. The Nechako River then flows east, past Vanderhoof and Isle Pierre, into the Fraser River at Prince George. Major tributaries in this reach are the Stuart River, which drains Stuart Lake from the North, and the Chilako River, which enters from the south near Prince George.

Kemano Completion was a proposed Alcan project designed to increase hydroelectric power generated at Kemano while increasing aluminum smelting capacity at other new sites. It proposed increasing the water supply to the Nechako Reservoir by diverting water from a lake system which presently drains northward via the Morice River to the Bulkley River and by decreasing the discharge to the Nechako River. It was contemplated that the flow and temperature of water entering the Nechako River would be controlled by building a dam at the outlet of Murray Lake and a cold water release structure at the Kenney Dam. This latter structure would once again allow water to flow from Knewstubb Lake into the Nechako River. The Kemano Completion project is presently postponed for an indefinite period.

Five major flow regimes have or could affect the water quality of the Nechako River. In overview, these are:

1. Pre-impoundment: Limited flow data exist for only one site, near Fort Fraser, prior to 1950.
2. Reservoir Filling (1952-1955): Flows were reduced in the Nechako River so that the reservoir could be filled.
3. Post-impoundment (1957 - July 1980): Flows in the Nechako River were regulated by Alcan by the release of water through the Skins Lake Spillway. There was a wide range of discharge rates in the

river during this period due to seasonal and yearly water requirements for power production. This was reflected in water diversions to the the Kemano power facility, which increased from 24.9 m^3/s in 1955 to 124 m^3/s in 1979 (mean annual values).

4. Post-impoundment (1980-present): Flows in this period have been regulated by an injunction from the B.C. Supreme Court.
5. Future Flows: The flows that Alcan has proposed for the Kemano Completion project will be examined, along with the projected waste loadings, to determine impacts on receiving water quality. A court case, filed before the Supreme Court, will undoubtedly determine flows in the river, and will have a major impact on any future development plans by Alcan.

Further details of the hydrology in each sub-basin will be examined as appropriate in the following chapters. They are also explained in great detail in baseline reports prepared by Envirocon Ltd.(4,7). An in-depth assessment of the hydrology of the Nechako River and its reservoir is contained in another Ministry of Environment and Parks document(40).

2. NECHAKO RIVER FROM THE KENNEY DAM TO THE NAUTLEY RIVER

Prior to the construction of the Kenney Dam, the Nechako River flowed from Natalkuz Lake, through the Grand Canyon of the Nechako River. However, the construction of the dam eliminated the flows through the Grand Canyon except for minor seepage. Flows at present are diverted from the reservoir through the Skins Lake Spillway and subsequently through Skins, Cheslatta and Murray Lakes prior to meeting the former Nechako River channel near Cheslatta Falls. The river flows northerly from Cheslatta Falls to Fort Fraser.

2.1 HYDROLOGY

Pre-impoundment flows were measured at Fort Fraser at Water Survey of Canada station 08JA001 (Figure 3) from 1915 to 1917 and from 1929 to 1952. During most of these years, data were collected only from April through December. Mean monthly flows for this period ranged from 127 m^3/s in October to 471 m^3/s in June. During 1930, flows were recorded in each month, with the lowest monthly mean discharge of 60 m^3/s occurring in February[2].

The Kemano power development began to affect flows in the Nechako River after 1952. The historic annual average 7-day low flow at Fort Fraser from 1956 to 1972 was about 48.4 m^3/s. This was calculated by subtracting the calculated 7-day flow for that time period on the Nautley River at Fort Fraser (Water Survey of Canada station 08JB003) from data collected on the Nechako River at Vanderhoof (Water Survey of Canada station 08JC001)[3]. When flow records from both stations for the period 1973 to 1982 are included with the 1956 - 1972 data, the average 7-day low flow is reduced to about 43.9 m^3/s.

However, the Kemano power development did not begin to use the maximum amount of water from the reservoir until 1978. Full capacity operation caused reduced flows in the Nechako River since less water was released at the Skins Lake Spillway. Another factor which has caused reduced flows has been recent short-term climatic changes (dry period) in the watershed.

In order to determine the appropriate annual average 7-day low flow for assessing waste discharges to the Nechako River upstream from the confluence of the Nautley River, flow records prior to 1978 were not considered since water demands by Kemano were not maximized. By using appropriate differences between the average 7-day low flows for both the Nechako River at Vanderhoof and the Nautley River at Fort Fraser, the annual 7-day average low flow for the period 1978-1983 was calculated to be about 23.1 m^3/s just upstream from Fort Fraser (Table 1). Data collected at a newly established Water Survey of Canada station (08JA017) downstream from Cheslatta Falls on the Nechako River during 1981 and 1982 indicate that this estimated flow may be slightly lower than the actual flow at Fort Fraser (Table 1).

Another factor which has influenced flows was an injunction issued in 1980 by the B.C. Supreme Court requiring certain minimum flows in the Nechako River to protect fish. These flows can vary, depending upon the year. In order to reflect the influence of using maximum flows for power generation at Kemano and the 1980 injunction, Envirocon, Alcan's consultant, adjusted flow records (see Reference 4 for details) from 1957 to 1981. They determined annual 7-day average low flows at Fort Fraser to be from 39.8 m^3/s for a 1.01-year return period to 38.4 m^3/s for a 20-year return period[(4)]. The mean annual 7-day low flow for the period August 1980 to 1984 when the injunction applied was 30.5 m^3/s. Thus, the mean annual 7-day low flow for periods of normal precipitation and with the injunction applied would be somewhere between 30.5 m^3/s and 39.8 m^3/s. In this report, the annual 7-day average low flow will be considered to be 30.5 m^3/s at Fort Fraser, calculated from the actual measured flow for the period 1980 to 1984 when the injuction applied.

The 1984 Alcan Kemano Completion project proposed (Figure 5) a guaranteed 7-day low flow at Cheslatta Falls of 14.2 m^3/s (December through

March)[5]. Higher 7-day low flows would occur for the remainder of the year (Figure 5). The proposed minimum 7-day flow of 14.2 m^3/s from Cheslatta Falls to Fort Fraser will be considered for assessment purposes in this report as a "worst-case".

An in-depth examination of hydrology is included in Reference 40.

2.2 WATER USES

The following discussion is about water uses which relate to water quality. Figure 3 indicates locations of licensed water withdrawals on the Nechako River upstream from the Nautley River. There are two withdrawals of about 370 000 m^3/year for irrigation, two withdrawals of 9 m^3/d (0.0001 m^3/s) for domestic use, and one withdrawal of 455 m^3/d (0.005 m^3/s) for water works.

The Nechako River is an important recreational resource for activities such as boating, canoeing, fishing, nature viewing, camping, hunting, picnicking and swimming. Information on recreational use is contained in the Upper Nechako River Watershed Fisheries Management Plan[41].

The Nechako River upstream from the Nautley River is used by large numbers of fish species, including anadromous and non-anadromous fish stocks.

Rainbow trout, Dolly Varden (char), mountain whitefish, burbot and white sturgeon are the principal sportfish species present along with suckers, squawfish and assorted minnows[41]. The Upper Nechako River has been recognized by the Fisheries Branch as having the potential to become one of the most productive and heavily fished rivers in the Northern Region and therefore holds very high regional and provincial significance[41].

More than 60% of the Nechako River chinook spawning areas occur upstream from the Nautley River, the most important areas being upstream of

Greer Creek[42]. The Department of Fisheries and Oceans considers the present level of salmon production to be significant and feels the opportunity for increasing production is substantial[43].

2.3 WASTE DISCHARGES

Two landfill operations and a sewage treatment plant are located within this reach. Their locations are shown on Figure 3 by the permit numbers issued pursuant to the Waste Management Act.

2.3.1 EUROCAN PULP AND PAPER

This company operates a planermill and sawmill near Fort Fraser with an associated industrial refuse site. It is allowed by permit PR 1406 to dispose of 1 984 m^3 of material three times per year. Refuse disposed of consisted of log waste, yard clean-up, wood ash and clinker material; however, the site has had no wastes added since about 1980. The site is about 30 m from a ditch which leads to the Nechako River. It is not expected that this operation would affect the water quality of the river due to the volume and nature of refuse, the flows in the river, and the fact that no leachate production has been observed at this site.

2.3.2 FORT FRASER

The town operates a municipal landfill which is located about 150 m from an intermittent tributary to the Nechako River. Fort Fraser is allowed by permit PR 3391 to dispose of 8 m^3/d of typical domestic and commercial refuse, with regular burning of combustibles and covering once every seven days. It is not expected that this operation would affect the water quality of the Nechako River due to the volume and nature of the refuse, the flows in the river, and the fact that leachate problems have not been observed at this site.

2.3.3 REGIONAL DISTRICT OF BULKLEY-NECHAKO

The Regional District of Bulkley-Nechako operates a sewage treatment plant at Fort Fraser which discharges effluent to the Nechako River. Treatment is provided in a 0.8 ha facultative pond following treatment in two 545 m^3-capacity anaerobic cells which are operated in parallel. Permit PE 288 restricts the maximum daily discharge to 182 m^3/d (0.002 m^3/s) with maximum concentrations of 100 mg/L for BOD_5 and suspended solids. Data in this report generally were collected prior to construction of the two anaerobic cells which were completed in October 1983. The population of Fort Fraser is about 500, and is growing at a rate of about 2.9% per year[8].

2.3.3.1 Effluent Flows and Dilutions

The average effluent discharge rate measured by the Ministry of Environment was about 129 m^3/d. Flows have exceeded the permitted level of 182 m^3/d in April 1972 (200 m^3/d), November 1982 (250 m^3/d) and February 1983 (238 m^3/d). This indicates that the permitted flow was exceeded about 18% of the time (n=17). The highest effluent flows have been recorded from about November to April during the period of lowest river flows. This may indicate some water taps are being left open to prevent water lines from freezing.

The effluent presently is discharged from a single pipe on the river bottom. According to the engineering drawing (Figure 4), the outfall elevation is about 1.5 m above the deepest part of the channel cross-section. The river width at that depth of flow is about 91 m. The outfall has historically been visible, being covered by about 1 m of water during 1982 summer low flows. The plume from the outfall is not normally visible although it has been a distinct green colour during summer low-flow periods. After a distance of 10 m, the plume mixes with the river water and is no longer visible. The colour is associated with algae which are abundant in the facultative pond at that time of year.

The proposed guaranteed 7-day low flow by Alcan for the Nechako River, should the Kemano Completion project proceed, will be as low as 14.2 m^3/s (section 2.1). It is not likely that this flow will increase significantly between Cheslatta Falls and Fort Fraser, especially during the period from December through March. A stage-discharge curve produced by Envirocon (their Figure 3.2.12, reference 7, Figure 6 in this report) for the Nechako River at Fort Fraser indicates that at a flow of 14.2 m^3/s, the water depth will be only about 0.8 m. At this flow the outfall would be out of the water.

Various dilutions are provided to the effluent at various river flows and effluent discharge rates. These assume complete mixing of the effluent and the river water, a situation which likely will not occur at the edge of the initial dilution zone, but further downstream.

Dilutions Provided at Various Effluent and River Flows
After Complete Mixing

Average 7-day Low Flow (m^3/s)	Effluent Flow (m^3/d)		
	Average Recorded 129	Permit Limit 182	Maximum Recorded 250
	Dilution Ratios		
14.2 (Alcan proposal)	9 510	6 740	4 910
23.1 (1978-1983)	15 470	10 970	7 980
30.5 (1980-1984)	20 333	14 455	10 540
43.9 (1952-1982)	29 400	20 840	15 170
48.4 (1956-1972)	32 390	22 960	16 710

If the population of Fort Fraser continues to grow at 2.9% per annum[8], it will reach about 725 in 1995. If effluent flows are maintained in proportion to population, the dilution ratio for the lowest 7-day low flow at maximum effluent flow will be reduced from 4910:1 to 3390:1. Since this still exceeds 2000:1, the present effluent quality limits of 100 mg/L BOD_5 and suspended solids would still apply[9]. Thus, for these two characteristics, any upgrading of the facility required in the forseeable future, other than possibly extending the outfall, will not be due to Kemano Completion but natural population growth.

2.3.3.2 Biochemical Oxygen Demand

The average BOD_5 value was 56 mg/L (Table 2), although several BOD_5 values have exceeded the limit of 100 mg/L. These higher values have occurred between January and April of several years, and can be expected from a lagoon operating during cold weather. The addition of the two anaerobic cells which are operated in parallel ahead of the facultative pond may reduce the frequency of these higher BOD_5 values.

The impact of the maximum recorded BOD_5 concentrations in the effluent (occurring in winter) on the Nechako River, assuming maximum recorded effluent flow rates (occurring in winter), would be minimal. Assuming the proposed 7-day low flow should Kemano Completion proceed, and assuming that complete mixing of effluent and river water occurs, the increase in BOD_5 in the river would be only 0.03 mg/L (138 mg/L x 1/4910). With increased effluent flows, the dilution in 1995 (3390:1) would still be adequate so that the increase would be only 0.04 mg/L. Such small changes would not be measurable in the river.

Data for BOD_5 have been collected upstream and downstream from the outfall in the Nechako River on 4 occasions in 1976, at sites 0400629 and 0400631 (Figure 3). All values at both sites were <10 mg/L. This was also the case for data collected from within the initial dilution zone at site 0400630.

2.3.3.3 Suspended Solids

The average suspended solids in the effluent was 76 mg/L (Table 2), although several values exceeded the permitted value of 100 mg/L. These generally occurred between June and November of several years (mostly prior to 1977), and can be expected from a pond in the summer months when large quantities of algae would be produced and measured as suspended solids.

The impact that the maximum recorded suspended solids effluent concentration would have on the Nechako River would be at least as small as predicted for BOD_5. The reason is that the maximum effluent suspended solids loading was smaller than the maximum BOD_5 loading and it occurred in the summer when the maximum BOD_5 loading occurred and when the proposed 7-day low flows would be twice those in winter.

Data for suspended solids were collected upstream and downstream from the outfall and in the initial dilution zone at sites 0400629, 0400631 and 0400630, respectively. The data are shown below.

SUSPENDED SOLIDS (mg/L) U/S AND D/S FROM
FORT FRASER STP

DATE	U/S 0400629	IDZ 0400630	D/S (100 m) 0400631
76 05 27	56	1470	70
76 06 17	18	9	12
76 07 22	34	5	10
76 08 12	17	9	5
82 07 21	22	18	23
82 08 18	7	6	5
82 09 29	3	3	3
82 12 09	3	-	2

These data indicate that with one exception (76 05 27), the discharge has not affected values in the river either inside or outside the initial dilution zone (IDZ).

2.3.3.4 Bacteriological Quality

Fecal coliform values in the effluent have been as high as 1 600 000 MPN/100 mL. Most values collected between November and April exceeded 100 000 MPN/100 mL, while values in other months were generally lower than this. The dilution available in the river, assuming maximum fecal coliform values and effluent flows, complete mixing of the effluent and river water, and minimum river flows proposed for the Kemano Completion project, could result in a maximum increase of about 325 MPN/100 mL in the river. It is projected that this could increase to about 475 MPN/100 mL in 1995. These compare to an increase of about 200 MPN/100 mL which would have occurred during the average 7-day low flow for the period 1980-1983.

Fecal coliform values have been measured upstream and downstream from the outfall in the Nechako River. The results of these samplings are indicated below.

FECAL COLIFORMS (MPN/100 mL) U/S and D/S
FROM FORT FRASER STP

DATE	U/S 0400629	D/S (100 m) 0400631
76 05 27	13	130
76 06 17	21	49
76 07 22	13	26
76 08 12	7	8
82 07 21	49	49
82 08 18	11	5
82 09 29	5	350

These data indicate that increases have been noted downstream from the outfall from the sewage treatment facility. These increases would be greater should the proposed 7-day low flows of 14.2 m^3/s for the Kemano Completion project be realized.

2.3.3.5 Nutrients

Limited data have been collected on nutrients. The maximum recorded total dissolved phosphorus value in the effluent was 6.92 mg/L. This could cause an increase in the river after complete mixing, at maximum recorded effluent flows, and assuming the proposed 14.2 m^3/s 7-day low flow, of 1.4 μg/L (6.92 mg/L ÷ 4910). By 1995, this would be increased to 2 μg/L (6.92 mg/L ÷ 3390). Increases during the summer months would be about half of these, using the proposed 7-day low flow of Kemano Completion (31.1 m^3/s from April through August and 28.3 m^3/s in September and October[(5)]). It is therefore unlikely that phosphorus increases as a result of this sewage discharge alone, would create a problem in the river during the summer months with either present or 1995 effluent flow rates.

Total dissolved phosphorus values measured upstream and downstream from the outfall (sites 0400629 and 0400631, respectively) were all 0.005 mg/L on 3 occasions in 1982. Orthophosphorus values have been measured more frequently and are detailed below.

ORTHOPHOSPHORUS (mg/L) U/S and D/S
FROM FORT FRASER STP

DATE	U/S 0400629	D/S (100 m) 0400631
76 05 27	0.003	<0.003
76 06 17	0.003	0.004
76 07 22	0.007	0.009
76 08 12	0.003	0.010
82 07 21	<0.003	<0.003
82 08 18	<0.003	<0.003
82 09 29	<0.003	<0.003

Except for one occasion in 1976, orthophosphorus values did not appear to be affected considerably by the discharge.

Winter effluent values for total ammonia were the highest with a maximum of 36.2 mg/L. This concentration could potentially increase total ammonia values in the river, at the maximum effluent discharge rate and with complete mixing, by 0.007 mg/L assuming river flows and subsequent dilutions associated with Kemano Completion. This increase would rise to 0.011 mg/L total ammonia with the 1995 projected discharge rates. These values would be well within safe levels for aquatic life in terms of resulting un-ionized ammonia concentrations.

Total ammonia values upstream and downstream from the outfall (sites 0400629 and 0400631, respectively) have increased on 2 of 7 occasions when concurrent samples were collected. Values on those occasions increased from 0.019 to 0.027 mg/L and from <0.005 to 0.005 mg/L. Interestingly enough, a larger decrease than the highest increase, from 0.033 to 0.011 mg/L, has also been recorded. These results indicate the need for more intensive sampling if a conclusive trend is to be found. The levels measured to date are of no concern to any water use.

2.3.4 DIFFUSE SOURCES

The effects of forestry and residential developments have not been examined in this assessment. However, each would have some inpact on water quality. The locations of cattle in the Nechako watershed are shown on Figure 3. The number of cattle was estimated from statistics of the Beef Assurance Program of the B.C. Ministry of Agriculture. The estimates for nutrient coefficients proposed by Bangay[31] were used to calculate potential maximum nutrient annual loading from cattle.

	Kg P/year	Kg N/year
Cows	6 447	55 352
Yearlings	3 333	41 297
Calves	38	827
Total	9 818	97 476

The impact of these nutrients on river water quality will depend upon the release period to creeks, soil type, river flow and distance to river. This is elaborated upon in Section 2.4.3.

2.4 AMBIENT WATER QUALITY AND PROVISIONAL WATER QUALITY OBJECTIVES

Water quality data for the Nechako Reservoir are limited. Water chemistry and dissolved gas data were collected at Knewstubb Lake near the Kenney Dam and at Tahtsa Lake near the tunnel in 1974 and 1979 by the International Pacific Salmon Fisheries Commission (IPSFC) (1979) and in 1971, 1981, and 1983 by Envirocon[4]. In June 1982, the Ministry of Environment collected water quality samples at Whitesail, Tahtsa and Eutsuk Lakes.

Reservoir water is soft and low in dissolved solids, nutrients and metals. This contribution of soft water to the Fraser River is undoubtedly related to runoff from the Coast Mountains into the reservoir. The low levels of nutrients support Envirocon's comparison of the lake to an oligo- to mesotrophic lake. Metal levels were below aquatic life criteria concentrations except for two total copper values. Further attention should be directed to this characteristic in future sampling.

Water quality data for the Cheslatta system (Skins, Cheslatta and Murray Lakes) are lacking except for some suspended solids and temperature measurements taken by Envirocon in 1982 and 1983. These revealed what is evident when flying over these lakes in summer. Peak flow releases from the spillway result in erosion of large amounts of river bank material. This increases suspended sediment concentrations in Cheslatta and Murray Lakes and both lakes become extremely turbid for the remainder of the summer after such spillway discharges. The effect of increased sediment loads and fluctuating lake and river levels is undoubtedly to reduce summer lake productivity. The lakes contain a variety of sports fish and the provincial Fisheries Branch has identified a plan to restore the depressed fishery and thereby enhance recreational opportunities and restore the native Indian food fishery[41]. Basic physical, chemical and biological monitoring of these lakes is necessary to assess Kemano 1 impacts, determine present trophic status, and monitor productivity improvements as the system is restored.

Ambient water quality data have been collected at several river sites within this sub-basin. Data collected near the Kenney Dam (Site 0920067) were limited to dissolved gas measurements in 1974. Data were also collected at site 0920068 at Fort Fraser for similar variables. Data collected 100 m upstream from the sewage treatment facility at Fort Fraser (Site 0400629) were the best ambient water quality data available, since they were collected in 1976, 1982 and 1983 for several characteristics. The data for this site are summarized in Table 3. A summary of common water quality characteristics and working criteria for specific water uses is given in Table 4.

Designated water uses are the preservation and protection of sensitive aquatic life, wildlife, drinking water supply, (partial treatment) irrigation, livestock watering and primary-contact recreation. These are the present water uses.

2.4.1 pH AND BUFFERING CAPACITY

Alkalinity and pH values were recorded only at site 0400629 at Fort Fraser. Values for pH were generally alkaline, with a median value of 7.5 and a maximum value of 7.6. All values were within the range of water quality criteria (6.5-9.0) for the protection of sensitive aquatic life[12] and drinking water supplies (6.5 to 8.5)[12]. These near-neutral pH values should be maintained to minimize the formation of toxic concentrations of ammonia near the Fort Fraser STP. A provisional water quality objective therefore is proposed for pH. The objective, applicable to discrete samples collected from outside the initial dilution zones of effluents, is that the pH in any discrete sample should not be outside the range 6.5 to 8.5. By restricting the upper limit of pH to 8.5 instead of 9.0, the percentage of toxic ammonia in aqueous ammonia solution will be about one-third that which would occur at pH 9[22].

This objective will apply to any part of the Nechako River, upstream from the confluence of the Nautley River to Cheslátta Falls. The excluded initial dilution zones of effluents are defined as extending up to 100 m downstream from the discharge. They should occupy no more than 50% of the width of the river around the discharge point, from the bed of the river to the surface. In the case of the Nechako River, the initial dilution zone should occupy no more than 25% of the width of the river, due to its size.

Alkalinity values were nearly 30 mg/L, indicating that the river water is adequately buffered to acidic inputs and exceeds the minimum criterion of 20 mg/L for the protection of sensitive aquatic life[12]. No objective is proposed for alkalinity since it is expected that the discharge of effluent from the Fort Fraser sewage facility will not affect alkalinity values.

2.4.2 HARDNESS AND METALS

Values for hardness were less than 30 mg/L, indicating that the water would be classified as being very soft. Metal values were measured infrequently and were often below detection and the working water quality criteria in Table 4. Exceptions were total copper which had one detectable value (n=3) of 0.003 mg/L and a water quality criterion of 0.002 mg/L, and total aluminum with a maximum value of 0.08 mg/L and a water quality criterion of 0.05 mg/L[10]. Envirocon noted some detectable levels of total lead (0.032mg/L) and total mercury (0.0003 mg/L)[7]. These are believed to be naturally occurring levels.

2.4.3 NUTRIENTS

All forms of nitrogen were usually at low levels in the river at Site 0400629. Ammonia and nitrate/nitrite nitrogen values were generally below their detection limits of 0.005 mg/L and 0.02 mg/L, respectively. The organic nitrogen values were also generally low, with a mean value of 0.11 mg/L. The maximum recorded ammonia value of 0.033 mg/L (Table 3), when taken in conjunction with the maximum recorded pH (7.6) and an assumed temperature of 20°C, is considerably less than the British Columbia water quality criteria in Tables 31 and 32 for the protection of sensitive aquatic life under continuous exposure to total ammonia[14].

It was shown in Section 2.3.3.5 that total ammonia concentrations might increase by 0.011 mg/L in the river due to discharges from the sewage treatment facility at Fort Fraser. These increases would not affect ammonia values considerably in the river compared to those measured upstream. Nevertheless, in order to protect the sensitive fishery in the Nechako River, <u>a provisional water quality objective is proposed for total ammonia.</u> The objective, which will apply to the Nechako River upstream from the Nautley River confluence and below Cheslatta Falls, exclusive of initial dilution zones described in Section 2.4.1, will be that <u>the average concentration of total ammonia should not exceed the value listed in Table</u>

32, while the maximum value in any discrete sample should not exceed the value listed in Table 31. The average applies to a minimum of five weekly samples taken in a period of 30 days.

Data in Table 3 show that values of nitrite nitrogen were all <0.005 mg/L at Site 0400629. This was also the case at Site 0400631, downstream from the outfall. However, ammonia discharged in the effluent can be oxidized to nitrite, which itself can be toxic to aquatic life. Therefore, to protect aquatic life, a provisional objective is proposed for nitrite nitrogen. The objective is that the average value should not exceed 0.02 mg/L, and the maximum value should not exceed 0.06 mg/L. These objectives apply to the Nechako River from Cheslatta Falls to the Nautley River confluence. The average values are to be calculated from a minimum of five weekly samples collected in a 30-day period.

As discussed in Section 2.3.4, diffuse sources (cattle) can increase phosphorus and nitrogen values in the river. The greatest potential for these increases is after winter, when waste has accumulated. Assuming a six month accumulation, the following increases are the maximum possible, depending upon release periods and river flows. These assume 100% transmission to the river.

MAXIMUM POTENTIAL INCREASES (mg/L) IN PHOSPHORUS AND NITROGEN FROM DIFFUSE SOURCES

Release Period	14.2 m^3/s (Alcan)		23.1 m^3/s (1978-1983)		43.9 m^3/s (1952-1982)	
	P	N	P	N	P	N
1 week	0.57	4.62	0.35	2.84	0.18	1.46
2 weeks	0.29	2.31	0.18	1.42	0.09	0.73
4 weeks	0.14	1.15	0.09	0.71	0.05	0.36

These data indicate considerable phosphorus and nitrogen increases can occur due to cattle wastes, but the relatively few measurements made to date suggest that this may not be occurring. A large part of this would be organic and particulate form, and not immediately available to algae.

Orthophosphorus values have generally been low, and at or below the detection limit of 0.003 mg/L (Table 3). Total dissolved phosphorus values have been considerably higher, with a mean value of 0.007 mg/L and a maximum value of 0.011 mg/L (Table 3). This could be considered to be a moderate level of dissolved phosphorus which is naturally occurring. Information in Section 2.3.3.5 indicates that should the Kemano Completion project proceed, the effluent from the Fort Fraser sewage treatment facility could increase these natural levels by 0.002 mg/L by 1995.

The present nitrogen to phosphorus ratios could not be calculated since most of the orthophosphorus and dissolved inorganic nitrogen (nitrate and ammonia) values were below detection limits. Thus it is not known whether either phosphorus or nitrogen is the nutrient limiting growth in the Nechako River. Sampling is presently being carried out to answer this question.

2.4.4 AQUATIC PLANTS

The moderate levels of total dissolved phosphorus have supported aquatic macrophytes in the river in this reach near the Fort Fraser sewage outfall. Plant growth was abundant and did not appear to vary in density either upstream or downstream from the outfall. Aquatic plant collections were taken from the river at Fort Fraser and Vanderhoof.

Ranunculus aquatilis was the most dominant plant at Fort Fraser. This plant grows in dense masses with its small white flowers protruding above the surface of the river. Other abundant rooted macrophytes included *Potamogeton richardsonii* and *Sagittaria cuneata* (arrowhead). Long strands of filamentous green algae up to about 1 m in length were commonly attached to the rooted plants, especially in late summer when the water was less turbid.

The nutrients from the Fort Fraser sewage discharge, from a visual inspection, have had no apparent major effect on the plant community of the Nechako River. The flow regimes proposed for the river, should the Kemano Completion project proceed, could have a noticeable impact. Some of the influences may increase aquatic plant productivity, and some may tend to decrease it.

The following could tend to increase productivity:

1) At present, the Nechako River is turbid during most of the summer due to the high flows released through the Skins Lake Spillway during July and August. Construction of a Kenney Dam cold-water release-structure would likely greatly improve the water clarity as less water would be released through the Skins - Cheslatta Lakes system.

2) Any reduced flows would decrease the water depth. This would increase the potential littoral area, especially in combination with increased light penetration due to improved clarity.

3) Alcan has considered installing a cold water structure to release hypolimnetic water from behind the Kenney Dam. If this water is richer in phosphorus than surface water, then there is a potential for increased algal growth in the Nechako River.

Great increases in aquatic plant and algal growths could, in the extreme, potentially block migration routes of salmon and encourage coarse fish production, deoxygenate the water at night, or impair recreational pursuits such as boating and swimming.

The following could tend to offset increases in aquatic plant productivity:

1) Cooler river water resulting from something such as the once planned cold-water release potentially could reduce productivity. Although this may not greatly affect algal productivity, it may decrease the growth rate of rooted macrophytes.

2) The proposed flow regime would result in less siltation of the river. This may affect weed beds by removing the continual supply of substrate and nutrients.

Periphyton chlorophyll-a values have not been measured in the Nechako River. However, the Ministry of Environment has recommended a level of 50 mg/m^2 to protect recreational use of rivers[30]. To ensure that periphyton growth does not become a problem, a provisional objective is proposed for the Nechako River from the Kenney Dam to Fort Fraser, except in initial dilution zones of effluents, described in Section 2.4.1. The objective is as follows: the average of at least five periphyton chlorophyll-a values from natural substrate on any sampling occasion should not exceed 50 mg/m^2. Monitoring will be needed to confirm that this is a realistic objective for the Nechako River.

2.4.5 DISSOLVED OXYGEN AND OXYGEN-CONSUMING MATERIALS

Dissolved oxygen values (n=2) were high and above the working water quality criterion of 7.75 mg/L to provide a high level of protection to salmonids[16]. Percent saturation values were about 90%. Since the river is an important migratory route and spawning river, it is proposed that a provisional water quality objective should be established for dissolved oxygen to protect present high levels. This objective is that the minimum dissolved oxygen concentration should not be less than 7.75 mg/L in order to continue to provide a high level of protection to the salmonid populations which utilize this reach of the river. The level should be a minimum of 11.2 mg/L when fish eggs are in the "eye" to hatch stage and 8.0 mg/L when fish eggs and/or larvae or alevin are present. This value will apply to any discrete sample collected from outside the initial dilution zones of effluents, described in Section 2.4.1.

BOD_5 values were only measured on two occasions and were below the detection limit of 10 mg/L. Information in Section 2.3.3.2 indicates that these values will not be increased appreciably by the discharge from the Fort Fraser sewage treatment facility.

2.4.6 SOLIDS

Dissolved solids values in the river were generally low, with the maximum recorded value being 60 mg/L. Suspended solids data for this stretch of river are very limited and increases in suspended solids during July and August, resulting from increased flows (resulting from the injunction), have not been studied. However, considerable increases in turbidity have been apparent visually in the Cheslatta system and in the Nechako River. The high sediment load and the present high flows used for cooling during summer months are depressing the sport fishery[41]. Data directed specifically at suspended solids are required.

The few available data indicate that suspended solids were generally low, although one higher value of 56 mg/L was recorded in May 1976 and was likely the result of a higher than average freshet. The mean monthly river flow in May 1976 was about 410 m^3/s compared to a long-term mean value of 215 m^3/s for all flows recorded in May of all years[2]. (These values were calculated by subtracting flows for the Nautley River at Fort Fraser from the flows for the Nechako River at Vanderhoof).

All other measured suspended solids values were less than 25 mg/L, a value low enough to provide a high level of protection to aquatic life[13]. The few turbidity measurements (n=4) indicate that removal of turbidity prior to drinking water use will be necessary. Thus more data are required to address concerns with respect to solids during July and August.

2.4.7 BACTERIOLOGICAL QUALITY

Measured fecal coliform values at the upstream site 0400629 have ranged from 2 to 49 MPN/100 mL (Table 3). Such levels would require disinfection and possibly filtration of the raw water if it is to be used as a drinking water supply, according to working water quality criteria[11]. However, an adequate number of samples have not been collected to verify this tentative conclusion. The data indicate that there are some diffuse contributions of fecal coliforms upstream from Fort Fraser. Potential sources could include cattle (Figure 3), waterfowl and human influences from the southern portion of Fort Fraser, and houses along the river.

Information in Section 2.3.3.4 shows that fecal coliforms have been increased by a maximum 350 MPN/100 mL from site 0400629 to 0400631, just outside the initial dilution zone of the Fort Fraser sewage treatment plant discharge. In addition, it has been calculated that even with complete mixing of the effluent and river water, fecal coliform values at flows typical of the Kemano Completion project could increase in the river by 325 MPN/100 mL immediately, or by 475 MPN/100 mL in 1995. This compares to an increase of about 200 MPN/100 mL with flows typical of the period 1980-1983. These increases would occur in winter and not during the recreation season.

The water quality of the Nechako River downstream from the Fort Fraser discharge should be maintained at a level suitable to permit water-contact recreation during the summer period (June 1 - September 30). This type of use first occurs about 1.5 km downstream from the outfall. It is therefore proposed that a provisional objective for fecal coliforms apply to the Nechako River from 1 km below the Fort Fraser sewage outfall to the confluence with the Nautley River. The objective is that the geometric mean value should be ≦ 200 MPN/100 mL, and the 90th percentile value ≦ 400 MPN/100 mL, and is applicable from June through September. These values ideally should be calculated based upon at least five weekly samples in a 30-day period. Downstream from the discharge from the Fort Fraser sewage outfall to the Nautley River, no drinking water withdrawals occur. Therefore, recreational uses determine the level of bacteriological protection required in that reach. Since partial treatment of drinking water upstream from the outfall is likely required to remove turbidity, a corresponding provisional objective for fecal coliforms will apply to the Nechako River from Cheslatta Falls to the initial dilution zone for the Fort Fraser sewage outfall. The objective is that the 90th percentile value should not exceed 100 MPN/100 mL.

Fecal coliform results from the Fort Fraser lagoons during the summer period are consistently below 100 000 MPN/100 mL. Calculations indicate that the provisional objective downstream from the sewage outfall will be easily met by dilution provided by the proposed Kemano Completion flows in 1995.

During the winter the situation will be different due to the treatment system being less efficient at reducing coliforms and less dilution available in the river. It has been calculated that, with complete mixing of the effluent and river water, fecal coliform values at flows typical of the Kemano Completion project could increase by 325 MPN/100 mL immediately or by 475 MPN/100 mL in 1995. This compares to a calculated winter increase of about 200 MPN/100 mL with flows typical of the period 1980-1983.

The potential winter increases identified above are not thought to represent a problem due to the following reasons:

1. Recent treatment system upgrading may result in improved effluent quality with respect to fecal coliforms.
2. There is no water-contact recreation in winter due to ice cover.
3. The confluence of the Nautley River a few kilometres below the Fort Fraser discharge provides a sizeable increase in dilution.

It is anticipated that at present this objective can only be met during the summer months at periods of high river flows and when the bacteria in the stabilization ponds are removed by ultraviolet radiation. It is possible that, at some time in the future, the effluent might have to be disinfected at least part of the year. Should this be carried out using chlorine, de-chlorination using sulphur dioxide will likely be required to prevent chlorine toxicity to salmonids. To protect salmonids, the working water quality criterion for chlorine residual has been adopted from the United States Environmental Protection Agency[12]. <u>The proposed water quality objective is that the total chlorine residual in any discrete sample should not exceed 0.002 mg/L</u>. This objective applies in the Nechako River from the Kenney Dam to the confluence of the Nautley River, except in the initial dilution zones of effluents, described in Section 2.4.1. Since the objective is less than the minimum detectable concentration, it would be necessary to estimate the receiving water concentration using effluent loading and streamflow.

2.4.8 TEMPERATURE

Limited data were collected for river water temperatures. High water temperatures can accelerate the rate at which the energy reserves of adult salmon in the river are utilized. Adult female sockeye salmon from the Stuart River run have used 96% of body fat and 53% of their protein by the time their eggs are laid[6]. The scope for activity of juvenile sockeye salmon decreases as the optimum temperature of 15°C is exceeded[6].

The upper lethal temperature for juvenile and adult sockeye salmon was estimated to be 24°C to 25°C[6]. For an exposure period of 15-days, no mortalities were recorded at temperatures from 18°C to 21°C[6]. Envirocon cited an International Pacific Salmon Fisheries Commission document which concluded that a safe objective for Nechako River temperatures would be not to exceed a daily mean temperature of 20°C[6]. The maximum 20°C daily mean temperature presents no concerns for the freshwater fishery.

The American Fisheries Society has indicated that reproductive seasons are April through June and September through October[18]. Envirocon reported the following life patterns: chinook salmon adults arrive in August and September, spawn in September and October, hatch from this time to December, with fry emergence during March through May; sockeye adults migrate from July to October; and rainbow trout spawn in May and June[6]. Dolly Varden and mountain whitefish spawn in the Nechako River in the Autumn, while white sturgeon spawn in the spring. Rainbow trout, at least in the Upper Nechako, are believed to spawn primarily in the tributary streams in the Spring.

Alderdice and Jensen took into account the influence of temperature on the growth of chinooks, and the relations between higher temperatures and disease. They concluded that 17.5°C (average) was an acceptable maximum in the Nechako for the protection of chinook and sockeye during migration[47]. As well, the daily maximum should not exceed 20°C.

A set of working water quality criteria is that the water temperature should not exceed 20°C at any time, nor 15°C in rearing areas or migratory routes; nor 13°C in spawning areas, for egg and fry incubation[24]. At the same time, the growth of rainbow trout is maximized in the range from 13° to 18°C. To protect the sensitive fishery in the Nechako, the following <u>provisional water quality objective for a temperature regime</u> is proposed for the Nechako River 100 m downstream from Cheslatta Falls. The objective is that <u>the maximum mean daily temperature outside the initial dilution zones of effluents, should not exceed 15°C</u>. The maximum value stated in this objective does not detract from the fact that water temperatures further downstream in the Nechako River must be controlled through water releases, so that the provisional water quality objective for the temperature in the Nechako River just upstream from the Stuart River confluence (Section 4.4.8) will be met. Thus, lower temperatures than these maxima may be required to meet other downstream objectives.

Temperature affects fish mostly in areas closest to the shore since it is shallowest and provides suitable habitat. Smaller fish are also found in this area, since it provides protection against predation. The main area affected is from each shore, to a depth of 1.6 m. Since these areas are the most prone to causing temperature stress in fish, temperature objectives should be checked at a greater number of locations in these areas. However, water in the remainder of the river channel cannot be ignored when checking temperature objectives, since it can mix with the near-shore water at any river bend. The average water velocity at any vertical line in a cross-section is the average of the velocities measured at 0.2 and 0.8 of depth along the line.

Therefore, to check the temperature objective at any cross section while taking the aforementioned factors into account, the following procedure is proposed. Temperature measurements will be made at 0.2 and 0.8 of the depth at each of five points at any river cross section. The five verticals at each cross section should be at the following locations: where a depth of 1.6 m is achieved going out from each shore, half the distance from this point to the adjacent shore, and at the mid point of the river. Three sets of these measurements should be taken at approximately equal time intervals through the daylight hours, and the thirty measurements averaged to calculate the mean daily temperature.

2.4.9 TOTAL GAS PRESSURE

Total gas pressure (TGP) is the sum of partial pressures created by all dissolved gases in solution, predominantly oxygen and nitrogen. TGP can cause gas bubble disease in fish, which can result in chronic or acute toxicity. TGP can be increased by intrusion of air into water, heating of water, excessive biological productivity, and biochemical transformations in groundwater. Of particular relevance to the Nechako River system is intrusion of air at the Skin's Lake Spillway and at Cheslatta Falls.

The effect of total gas pressure on fish depends upon several factors:

1. Duration of exposure: Meekin and Turner[32] found that juvenile chinook salmon and steelhead could repeatedly tolerate 122% TGP for 16 hours provided they were returned to 100% TGP for eight-hour periods. This does not mean that short-term elevated TGP as would be associated with excess biological productivity is of minor concern, since exposure to excess total gas pressure levels (104-109+%) associated with Gas Bubble Trauma can result in mortalities of 1.5 to 5% over exposure periods of about 3 months[47].

2. Temperature: Jensen[33] reported significant mortalities (13% in 53 days) of alevins at temperatures of 12°C, but not at 8°C or 10°C, all at 110% TGP.

3. Water Hardness: Jensen[33] also reported that the significant mortalities at 12°C and TGP of 110% were at a hardness of 10 mg/L. At a hardness of 100 mg/L, but 12°C and TGP of 110%, no significant mortalities occurred.

4. Life Stage: Several researchers have found that tolerance to TGP is very high for eggs and adults, but very low in larval and juvenile stages[33,35,36,37]. Alderdice and Jensen accounted for the resistance in eggs being due to internal pressures in salmonid eggs[48].

5. Hydrostatic pressure: Greater water depths can reduce the risk of gas bubble disease[34]. A TGP of 110% is reduced to about 103% at 70 cm depth, and 100% at 1 m depth.

6. Oxygen-Nitrogen Ratios: If these ratios are varied, mortality does not necessarily correlate linearly with TGP. Rucker[38] found mortality at TGP of 119% was reduced significantly when the oxygen-nitrogen ratio increased from 159%/109% to 173%/105%.

Alderdice and Jensen[39], in reviewing gas supersaturation in the Nechako River, recommended that TGP should be less than 110% to guard against acute conditions, although as much as 5% mortality (cited as chronic) would occur between 105% and 110% TGP. Chronic conditions would occur in the range of 108% to 110%.

Envirocon[7] reported TGP from Cheslatta Falls to Fort Fraser for selected periods between October 1980 and August 1982 (flows from 32 m^3/s to 252 m^3/s). The average values in this reach were as follows:

	Total Gas Pressure (%)
Above Cheslatta Falls	107.8
D/S Cheslatta Falls	
2 km	109.2
8 km	107.5
12 km	107.8
22 km	101.2
≈Fort Fraser - 50 km	102.6

These data indicate that total gas pressure is already high above Cheslatta Falls, presumably from the Skin's Lake spillway. Values increase because of Cheslatta Falls. Values as high as 116% were measured at Cheslatta Falls in July 1982 at a flow of 170 m^3/s.

Since aquatic life needs low TGP, a provisional objective is proposed for the reach from the Kenney Dam to Fort Fraser. The objective is that the total gas pressure at any point should not exceed 109%. This value is normally met, however some higher values have been recorded. When values are close to 110%, chronic conditions possibly will exist.

2.5 MONITORING PROGRAMS

Provisional water quality objectives have been proposed for the river both just downstream from Cheslatta Falls and for the entire reach, from Cheslatta Falls to the Nautley River confluence. Monitoring of water temperatures associated with the Cheslatta Falls site should be undertaken at least once per year, between mid-July and mid-August, following periods of warmer weather and coincident with sampling outlined in Section 4.5. In addition, thermal sampling should also be undertaken at any time that temperatures measured just above the Stuart River confluence exceed 20°C.

It is recommended that monitoring to check the remaining proposed water quality objectives should be carried out upstream and 100 m downstream from the Fort Fraser sewage treatment facility at least once between mid-July and mid-August during summer low flows, and once during the winter low flow period, preferably in February or March. Samples at the Fort Fraser sites should be analyzed for pH, temperature, ammonia, nitrite, dissolved oxygen, fecal coliforms, and chlorine residual (calculated if chlorination occurs). Locations of aquatic plant growths (as well as approximate density) should be noted in summer. Other variables which might be considered for analysis include orthophosphorus and nitrate nitrogen.

Actual monitoring undertaken will be dependent upon budgets and Regional priorities.

2.6 CONCLUSIONS

There are three operations with waste discharges in this sub-basin, two of which are landfills which do not affect water quality. The third is the sewage treatment facility at Fort Fraser, which calculations show could increase fecal coliforms in the river. Calculated increases in the river of up to 200 MPN/100 mL could rise to 325 MPN/100 mL with implementation of the Kemano Completion Project at low river flows and maximum effluent loadings. In fact, large increases have been measured in the river downstream from the outfall. All other variables in the effluent were calculated, and/or were measured as not affecting water quality downstream from the outfall.

The effluent from the sewage treatment facility has had higher BOD_5 values in winter and higher suspended solids values in summer than at other times of the year. These results are typical of lagoon systems, with high suspended solids usually being due to algal growths in the ponds. A just-completed sewage treatment facility expansion should result in lower BOD_5 values during the winter. The Kemano Completion project as proposed in 1984, will not reduce available dilutions for the effluent to the point where BOD_5 and suspended solids effluent limits would have to be made more stringent. Modifications to the outfall would be required.

Designated water uses including irrigation, livestock watering, drinking water supply, primary-contact recreation and the protection and preservation of sensitive aquatic life and wildlife have been proposed for the Nechako River from the Kenney Dam to the Nautley River or sections thereof. Water quality objectives for pH, dissolved oxygen, un-ionized ammonia, fecal coliforms, chlorine residual, nitrite, chlorophyll a, total gas pressure, and temperature have been proposed to protect these designated uses.

The water quality of the Nechako River from Cheslatta Falls to the Nautley River confluence was good. This is reflected in generally low values for nutrients, suspended solids and metals, and high dissolved oxygen concentrations. Cooling water releases during the summer through the Skins Lake Spillway have resulted in bank erosion and increased turbidity in the Cheslatta/Murray Lake system and the Nechako River. This turbidity decreases both recreational and freshwater fishery values.

The Kemano Completion project as proposed by Alcan would reduce low flows in the Nechako River to 14.2 m^3/s. This potentially could result in a larger impact on the water quality of the Nechako River from effluents now being discharged.

3. STUART RIVER

The Stuart River is a major tributary (over 14 600 km^2) to the Nechako River, meeting the Nechako River about 30 km downstream from Vanderhoof, and 30 km upstream from Isle Pierre. Its headwaters are Pinchi and Tezzeron Lakes, which flow into Stuart Lake through Pinchi Creek and the Tachie River, repectively (Figure 3 and 3a).

3.1 HYDROLOGY

The Stuart River at low flow has historically equalled about 75% of the recorded 7-day low flow in the Nechako River at Vanderhoof (Table 5). The average annual 7-day low flow in the Stuart River near Fort St. James has been 40.1 m^3/s.

Stuart Lake has a mean water retention time of 1.75 years, while Pinchi Lake has an estimated retention time of about 15 years. Similar estimates could not be made for Tezzeron Lake, since no outflow data exist.

3.2 WATER USES

Along the Stuart River system, there are 9 withdrawals (near Fort St. James) for 246 m^3/d (0.003 m^3/s) for industry and 13.6 m^3/d (0.0002 m^3/s) domestic consumption. On Stuart Lake, two withdrawals are licensed for 11.4 m^3/d domestic use and 11.4 m^3/d industrial use.

The Stuart River is used by chinook salmon for spawning in the upper portion near Stuart Lake, with a mean escapement of 600 individuals per year from 1975 to 1979 (Range: 225-1000)[23]. This river is also an important freshwater fishery, containing rainbow trout, Dolly Varden and mountain whitefish. Pinchi Creek, which connects Pinchi Lake to Stuart Lake, had a mean escapement of 15 chinook and 600 sockeye salmon in the period 1975 to 1979[23].

Many varieties of fish were found in 1975 in bathymetric surveys (by the Ministry of Environment) of Pinchi, Tezzeron and Stuart Lakes. These varieties included mountain whitefish, pygmy whitefish, lake whitefish, coarse scale suckers, white suckers, longnose suckers, laketrout, rainbow trout, peamouth chub, kokanee, prickly sculpins and squawfish. Other species believed to be present are burbot and white sturgeon. All these would not necessarily be found in each lake.

Due to its water quality, topography and scenic wilderness values, the Stuart River is popular for canoeing.

3.3 WASTE DISHCARGES

Most operations discharging effluents in this sub-basin are located near Fort St. James on the Stuart River. Their locations are shown on Figure 3 by permit numbers issued pursuant to the Waste Management Act.

3.3.1 VILLAGE OF FORT ST. JAMES

The Village of Fort St. James operates a municipal sewage treatment facility which discharges to the Necoslie River, a short, low-flow river, about one km upstream from its confluence with the Stuart River. The facility consists of a 5-cell lagoon system, with two anaerobic cells, the third cell being mechanically aerated, the fourth cell providing retention and the fifth cell providing the potential to aerate the final effluent, if required. These were fully operational by May, 1985.

Permit PE 239 allows the maximum discharge of 3200 m^3/d, at maximum concentrations of 85 mg/L suspended solids and 75 mg/L BOD_5 until September 30, 1984. From October 1, 1984 until September 30, 1989 these limits are reduced to 60 mg/L and 45 mg/L respectively, for the period May 1 to July 31, and 40 mg/L and 30 mg/L respectively, for the period August 1 to April 30. A limit of 1000 MPN/100 mL is also imposed on fecal coliform concentrations at all times.

A data summary for this discharge is in Table 7. The data indicate that the permit limit for BOD_5 was generally not met, although the limit for suspended solids was. Chlorine residual data reported in Table 7 were collected prior to recent plant modifications (i.e., addition of dechlorination facilities). High fecal coliform values were measured in the effluent. The poor effluent quality was a prime reason for the extensive upgrading of the treatment works.

The sewage treatment facility is not expected to impact the Stuart River after complete mixing, since a minimum dilution of about 700:1 is available based upon the maximum permitted flow rate and the 10-year, 7-day average low flow in the Stuart River (Table 6). Some impact, however, may be evident near the mouth of the Necoslie River and for some distance downstream in the Stuart River, until complete mixing occurs.

The effect on the water quality of the Necoslie River is shown by data in Table 8. The data indicate that fecal coliforms, ammonia, BOD_5, total phosphorus and orthophosphorus values were usually increased measurably in the river. Should the effluent meet the new limit for fecal coliforms of 1000 MPN/100 mL, the major impact of the effluent in terms of downstream water users on the Stuart River should be eliminated.

Another concern related to the water quality in the Necoslie River is un-ionized ammonia. Values of total ammonia nitrogen in the river recorded in December 1983 and February 1984 were 18.1 mg/L and 11 mg/L, respectively (Table 8). Concurrent pH and temperature data were not available for these two dates, but if a pH value of 8.0 and temperature value of 5°C were assumed, then the criterion for the maximum concentration of ammonia nitrogen to protect aquatic life would be 6.14 mg/L[14] (see Table 31). However, aquatic life criteria should not apply to the Necoslie River since the river is not utilized by salmon, and biologists at the regional office of the B.C. Fish and Wildlife Branch feel that the river has a very limited freshwater fishery.

The chlorination of the effluent and the aeration in the polishing cell should reduce ammonia levels in the effluent, and therefore in the Necoslie River.

3.3.2 BRITISH COLUMBIA BUILDINGS CORPORATION (BCBC)

BCBC is responsible for the Fort St. James Forest Service ranger station, which consists of two offices and a bunkhouse beside Stuart Lake. Sewage from the station is treated in a secondary-type extended aeration plant followed by effluent chlorination. The effluent is discharged into the lake 92 m from the shoreline into a minimum of 3 m of water (in mid-summer).

Permit PE 2246 restricts the discharge to a maximum 7.3 m^3/d, with maximum concentrations of 60 mg/L suspended solids and 45 mg/L BOD_5. A chlorine residual of 0.5 to 1.0 mg/L is to be maintained, and a chlorine contact time of 1 hour is to be provided at average flow.

The data in Table 9 indicate that permit values were met about 50 percent of the time, and that some higher BOD_5 and suspended solids have occurred. Higher values since 1975 were recorded at times when effluent flows were not measured.

However, higher values in 1975 were recorded with coincident flows greater than the maximum permitted, and therefore greater than design flows for the plant. This would imply that settled solids in the extended aeration plant were being washed out as a result of high flows. These higher results were generally recorded prior to 1980. Since that time, values for BOD_5 and suspended solids higher than permitted were recorded about once yearly, and recorded flows were always less than permitted. This shows that the plant can produce a high quality effluent, when properly operated.

It is expected that the small volume of effluent discharged into the lake should not affect the lake outside the initial dilution zone with complete mixing, assuming the effluent meets permit conditions. Conditions in the lake outside the initial dilution zone should be checked when the effluent is not meeting the permit conditions.

3.3.3 THOMAS B. GOODSON

This 30-unit trailer park is located on the east shore of the Stuart River, south from the confluence of the Necoslie River. Sewage from the trailer park is treated in two stabilization ponds in series prior to chlorination and dechlorination. Dechlorination of the effluent was instituted in 1984.

Permit PE 364 allows the discharge of 34 m^3/d to the Stuart River with maximum concentrations of 100 mg/L BOD_5 and 100 mg/L suspended solids. The discharge would not affect the water quality of the Stuart River since it would be diluted by a factor of over 62 000:1, assuming complete mixing of the maximum permitted discharge rate and the 10-year, 7-day average low flow in the Stuart River.

The data in Table 10 indicate that suspended solids values greater than permitted were recorded about 50 percent of the time. These high values were generally recorded between July and November, and were likely the result of algal growths in the lagoon. There were no apparent trends to the higher than permitted BOD_5 values.

Data were collected on one date in 1976 upstream and downstream from the discharge. The data in Table 11 indicate that fecal coliform values measured at the downstream edge of the initial dilution zone were increased from 23 to 110 MPN/100 mL. This should not be a concern in the future if a proposed effluent limit of 1000 MPN/100 mL is finalized and subsequently met.

3.3.4 ROY WILLICK LOGGING LTD.

This company operates a 33-unit trailer park on the west side of the Stuart River, just south from Fort St. James. Domestic sewage from the trailer park is treated in a waste stabilization pond with a surface area of 4000 m^2. Permit PE 2572 allows the discharge of 40 m^3/d to the Stuart River at maximum concentrations of 100 mg/L BOD_5 and suspended solids. The effluent would be diluted by a factor of over 50 000:1, assuming complete mixing of the effluent and the river water (the maximum permitted discharge rate and the 10-year 7-day low flow in the Stuart River).

An effluent data summary is in Table 12. It indicates that BOD_5 and suspended solids limits were met over 50 percent of time (about 75 percent), while flows were always less than permitted. All suspended solids values above the permit level were recorded prior to 1979. The highest BOD_5 levels were generally associated with cold weather months (November to April), when biological activity would be reduced in the stabilization pond.

The maximum fecal coliform values in the effluent would increase values in the river by only about 11 MPN/100 mL assuming a minimum dilution of 50 000:1 and complete mixing. This is not considered to be a concern since there are no downstream water users.

Thus this effluent will not affect the Stuart River. This is verified by data collected upstream and downstream from the discharge (Table 13) in 1976.

3.3.5 REGIONAL DISTRICT OF BULKLEY NECHAKO (FORT ST. JAMES)

The Regional District of Bulkley Nechako operates a municipal refuse site located about 2 km south from Fort St. James. Permit PR 4081 allows the discharge of 30.5 m^3/d of domestic refuse, and requires that cover be applied once every seven days. The site is located about one kilometre from the Necoslie River.

Data have been collected on several occasions in the Necoslie River near the refuse site and in a swamp near the site on a tributary to the river. These data are in Table 14. The data indicate that manganese and ammonia may be entering the river, but that the effect on the river is minor downstream from the refuse site.

3.3.6 NECHAKO SCHOOL DISTRICT

The Nechako School District has a permit (PE 6240) for the discharge of domestic sewage. The sewage from a 12-room school is treated in a septic tank and disposed of in two tile fields with 660 m of tile each, located within one kilometre from the Stuart River. The permit allows the discharge of 22.5 m^3/d. Due to the small quantity of effluent discharged to the soil and its distance to the river, this discharge should not affect the water quality of the Stuart River.

3.3.7 DIFFUSE SOURCES

The effects of forestry and residential developments have not been examined in this assessment. However, each would have some impact on water quality.

The locations of cattle in the Stuart River watershed are shown on Figure 3. The number of cattle was estimated from statistics of the Beef Assurance Program of the B.C. Ministry of Agriculture. The estimates for nutrient coefficients proposed by Bangay(31) were used to calculate potential nutrient contributions from cattle. The majority of cattle were in the Necoslie River drainage. The few cattle immediately adjacent to the Stuart River should not have a considerable impact on water quality.

3.4 AMBIENT WATER QUALITY AND PROVISIONAL WATER QUALITY OBJECTIVES

Licensed water uses on the Stuart River are for domestic use and for industry. The river is also an important migratory route for salmon and recognized for its resident trout and char populations. These uses, secondary-contact recreation and protection of wildlife, therefore should be designated for protection. Uses which may need to be protected for the future are irrigation and livestock watering.

Several waterbodies upstream from Stuart Lake have been sampled, specifically Tezzeron and Pinchi Lakes and their tributaries. Both of these lakes drain to Stuart Lake. These are discussed below.

3.4.1 TEZZERON LAKE AND ITS TRIBUTARIES

Data for Tezzeron Lake are summarized in Table 16, while those for its tributaries are in Table 15. Sites are shown on Figure 3a. In Tezzeron Lake, Sites 0400605, 0400606 and 0400607 are located near the southeast end of the lake, with Site 0400605 being near the inlet from Tezzeron Creek. Site 0400608 is located near mid-lake, opposite the inlet from Hatdudatehl Creek, Site 0400609 is in a bay across the lake, while Site 0400610 is located near the lake outlet to the Tachie River. Site 0400612 is on Tezzeron Creek, and Site 0400613 is on Hatdudatehl Creek, both near their confluence with the lake. Site 0400611 is on the Kuzkwa River near the lake outlet.

Generally, only about three data points were available for each characteristic on the tributaries, compared to about ten for the lake.

There are no licensed water withdrawals for Tezzeron Lake or any of its tributaries. Therefore, the recommended designated water uses will be for the protection and preservation of aquatic life and wildlife in Tezzeron Lake, Tezzeron Creek and Hatdudatehl Creek.

3.4.1.1 pH and Alkalinity

The pH of Tezzeron Lake is between 7.4 and 8.3 (Table 16). Values in the tributaries to the lake were generally within this range, although some values as low as 7.0 have been recorded at Site 0400613 on Hatdudatehl Creek and Site 0400614 on an unnamed creek (Table 15).

Recorded alkalinity values were generally as high as would be expected for pH values in this range. Values in the lake were between about 40 to 60 mg/L (Table 16). Values in the tributaries were as high as 160 mg/L.

The pH and alkalinity of Tezzeron Lake and its tributaries were suitable for all water uses.

3.4.1.2 Hardness and Metals

Values for hardness recorded in the south end of Tezzeron Lake at Sites 0400605, 0400606, and 0400607 were considerably lower than at other sites in the lake. The maximum value at these sites was only about 56 mg/L, compared to a maximum value of 233 mg/L at site 0400610. Hardness values in tributary creeks ranged from about 50 mg/L to 210 mg/L (Table 15), which help to explain the range of values in the lake.

Total metal values in Tezzeron Lake were generally low and below common working water quality criteria listed in Table 4. Exceptions to this were maximum recorded concentrations for: cadmium at Site 0400609 which was 0.0028 mg/L and exceeded the criterion of 0.0002 mg/L[10]; copper and iron (maximum values of 0.009 mg/L and 2.4 mg/L) at all six sites, which met or exceeded the criteria of 0.002 mg/L and 0.3 mg/L, respectively[10]; and lead (maximum 0.007 mg/L) at Sites 0400606, 0400607, 0400609, and 0400610 which equalled or exceeded the criterion of 0.005 mg/L at a hardness <95 mg/L[10]. All working water quality criteria cited are for the preservation and protection of sensitive aquatic life. These higher values are not suspected of being from anthropogenic sources, therefore they likely are naturally occurring.

Metal values in the tributaries to Tezzeron Lake were generally low and below water quality criteria for the protection of sensitive aquatic life (Table 15). Exceptions to this were maximum recorded values for copper, iron and lead at Sites 0400611 (Kuzkwa River), 0400612 (Tezzeron Creek), 0400613 (Hatdudatehl Creek) and 0400614 (Unnamed Creek). However, these maximum total metal values occurred when high values of suspended solids were present in the creeks. This indicates that the metals likely were not dissolved, but were associated with suspended matter and not directly available to aquatic life.

A number of fish were collected in 1970 from Tezzeron Lake and fish muscle analyses for mercury were reported as follows by Peterson *et al*.[26]:

		Mercury Concentration ppm (wet weight) in Muscle Tissue		
Species	Number	Range	Mean	Standard Deviation
Rainbow Trout (1)	6	0.05	0.05	0
Rainbow Trout (2)	6	unknown	0.04	unknown
Lake Trout (1)	3	0.30-0.40	0.33	0.06
Lake Trout (2)	6	unknown	0.27	unknown
Mnt. Whitefish	1	0.17	-	-
Peamouth chub	1	0.18	-	-
White Sucker	1	0.27	-	-
Northern Squawfish	1	0.64	-	-

(1) Analyzed by Cominco Ltd., Trail

(2) Analyzed by Freshwater Institute, Winnipeg

These data indicate that all species except the northern squawfish had mercury levels within the Canadian Food and Drug Directorate guideline level of 0.5 ppm wet weight for human consumption.

3.4.1.3 Nutrients

Nutrient samples were collected at two depths in Tezzeron Lake in June, July, August, and October of 1976. Adequate data were not available to determine if the lake was completely mixed on any of the samplings. The mean depth of the lake is 12 m and the maximum depth is 42 m. Orthophosphorus and total dissolved phosphorus values generally were below 0.010 mg/L and total phosphorus values averaged around 0.015 mg/L. This indicates that the lake is likely mesotrophic. Chlorophyll-a measurements would be required to determine algal productivity and assist in verifying the lake trophic status.

Nitrogen values in the lake were all low except at Site 0400610. Ammonia nitrogen values were all less than 0.025 mg/L at most sites. At the maximum recorded temperature (19°C) and pH (8.3), the maximum criterion for total nitrogen is 2.91 mg/L (Table 31) and the average criterion is 0.424 mg/L (Table 32) for continuous exposure of salmonids. Nitrate/Nitrite values were all less than 0.02 mg/L, and organic nitrogen values less than about 0.45 mg/L. These values are believed to be typical of background nitrogen levels in lakes in this area.

The higher recorded phosphorus and nitrogen values at Site 0400610 are believed to be associated with its close proximity to a creek entering Tezzeron Lake from the north (Figure 3a).

Many phosphorus and nitrogen values recorded for tributaries to Tezzeron Lake were similar to those cited for the lake. However, some maximum values were considerably higher and were associated with an occurrence of higher suspended and dissolved solids concentrations in the creeks

(Table 15). The highest ammonia value of 0.255 mg/L was at site 0400611, on the Kuzkwa River near the outlet from Tezzeron Lake. The concurrent pH was 7.5. This is less than the B.C. water quality criteria for the protection of sensitive aquatic life in Table 31. The maximum nitrate/nitrite (0.09 mg/L) and organic nitrogen (1.79 mg/L) values were recorded at Site 0400613 at Hatdudatehl Creek as it entered the lake.

The maximum phosphorus values were recorded at Site 0400614, on an unnamed creek as it entered Tezzeron Lake, with 0.006 mg/L orthophosphorus, 0.013 mg/L total dissolved phosphorus, and 0.418 mg/L total phosphorus. This indicates that a considerable amount of phosphorus could be entering Tezzeron lake naturally.

3.4.1.4 Dissolved Oxygen

Dissolved oxygen values in the lake were high, with all values exceeding 7.2 mg/L. The lowest percent saturation value in the lake (66%) was recorded at Site 0400606, in the centre of the south bay of the lake. It is expected that this value may be an artifact of sampling (i.e., an imprecise temperature measurement).

3.4.1.5 Solids

Suspended solids values in Tezzeron Lake (Table 16) were generally low. The maximum value was 31 mg/L, recorded at Site 0400609. Values less than about 25 mg/L are thought to provide a high level of protection to aquatic life(13). Limited data on suspended solids values in tributaries to Tezzeron Lake indicated that aquatic life would be ensured at least a moderate level of protection, since all values were generally less than 80 mg/L(13). The maximum value was 85 mg/L in Hatdudatahl Creek (Site 0400613).

Dissolved solids values in Tezzeron Lake changed dramatically from the southeast to the northwest basins. Values at Sites 0400605, 0400606 and 0400607 were in the order of 85 mg/L. Maximum values were about 450 mg/L at Site 0400608 and 340 mg/L at Site 0400609. The reason for this marked change in dissolved solids values throughout the lake is not known, although it follows a similar pattern to hardness and therefore may be due to tributaries.

3.4.2 PINCHI LAKE AND ITS TRIBUTARIES

Pinchi Lake is located along the Pinchi Lake Fault Zone, a geological feature that extends for a distance of about 250 km northwest from Fort St. James[25]. The area contains numerous mercury-bearing ore deposits (cinnabar)[25].

The only licensed water withdrawal for Pinchi Lake is for 2 360 m^3/d for mining. Designated water uses will therefore be industrial use, the protection of wildlife and aquatic life in Pinchi Lake with the proviso that fish should not be consumed. Designated water uses in Pinchi Creek, Tsilcoh Creek, and Ocock River will be the protection of aquatic life and wildlife.

3.4.2.1 pH and Alkalinity

The pH of Pinchi Lake was in the range from 7.3 to 8.3 (Table 18). This range of values was also representative of pH values in creeks tributary to the lake.

The buffering capacity of Pinchi Lake to acidic inputs was good, with alkalinity values from about 75 to 82 mg/L (Table 18). Wider ranges of alkalinity values were present in the tributaries to the lake. Values ranged from 48 to 117 mg/L in Tsilcoh Creek (Site 0400623) as it entered the lake, and from about 74 to 142 mg/L in Ocock Creek (Site 0400626) as it entered Pinchi Lake (Table 17).

The pH and alkalinity of Pinchi Lake and its tributaries were suitable for all water uses.

3.4.2.2 Hardness and Metals

A mercury mine operated at Pinchi Lake from 1940 to 1944[25]. It dumped untreated tailings into the lake[25]. Cominco Ltd. re-opened the mine in August 1968[25], but it closed in the mid 1970's. The latter facility used a tailings pond.

Reid and Morley[25] reported on mercury analyses of 40 fish muscle samples collected from Pinchi Lake in August 1974. Peterson _et al_. had collected fish in 1970[26]. The following are the data reported by Reid and Morley:

Species	Number	Mercury Concentration ppm (wet weight) Range	Mean	Standard Deviation
Rainbow Trout	10	0.15-0.73	0.40	0.17
Lake Trout	11	0.36-8.31	5.23	3.39
Kokanee	6	0.32-0.76	0.49	0.18
Largescale Sucker	3	2.03-3.27	2.59	0.64
Peamouth Chub	3	1.68-2.25	1.90	0.31
Mountain Whitefish	2	0.49-0.83	0.66	0.24
Lake Whitefish	3	0.28-7.41	2.47	4.07
Livers (lake trout)	2	15-29	22	9.90

These values are similar to those reported by Peterson _et al_. for fish collected in 1970. However, Peterson _et al_. had collected and analyzed considerably more mountain whitefish. The following data are from Peterson _et al_.[26]:

Species	Number	Mercury Concentration ppm (wet weight) Range	Mean	Standard Deviation
Mountain Whitefish(2)	10	<0.5-1.1	0.67	0.25
(3)	6	Unknown	0.13	unknown
(1)	8	Unknown	0.73	unknown
Peamouth Chub(1)& (2)	5	0.41-1.2	0.77	0.31

(1) Analyzed by Freshwater Institute, Winnipeg

(2) Analyzed by Cominco Ltd., Trail

(3) Analyzed by B.C. Dept. of Agriculture, Vancouver

These data indicate that the fish in Pinchi Lake have considerable mercury contamination, exceeding the Canadian Food and Drug Directorate guideline of 0.5 ppm (wet weight) for human consumption. The lake is posted to warn the public not to consume the fish. Large fish concentrate contaminants more than small fish, particularly large trout (char). A sampling program is being undertaken in 1986 to determine any changes since 1970.

The Waste Management Branch, Northern Region, has summarized water and sediment data for Pinchi Lake and some other lakes in the Pinchi-Fault area[45]. Water chemistry data in Table 18 show that mercury levels in the water column usually were below the detection limit of 0.00005 mg/L. Exceptions to this were data for samples collected at Sites 0400619 and 0400620 in 1976-77, with maximum values of 0.0033 and 0.00007 mg/L, respectively. The former value is of most concern, and was associated with a sampling site near the mine (and possibly the tailings disposal site). These data indicate that it is possible that the tailings were still contributing mercury to the water column. These data were from water samples collected near the lake bottom. Disturbance of bottom sediments may have caused particulate matter to be incorporated into the sample, causing the high results. This speculation is supported by the observation that all other values at these and other lake sites are at or below the detection limit. This result, therefore, appears to be anomalous. Recent sampling of water draining out of the tailings pond has not revealed increased mercury content.

Mercury data collected on tributaries to Pinchi Lake (Table 17) were all ≦0.00005 mg/L. This shows that mercury present in the lake is likely not from any source other than the old mining operation. This conclusion is supported by sediment sampling data as well. Pinchi lake cores, especially those near the old mine, contain mercury levels 2-3 orders of magnitude greater than surrounding lakes. The mercury is also noted to be in the top several centimetres of each core.

Hardness values can influence the toxicity to aquatic life of some metals which can be in the water. Most hardness values in Table 18 exceeded about 70 mg/L. Using this value, the following criteria based upon EPA equations in Table 4 can be calculated for copper and lead:

Copper: maximum. 0.013 mg/L
average: 0.009 mg/L
Lead : maximum: 0.052 mg/L
: average: 0.002 mg/L

Values determined from equations put forth by the U.S. E.P.A.[27,29], are more realistic than the maximums put forth by Environment Canada of 0.002 mg/L copper and 0.005 mg/L lead[10].

The maximum total copper value was 0.006 mg/L, and was recorded at Sites 0400622 at the northwest corner of the lake and Site 0400643 nearer the mine. These maximum values exceed the Environment Canada criterion for copper of 0.002 mg/L[10], but meet the EPA maximum and average for waters of 70 mg/L hardness, of 0.009 mg/L[29]. The sites where these samples were collected were widely separated. Therefore, some concern may exist for copper levels in the lake. Maximum values of 0.006 mg/L were also reported for tributaries at Sites 0400623 and 0400625 (Table 17). These higher values were not correlated with high suspended solids. Thus, the copper is likely entering the lake from natural sources within the watershed.

Maximum recorded total lead values in Pinchi Lake exceeded both the Environment Canada and EPA average criteria of 0.005 and 0.002 mg/L, respectively. All other values met the 0.005 mg/L criterion. However, all values met the 0.052 mg/L EPA maximum. These high maximum lead levels were reported for Sites 0400622 and 0400615, with values of 0.026 and 0.023 mg/L, respectively. The maximum recorded lead value in a tributary to Pinchi Lake was 0.006 mg/L, recorded at Site 0400625. This value was not correlated with high suspended solids values.

Other metal values in the lake generally met the working water quality criteria (Table 4). An exception to this was the maximum iron value recorded at six of the eight sites in Pinchi Lake. However, mean and median values met the water quality criterion of 0.3 mg/L for the protection of aquatic life. The high iron values in Pinchi Lake likely originate in the watershed to the lake, since all iron and manganese values recorded (Table 17) in Tsilcoh, Hyman and Ocock Creeks exceeded the water quality criteria of 0.3 and 0.05 mg/L, respectively.

3.4.2.3 Nutrients

Nitrogen values were generally fairly consistent throughout Pinchi Lake, with nitrate/nitrite nitrogen values ≤0.1 mg/L, organic nitrogen values less than about 0.5 mg/L, and ammonia nitrogen values less than 0.04 mg/L (Table 18). Exceptions to this were maximum organic nitrogen and ammonia values of 0.91 and 0.048 mg/L, respectively, at Site 0400615; maximum nitrate/nitrite and ammonia nitrogen values of 0.16 and 0.121 mg/L, respectively, at Site 0400616; and the maximum organic nitrogen value of 0.62 mg/L at Site 0400620 (Table 18). Tsilcoh and Ocock Creeks at the lake generally had values which met the aforementioned consistently low values, although maximum recorded organic nitrogen values in both creeks were 0.6 mg/L (Table 17).

Phosphorus values in the lake generally were below 0.02 mg/L for the total dissolved and 0.04 mg/L for total phosphorus. The maximum total phosphorus values at Sites 0400615 (0.176 mg/L), 0400620 (0.064 mg/L) and 0400617 (0.3 mg/L) exceeded the 0.04 mg/L value. Generally, lakes with total phosphorus values greater than about 0.02 mg/L at spring overturn can be considered to be eutrophic. However, no firm conclusions can be drawn since spring overturn values were not available, maximum total phosphorus values at some stations were at or near the 0.02 mg/L value, and chlorophyll-a measurements giving the algal mass present were not made.

Limited data on the two tributaries to Pinchi Lake (Table 17) show that the maximum total dissolved and total phosphorus values entering the lake also exceeded 0.02 and 0.04 mg/L, respectively.

3.4.2.4 Dissolved Oxygen

Limited data on dissolved oxygen values at the various sites in the lake showed that values were generally greater than 7.0 mg/L, depending upon the location in the lake.

The one dissolved oxygen value collected in a tributary to Pinchi Lake, in Ocock Creek (Table 17), was 8.7 mg/L.

3.4.2.5 Solids

Suspended solids values at most sites in Pinchi Lake were all less than 25 mg/L, the value cited as providing a high level of protection to aquatic life[13]. Exceptions were the maximum recorded values of 54 mg/L and 34 mg/L at Sites 0400615 and 0400620, respectively. These maximum values are less than the value of 80 mg/L, cited as providing a moderate level of protection to aquatic life[13]. Suspended solids values in Ocock and Tsilcoh Creek were all less than the 25 mg/L level, providing a high level of protection to aquatic life.

Dissolved solids values were generally about 120 mg/L throughout the lake, except at Sites 0400615 and 0400616. At the former site, dissolved solids were as high as 250 mg/L. Since this site is located between Tsilcoh and Ocock Creeks (Figure 3a), these higher values in Pinchi Lake could reflect dissolved solids entering the lake through the tributaries. In fact, values as high as 160 mg/L and 200 mg/L were recorded for these creeks at Sites 0400623 and 0400626, respectively.

3.4.3 STUART LAKE

No extensive data exist for the water quality of Stuart Lake. Therefore, an assessment of the water quality of the lake cannot be made. However, an examination of data collected on some tributaries to the lake can show if there may be some potential concerns within the Lake.

Licensed water withdrawals from Stuart Lake are for drinking water. The area also supports an important salmon run. The designated water uses for Stuart lake include its use as a drinking water supply (with only disinfection), primary-contact recreation, irrigation, livestock watering, and the protection of sensitive aquatic life and wildlife.

Peterson *et al.*[26] reported the following values in fish collected from Stuart Lake in 1970:

Mercury (ppm wet weight) in Fish Muscle

Species	No. of Values	Average Value
Rainbow trout	10	0.21
Northern Squawfish	1	0.20
Mountain Whitefish	1	0.17
Dolly Varden Char	1	0.35
Peamouth Chub	1	0.39
Longnose Sucker	1	0.26

These data show that the fish in Stuart Lake had considerably less mercury than those from Pinchi lake (Section 3.4.2.2), and met the criterion for consumption by humans of 0.5 ppm.

3.4.4 TRIBUTARIES TO STUART LAKE

Data are available for two streams feeding Stuart Lake: the Kuzkwa River (Site 0400611) near the outlet from Tezzeron Lake (Table 15); and Pinchi Creek at Sites 0400621 near the outlet from Pinchi Lake (Table 17) and at Site 0400628 near Stuart Lake (Table 19). The Kuzkwa River drains Tezzeron Lake into the Tachie River, which in turn flows from Trembleur Lake further north into Stuart Lake. For the two Pinchi Creek sampling locations, about twice the number of metal samples were collected near the outlet from Pinchi Lake as near Stuart Lake. The data from both these sites will only be discussed separately when a considerable difference occurs.

There are no licensed water withdrawals from the Kuzkwa or Tachie Rivers. Therefore the designated water uses are for the protection of sensitive aquatic life and wildlife.

3.4.4.1 pH and Alkalinity

The pH of the Kuzkwa River ranged from 7.5 to 7.9 (Table 15), while Pinchi Creek had a range from 7.8 to 8.2 (Tables 17 and 19). This difference in pH ranges was also reflected in the buffering capacity present.

Alkalinity values were slightly greater than 50 mg/L in the Kuzkwa River (Table 15), but between 75 and 80 mg/L in Pinchi Creek (Tables 17 and 19). Both these tributaries to Stuart Lake have good buffering capacities to acid, which will likely be reflected in Stuart Lake.

3.4.4.2 Hardness and Metals

Hardness values indicated that the Kuzkwa River was softer than Pinchi Creek, although both could be considered as being moderately soft. Minimum values of hardness, which are important in determining the safe levels of metals which aquatic life can tolerate, were about 50 mg/L in the Kuzkwa River (Table 15) and 70 mg/L in Pinchi Creek (Table 19).

The equations shown in Table 4 for criteria (EPA) for copper and lead yielded the following values for the Kuzkwa River and Pinchi Creek respectively: 0.008 mg/L and 0.011 mg/L for maximum copper; 0.006 mg/L and 0.008 mg/L for average copper; 0.025 mg/L and 0.040 mg/L for maximum lead; and 0.001 mg/L and 0.002 mg/L for average lead. Table 4 also shows Environment Canada maximum criteria of 0.002 mg/L for copper and 0.005 mg/L for lead.

In the Kuzkwa River (Table 15), maximum recorded values for iron (7.3 mg/L) and lead (0.099 mg/L) did not meet water quality criteria. The maximum copper value of 0.003 mg/L met the EPA criteria, but not that of Environment Canada (0.002 mg/L). All other data from the limited data base (n=3) for all the metals met the criteria.

In Pinchi Creek, maximum recorded values for lead (0.008 mg/L) at Site 0400621 (Table 17) exceeded both the EPA average (0.002 mg/L) and Environment Canada (0.005 mg/L) criteria, but not the EPA maximum of 0.040 mg/L. The maximum copper value of 0.004 mg/L at both sites (Tables 17 and 19) exceeded the Environment Canada criterion of 0.002 mg/L. The maximum recorded mercury value of 0.0004 mg/L at Site 0400628 (Table 19) exceeded the working water quality criteria of 0.0001 mg/L[10]. The mean values for lead, copper and mercury all met both EPA and Environment Canada criteria. These values are believed to be naturally occurring.

3.4.4.3 Nutrients

Only three samples were collected for nutrients in Kuzkwa Creek in comparison to about 8 on Pinchi Creek. Data for Sites 0400611 and 0400621, both approximately equidistant from the lakes they drain, had similar nitrogen values (except for the maximum ammonia in Kuzkwa River). Values at Site 0400628 near the Stuart River were slightly reduced (except for the maximum ammonia value) from those reported for Site 0400621.

Phosphorus values at both Pinchi Creek sites were similar (Tables 17 and 19). A higher maximum total phosphorus value was found in the Kuzkwa River (0.176 mg/L compared to 0.026 mg/L in Pinchi Creek).

3.4.4.4 Dissolved Oxygen

Dissolved oxygen measurements were not made on Pinchi Creek. The one value of 10.7 mg/L for the Kuzkwa River is high. It is expected that Pinchi Creek would reflect a good oxygen regime.

3.4.4.5 Solids

Suspended solids values in Pinchi Creek were all less than 10 mg/L (Tables 17 and 19), while one value in the Kuzkwa River reached 50 mg/L (Table 15). The former values would provide a high level of protection to aquatic life (<25 mg/L)[13] while the latter would provide a high to moderate (25-80 mg/L) level of protection[13].

Dissolved solids values in Pinchi Creek were fairly consistent, at about 110 mg/L. The two values for the Kuzkwa River were more variable, between about 90 and 260 mg/L. These values would be suitable for all water uses, with the exception of some industrial processes.

3.4.5 THE STUART AND NECOSLIE RIVERS

The Necoslie River joins the Stuart River at Fort St. James, just after receiving effluent from the Fort St. James STP. Provisional water quality objectives which will be proposed will apply to the Necoslie River, downstream from the Fort St. James STP, to its mouth. They will be based on the water use of the Stuart River, and its dilution capabilities. Data for the Necoslie River are in Table 20, while those for the Stuart River are in Table 21.

One water withdrawal is licensed for the Necoslie River, for 197 360 m^3 for irrigation. The withdrawal is located upstream from the Fort St. James STP. The designated water uses for the Necoslie River are for irrigation, livestock watering, and for water-contact recreation during the summer. Aquatic life will not be a designated use for the Necoslie River below the sewage treatment plant outfall. The Necoslie River is not used by salmon, and the B.C. Fish and Wildlife Branch feels that the river has a very limited freshwater fishery. Aquatic life criteria therefore will not apply to this section of the river, although the ensuing discussion of the Necoslie River will relate impacts to aquatic life from the sewage discharge. Designated uses of aquatic life, wildlife, drinking water, irrigation, livestock watering and water contact recreation will apply to the Stuart River.

3.4.5.1 pH and Alkalinity

The pH of the Necoslie River ranged from 7.5 to 8.1, and that of the Stuart River from 7.1 to 8.3. All values were within the range of water quality criteria (6.5-9.0) for the protection of aquatic life[12] and for drinking water (6.5-8.5)[11]. These near neutral pH values should be maintained to minimize the formation of un-ionized ammonia near the Fort St. James STP. A provisional water quality objective is therefore proposed for pH. The objective, applicable to discrete samples collected from outside the initial dilution zones of effluents, described in Section 2.4.1, is that the pH in any discrete sample should not be outside the range 6.5 to 8.5. By restricting the upper limit of pH to 8.5, the percentage of un-ionized ammonia in aqueous solution will be about one-third that which would be available at pH 9[22].

This objective will apply to the Stuart River, from the confluence of the Necoslie River to its confluence with the Nechako River.

Only one alkalinity value was collected on the Necoslie River (124 mg/L). Values for the Stuart River were considerably lower, from about 32 to 88 mg/L (Table 21). These latter values reflect the alkalinity of Stuart Lake.

3.4.5.2 Hardness and Metals

Limited data on hardness were available for the Necoslie River (n=3), although a good data base existed for the Stuart River. Hardness values ranged from about 40 mg/L in both rivers, to about 125 mg/L in the Necoslie River (Table 20) and to about 95 mg/L in the Stuart River. These data indicate that, generally, these waters would be considered as soft. For the Stuart River, most values were less than 50 mg/L (90th percentile value of 53 mg/L).

Assuming a hardness value of 40 mg/L and using the equations in Table 4, the following criteria (EPA) can be calculated for copper and lead:

Copper: maximum: 0.007 mg/L
: average: 0.005 mg/L
Lead : maximum: 0.026 mg/L
: average: 0.001

Table 4 also shows maximums of 0.002 mg/L for copper and 0.005 mg/L for lead, put forth by Environment Canada. All these values are meant to protect aquatic life, yet they are considerably different.

Copper values in the Necoslie River did not meet the Environment Canada criterion of 0.002 mg/L, and only the lowest recorded values met the EPA criteria for copper. In the Stuart River, some lower values met the EPA criteria and the more stringent Environment Canada criterion, as well. These high copper values likely originate from natural sources, since no anthropogenic activity is taking place to elevate these values.

Lead values in the Necoslie River did not always meet the EPA criterion for the maximum permissible concentration of 0.026 mg/L, nor the criterion of 0.005 mg/L put forth by Environment Canada. Values in the Stuart River were considerably lower, meeting both the EPA maximum and Environment Canada criteria. The lead values in the Necoslie River are thought to be naturally occurring.

Several values for other metals in the Necoslie River exceeded water quality criteria (Table 4), including all recorded values for aluminum, iron and manganese, and maximum recorded values for chromium and zinc. Given the turbid nature of the Necoslie River, and the fact that these high values were for total metals, a good portion of the metal likely was sorbed to particulate matter and was not biologically available. In the Stuart River, only the maximum recorded values for iron and manganese (Table 21) exceeded the criteria (Table 4).

These data tend to show that a part of the Stuart Lake area is highly mineralized, with considerable natural quantities of metals being present in some watersheds in this area.

3.4.5.3 Nutrients

In Section 3.3.1, it was indicated that phosphorus and nitrogen compounds could be increased in the Necoslie River due to the discharge from the Fort St. James STP. Such increases are apparent in the Necoslie River (Table 20) for all values recorded between Sites 0400800 and 0400801. It is expected that this discharge, due to its close proximity, may have a minor influence on values measured in the Stuart River. No negative impact is projected and the nutrients could have a beneficial stimulating effect on river productivity.

In order to protect migrating salmon and the freshwater fishery in the Stuart River system, a provisional water quality objective is proposed for total ammonia. The objective, which will apply to the Stuart River, exclusive of initial dilution zones of effluents described in Section 2.4.1, will be that the average concentration of total ammonia should not exceed the values outlined in Table 32, while the maximum should not exceed the values listed in Table 31. The average value is to be calculated from at least five weekly samples collected in a 30-day period.

Nitrite nitrogen potentially can be a problem below sewage outfalls at times when ammonia is oxidized to nitrite, but where the newly formed nitrite cannot be oxidized to nitrate. Nitrite nitrogen can be acutely toxic to aquatic life, therefore a provisional water quality objective is proposed for nitrite nitrogen to protect aquatic life. The objective, applicable to the Stuart River from Stuart Lake to the Nechako River except in initial dilution zones of effluents described in Section 2.4.1, is that the average nitrite nitrogen value should be ≦0.02 mg/L and the maximum nitrite nitrogen value should be 0.06 mg/L. The average is to be calculated from at least five weekly samples collected in a 30-day period.

Periphyton chlorophyll-a values have not been measured in the Stuart River. However, the Ministry of Environment has recommended a level of 50 mg/m^2 to protect recreational use of rivers[30]. To ensure that periphyton growth does not become a problem, a provisional objective of ≦50 mg/m^2 is proposed for the Stuart River, except in initial dilution zones of effluents, described in Section 2.4.1. The objective is the average of at least five values from natural substrate collected on any sampling occasion.

3.4.5.4 Dissolved Oxygen

Dissolved oxygen values were recorded for samples from the Necoslie River and showed minor depressions below the sewage outfall. It is suspected that low dissolved oxygen values might exist under ice cover when reaeration is not possible. As well, impacts on dissolved oxygen might be seen further downstream in the Stuart River, although this is not likely given the 700:1 minimum dilution.

In the Stuart River, only three samples were collected. All values were high (10-12 mg/L), exceeding the criterion of 7.75 mg/L to provide a high level of protection to salmonids[16]. To protect migrating fish and the freshwater fishery in the Stuart River, a provisional water quality objective is proposed for dissolved oxygen. The objective is that the minimum dissolved oxygen value, between Stuart Lake and its confluence with the Nechako River, should not be less than 7.75 mg/L. To protect spawning areas of the Stuart River, a minimum of 11.2 mg/L dissolved oxygen should be present when eggs are in the "eye" to hatch stage, or 8.0 mg/L when fish eggs and/or larvae or alevin are present. The 11.2 mg/L level will usually be applicable from October through December and from May to mid-June. The objective does not apply in initial dilution zones, described in Section 2.4.1.

3.4.5.5 Solids

Suspended solids values in the Necoslie River ranged naturally (Site 0400800-Table 20) from 27 to 319 mg/L. A value of 25 mg/L is cited as providing a high level of protection, 80 mg/L a moderate level, and 400 mg/L a low level of protection to aquatic life[13]. The data indicate that all these levels of protection are present at different times in the Necoslie River.

Values in the Stuart River were lower (Table 21), ranging from <1 to 259 mg/L. Most of these values represent approximately a high to moderate level of protection to aquatic life. However, the data base for both these rivers is not extensive, therefore these can only be deemed as tentative conclusions. However, the average turbidity value of 5.5 NTU at Site 0920101 (Table 21) indicates that suspended solids values likely would be low most of the time. These turbidity values indicate water of exceptional quality for drinking water for much of the time, but some filtration would be necessary when values higher than 5 NTU occurred.

The average colour value at Site 0920101 was 17.1 units. This is approximately equal to the maximum acceptable level of 15 units recommended for drinking water in British Columbia[11]. It indicates some treatment would be required to provide drinking water on a continuous basis at a level ≤15 colour units.

3.4.5.6 Bacteriological Quality

Coliform values reported for the Stuart River are in Table 21 and those for the Necoslie River are in Table 20. The data for Site 0400801 on the Necoslie River show that high fecal coliform values existed downstream from the Fort St. James STP, with a maximum value of >24 000 MPN/100 mL. This was predicted in Section 3.3.1. The Necoslie River downstream from the sewage outfall flows along the south edge of the Fort St. James Indian Reserve. The river water should be of sufficient quality to permit water-contact recreation. It is therefore proposed that <u>a provisional water quality objective be established to</u> protect this use in the Necoslie River, from a point 100 m downstream from the Fort St. James sewage outfall, to the confluence with the Stuart River, except in initial dilution zones of effluents, described in Section 2.4.1. The objective is that <u>the geometric mean fecal coliform value should be ≤200 MPN/100 mL, and the 90th percentile should be ≤400 MPN/100 mL</u>, from April through October. These values are to be calculated from a minimum of five weekly samples collected in a 30-day period.

Fecal coliform values in the Stuart River, collected at the highway 27 bridge, reveal the difference in water quality between the east and west sides of the river. The west side of the river at this point consists of Stuart Lake water, where fecal coliform values are very low. The east side of the river is mainly Necoslie River water, which accounts for the high fecal coliform results. The separation of water masses is clearly visible during freshet when the Necoslie River water is turbid. Water users in the area have taken this into account, locating domestic water intakes on the west side of the river. To maintain the quality of water in the Stuart River for downstream domestic water users, a provisional objective is proposed for fecal coliforms. It is proposed that not more than 10% of a minimum of five weekly samples collected in a 30-day period, should exceed 10 MPN/ 100 mL. This objective applies to drinking water that receives disinfection only. An exception to this is the east side of the Stuart River, between the Necoslie River confluence and a spot about 200 m downstream from the Highway 27 bridge (where complete mixing occurs due to rapids). In this reach, the 90th percentile fecal coliform value should not exceed 100 MPN/ 100 mL. This objective applies to drinking water that receives filtration or equivalent treatment plus disinfection prior to use. These objectives apply to the Stuart River, to samples collected outside of the initial dilution zones of effluents, described in Section 2.4.1..

Since the effluent from the Fort St. James newly-renovated sewage treatment facility has to be disinfected to meet the bacteriological limit in the permit, and since the facility is designed to carry out dechlorination to prevent toxicity to salmonids, the working water quality criterion for chlorine residual will be adopted from the United States Environmental Protection Agency(12). The provisional water quality objective is that the total chlorine residual, in any discrete sample, should not exceed 0.002 mg/L. This objective applies to the Stuart River. The objective applies to discrete samples collected at any point in the river, exclusive of initial dilution zones of effluents, described in Section 2.4.1. The objective is below the minimum detectable concentration, and thus receiving water concentrations will have to be estimated using effluent loadings and streamflows.

3.5 MONITORING PROGRAMS

Monitoring requirements for the Stuart River watershed can be broken into two categories: to check attainment of water quality objectives, and to provide information for possibly developing further water quality objectives.

To check attainment of objectives, sampling should take place upstream and just downstream from the initial dilution zone from the Fort St. James STP and/or at the highway bridge on the Necoslie River, and should concentrate on low flow conditions in the river. Sampling should take place 6 times the first year, and yearly thereafter. Samples should be analyzed for nitrogen and phosphorus forms, metals, pH, temperature, fecal coliforms, and dissolved oxygen.

On the Stuart River, a similar program should be carried out at the same frequency as the sampling for the Necoslie River. Samples should be collected from the highway bridge crossing the Stuart River, and upstream and just downstream from the initial dilution zones of the discharges from the two trailer parks. Samples should be analyzed for pH, dissolved oxygen, ammonia, nitrite, temperature, fecal coliforms, and chlorine residual (estimated).

Sampling programs which would be beneficial for the future development of objectives are much more extensive than those to check attainment of objectives.

The lack of a data base for the water quality of Stuart Lake should be overcome. Ideally, the lake would be sampled four times per year, as shown in Table 29. This Table shows frequency, time of year, characteristics to be examined, and sampling locations.

Also of importance, but a program which should be undertaken at a frequency of about once every ten years, would be monitoring fish in Pinchi Lake. Existing fish tissue data from Tezzeron and Stuart Lakes could act as a control for further Pinchi Lake sampling. Samples could also be taken from Stuart Lake if time, manpower and funding permitted to determine if contaminants were proceeding along the watershed.

Ideally, about five species would be collected from each of the lakes, with between 6 (minimum) and 10 (maximum) individuals (muscle tissue) being analyzed. Lake trout will be the most important species to collect since it is a sports fish, is at the top of the food chain and previous work has shown that it is the most contaminated due to its age, size, and feeding habits. Lake whitefish, largescale suckers, and peamouth chub could also be tested, resources permitting. Some livers should be randomly analyzed for metallothionein. Specimens should be weighed and measured, and analyzed for mercury, and if funds permit cadmium, copper, lead, and zinc. The actual species and number of individuals analyzed will depend totally on those specimens captured. However, every effort must be made to capture similar species for each lake so that comparisons between lakes, and through time, can be made. The fish should be sampled in early August if possible, to correspond with the time period reported by Reid and Morley[25]. Water chemistry analyses should also be made on the lake water at the fish sampling site when the fish are collected for the same characteristics as measured in fish. The collection and analysis of sediments should also be considered.

Additional information should also be collected on tributary streams. This is of particular importance for sites on Pinchi Creek and the Tachie River. Such sites would help to determine the incoming water quality and its importance relative to Stuart Lake water quality. This sampling should coincide with sampling undertaken in Stuart Lake, and the characteristics analyzed should also be consistent.

Monitoring of Tezzeron, Hatdudatehl and Tsilcoh Creeks, and the Ocock River is considered to be a secondary priority, since they are relatively undisturbed.

3.6 CONCLUSIONS

The Stuart River system is the major tributary to the Nechako River, contributing about 75% of its flow. Limited consumptive use is made of the water, although it is a major salmon spawning area.

Direct discharges to surface waters in the watershed include the discharge from the Fort St. James STP to the Necoslie River, treated domestic sewage from a ranger station to Stuart Lake, and treated domestic sewage from two trailer parks to the Stuart River. The only one affecting the receiving water is the Fort St. James sewage discharge, which increases values for fecal coliforms, ammonia, BOD_5, orthophosphorus, and total phosphorus near the mouth of the Necoslie River. No major impact from this operation is expected in the Stuart River if the recent improvements to the treatment system are as effective as anticipated. The impacts from the other operations are minor due to the large dilution available.

Minor increases in manganese and ammonia values have been noted downstream from a refuse site (operated by the District of Buckley-Nechako) on the Necoslie River. These will not affect water users. A school, located near the Stuart River, presents no problem since it discharges to the ground.

Tezzeron Lake and some of its tributaries (Tezzeron and Hatdudatehl Creek) were characterized by high pH, good buffering capacity, and soft water. Metal values in the tributaries generally met the working water quality criteria, but naturally occurring maximum values at some sites in the lake for cadmium, copper, iron and lead exceeded the criteria for aquatic life and drinking water (iron). Some mercury values in the flesh from one northern squawfish exceeded the criterion of 0.5 ppm (wet weight) to protect consumers of fish. The lake was probably oligotrophic due to low phosphorus values; however, chlorophyll-a measurements are required to confirm this. Phosphorus at higher levels than in the lake may be entering naturally through some of its tributaries. Dissolved oxygen values were high, and suspended solids were low enough to ensure a high to moderate level of protection to sensitive aquatic life.

Pinchi Lake and its tributaries (Tsilcoh Creek and the Ocock River) had high pH, good buffering capacity, and soft water. A mercury mining operation which disposed of its untreated tailings directly into the lake between 1940 and 1944 is likely responsible for high mercury levels in fish in the lake. Individuals of 7 species tested exceeded the criterion to protect consumers of fish of 0.5 ppm (wet weight) in muscle. Five of the seven species had mean mercury values which exceeded the criterion. Mercury was generally not detectable at most locations in the water column, although one site had a value, suspected of being anomalous, about thirty times the water quality criterion. Mercury levels in the water from the tributaries were not detectable.

Some high lead values in Pinchi Lake exceeded both Environment Canada and EPA average criteria for aquatic life. Some high iron values, exceeding aquatic life and drinking water criteria, were also noted in Pinchi Lake, Tsilcoh Creek, and the Ocock River. The tributaries also had high manganese values, exceeding the drinking water criterion for aesthetics. More phosphorus data would be needed to determine the trophic status of Pinchi Lake. Dissolved oxygen values were adequate and suspended solids were low enough for the water to offer a moderate to high level of protection to aquatic life in the lake. In the tributaries, suspended solids were low enough for the water to offer a high level of protection to aquatic life.

No water chemistry data existed for Stuart Lake. Some data on mercury values in fish tissue from individuals collected from Stuart Lake showed less mercury than in fish from Pinchi Lake. As well, all values met the criterion of 0.5 ppm (wet weight) for consumption.

Two tributaries to Stuart Lake had water chemistry data: Pinchi Creek and the Kuzkwa River which meets the Tachie River before entering Stuart Lake. Both these systems were characterized by soft water and good buffering capacity to acidic inputs. Maximum iron and lead in the Kuzkwa River, and maximum lead and mercury in Pinchi Creek, exceeded working water quality criteria for the protection of aquatic life. Copper values in both systems exceeded the Environment Canada aquatic life criterion. Dissolved oxygen (n=1) in the Kuzkwa River was high. Suspended solids in Pinchi Creek were high, offering a low level of protection to aquatic life. The one value in the Kuzkwa River indicated a high to moderate level of protection to aquatic life.

The Stuart and the Necoslie Rivers would be considered "soft", with good buffering to acidic discharges. In both rivers, some iron and manganese values exceeded working water quality criteria for drinking water and aquatic life (iron). In addition, copper in the Stuart River and aluminum and lead in the Necoslie River exceeded some criteria for aquatic life. Dissolved oxygen values in the Stuart River were high. Varying levels of suspended solids resulted in varying levels of protection in both rivers, from high to low in the Necoslie and from high to moderate in the Stuart River. Some high fecal coliform values were measured in the Necoslie River downstream from the Fort St. James sewage discharge which would prevent recreational use of the river.

Monitoring programs were proposed to check attainment of proposed objectives, and to increase the data base in order that further objectives might be developed in the future. Actual monitoring undertaken will depend upon available resources and other regional priorities.

4. NECHAKO RIVER FROM THE NAUTLEY RIVER TO ISLE PIERRE

This section of the river has two major tributaries: the Nautley River just downstream from Fort Fraser, and the Stuart River about 35 km downstream from Vanderhoof (Figure 3).

The Nautley River drains an area which includes Decker, Burns, Francois and Fraser Lakes. The Stuart River drains an area which includes Stuart, Pinchi and Tezzeron Lakes.

4.1 HYDROLOGY

The importance of water flows and of the quality of the Nautley River has increased since the flows were reduced in the Nechako River. The mean 7-day average low flow for the Nautley River (Water Survey of Canada station 08JB003) from 1980 to 1983 was 5.9 m^3/s, nearly 30% of the flow for the Nechako River at Fort Fraser (Table 5).

The importance of the Stuart River is more profound. Prior to 1973, the 7-day average low flow of the Stuart River (Water Survey of Canada station 08JE001) at Fort St. James was 68.5% of that in the Nechako River at Vanderhoof. When data to the end of 1982 were included, this increased to 74.9% and to 128.3% for the period 1980-1982. This increasing percentage is related to lower flows being released through the Skins Lake spillway to the Nechako River by Alcan.

The Kemano Completion project proposed a 7-day low flow of the Nechako River at Cheslatta Falls of 14.2 m^3/s from December through March[5], with higher 7-day low flows for the remainder of the year (Figure 5). The 7-day average low flows for the Nautley River at Fort Fraser from 1952 to 1983 are in Table 6. When these data were plotted, a 7-day low flow (10-year return period) of about 4.9 m^3/s was obtained by interpolation. Using these data, the expected 7-day average low flow (10-year return period) for the Nechako River at Vanderhoof with the Kemano Completion proposal would be the proposed low flow of 14.2 m^3/s (Figure 5) for the river at Cheslatta Falls, plus the minimum contribution of 4.9 m^3/s from the Nautley River, for a total of 19.1 m^3/s.

The 7-day average low flow has historically occurred at flow gauging station 08JC001 on the Nechako River at Vanderhoof anytime in the period from October through March. This low flow period would change to December through March should Kemano Completion proceed (Figure 5), since it is proposed to have about twice the flow recorded at Cheslatta Falls in October and November than in the December through March period.

To estimate low flows without the Kemano Completion project, the 7-day low flow for the post-injunction period (August 1980-1984) at Vanderhoof was calculated to be 38.2 m^3/s. For assessing water quality, low flows of 19.1 m^3/s and 38.2 m^3/s will be used for the Nechako River below the Nautley confluence.

Using a similar procedure to that used for the Nautley River, the 7-day average low flow with a 10-year return period for the Stuart River at Fort St. James (1931-1982) was calculated to be about 26.4 m^3/s. This would result in a projected 10-year 7-day average low flow for the Nechako River below the Stuart River confluence of 45.5 m^3/s (26.4 m^3/s + 19.1 m^3/s) with the Kemano Completion proposal or 64.6 m^3/s without Kemano Completion using post-injunction flows. For the Nechako River below the Stuart River confluence low flows of 45.5 m^3/s and 64.6 m^3/s will be used.

4.2 WATER USES

Figure 3 indicates locations of licensed water withdrawals on the Nechako River from the Nautley River to Isle Pierre. From the Nautley River to Vanderhoof, there are 11 withdrawals or applications which add up as follows: 14.6 m^3/d (0.0002 m^3/s) domestic (plus an application for 4.54 m^3/d), 4 546 m^3/d (0.05 m^3/s) for waterworks and 617 $dam^3/year$ for irrigation (plus an application for 5 951 $dam^3/year$). From Vanderhoof to

Isle Pierre, there are 9 withdrawals or applications totalling 1 171 810 m^3/year for irrigation (plus an application for 1 443 174 m^3/year) and an application for the withdrawal of 13.65 m^3/d (0.0002 m^3/s) for domestic use (drinking water and livestock watering). All of these uses would consume 1.8 m^3/s for irrigation (based on 60 days of withdrawal in summer when river flows are high) and 0.05 m^3/s for waterworks and domestic consumption.

Chinook and sockeye salmon utilize this stretch of the Nechako River as a migratory route[6]. Rainbow trout spawn in several small tributaries to the Nechako River[6]. Several other non-salmonid species use the river downstream from the Nautley River. White sturgeon populations are found in this section, with fish attaining sizes in excess of 150 kg.

The entire Nechako River is used extensively for primary-contact recreation.

4.3 WASTE DISCHARGES

Two landfills are located within this sub-basin as well as two other operations, one which discharges directly to the Nechako River and a second which discharges to the ground. Their locations are shown on Figure 3 by permit numbers issued pursuant to the Waste Management Act.

4.3.1 VILLAGE OF VANDERHOOF (REFUSE SITE)

The Village operates a refuse site located about 300 m from the Nechako River. It receives 80% domestic waste and 20% commercial waste. Permit PR 3387 allows the discharge of 70 m^3/d to this open-fill and compaction site.

This site should not affect the water quality of the Nechako River due to the small volume of wastes and the distance to the river.

4.3.2 L & M LUMBER LTD.

This company is located about 4 km west from Vanderhoof. It operates a refuse site in which wood-type wastes are deposited. Permit PR 6031 allows the discharge of 10 m^3/d of wood (50%), bark (25%) and soil (25%) to a site, located 100 m from the nearest watercourse (Stoney Creek, a tributary to the Nechako River). The waste is covered once per week. It is not anticipated that leachate will affect local water quality due to the small volumes of waste and the distance to local watercourses.

4.3.3 CHEVRON LTD.

This company operates a commercial fuelling installation in Vanderhoof, located about 100 m from the Nechako River. Runoff is treated in an oil separator, and is discharged to an 18 m^3 rock pit. Permit PE 6070 allows a discharge of 6.8 m^3/d to the rock pit with a maximum 15 mg/L oil and grease concentration. It is not expected that this operation would impact the river.

4.3.4 VILLAGE OF VANDERHOOF SEWAGE TREATMENT FACILITY

The Village of Vanderhoof operated a conventional wastewater stabilization pond (4 ha) designed for a population equivalent of 2 300. By August 1978 a second 4 ha pond was constructed to increase the design capacity to a population equivalent of 3000. Permit PE 296 restricts the maximum daily discharge to 1 640 m^3/d, with maximum concentrations of 100 mg/L BOD_5 and suspended solids. Effluent chlorination is not required, but provision is to be made for disinfection.

The effluent is discharged to the Nechako River just downstream from the north-east village boundary. It is discharged through an open pipe, not a diffuser, and the effluent tends to stay close to the south shore during low flow conditions. During low flows, the river is quite shallow (0.5 to 1 m) in the Vanderhoof area. Observations of the river flow pattern suggest that mixing with 50% of the river occurs about 500 m downstream from the discharge.

A summary of monitoring data is included as Table 22. The data indicate that permit limits for BOD_5 (65 of 66 samplings) and suspended solids (63 of 66 samplings) were almost always met.

Section 4.1 showed that the 7-day average low flow at Vanderhoof could be assumed to be 38.2 m^3/s without Kemano Completion and 19.1 m^3/s with the proposed Kemano Completion. Such flows would dilute the effluent from the sewage treatment facility by about 2010:1 and 1000:1, respectively, at the maximum permitted discharge rate after complete mixing. The present dilution using peak effluent flow is greater than 2000:1, therefore revision of effluent quality limits is not required. Implementation of the proposed Kemano Completion flows would warrant revision of the effluent quality limits according to effluent quality objectives[9]. These objectives required a BOD_5 of 45 mg/L and suspended solids of 60 mg/L when effluent dilution is in the range of 1000 to 1.

4.3.4.1 Effluent Flows

Flow data from 1980 to 1982 indicate that peak effluent flows occurred in the winter months. This is presumably due to households leaving water taps open to prevent water lines from freezing.

The population of Vanderhoof is projected to increase by 2.4% per year to 1997[46]. The maximum recorded effluent flow could increase from 1596 m^3/d to 2278 m^3/d. This would result in a minimum dilution ratio of 1470:1 without Kemano Completion and 724:1 with the Kemano Completion proposed and would likely require a downward revision of effluent limits. In terms of suspended solids and BOD_5, the system meets the more stringent effluent quality objectives (60 and 45 mg/L, respectively) that would be required for dilution between 200:1 and 2000:1. This projected increase, with no change in permitted levels of discharge, would also mean that the facility, expanded to handle wastes from a population equivalent of 3000, would reach its design capacity in about 1992.

The maximum effluent flow was recorded in March 1980. Flows greater than the 90th percentile value of about 1400 m^3/d have occurred in the period December 1980 through February 1981. This is similar to the situation at Fort Fraser where higher flows were experienced in winter months, presumably due to taps being left open to prevent frozen water lines.

4.3.4.2 Biochemical Oxygen Demand

Values for BOD_5 were usually less than the maximum permitted level of 100 mg/L, with a 90th percentile value of 72 mg/L and a mean value of 43.6 mg/L. Since 1983, results for BOD_5 have been less than 45 mg/L except for occasional winter values.

Values greater than about 70 mg/L (approximate 90th percentile value) have occurred between October and March in several years. Such a result is to be expected since biological activity in the lagoon would be slowed with cold weather. It occurred at the same time as maximum effluent discharge rate and 7-day average low flow periods, allowing these factors to be combined. Thus, using the maximum permitted discharge rate, the maximum recorded BOD_5 concentration, and the 10-year 7-day average low flow, it is projected that with complete mixing of the effluent and river water the BOD_5 values could increase in the river by 0.08 mg/L without Kemano Completion and 0.16 mg/L with the Kemano Completion proposal. These values could increase to 0.10 mg/L and 0.21 mg/L, respectively, by 1995. The effect on dissolved oxygen in the river would not be significant as long as proper mixing occurred.

Dissolved oxygen or BOD_5 were not measured immediately downstream from the discharge (Table 23).

4.3.4.3 Suspended Solids

Suspended solids values usually were less than the maximum permitted value of 100 mg/L (Table 22), with a 90th percentile value of 94 mg/L and a mean value of 45 mg/L. Since 1983, values have generally been less than 60 mg/L.

Values greater than 94 mg/L (90th percentile) have occurred between May and October in several years. This is to be expected since algal growths in warmer months increase the amount of material in suspension. Thus, it is not likely that maximum suspended solids concentrations will occur with maximum effluent discharge rates, and 7-day average low flows. However, even if these factors were combined, values in the river with complete mixing of the effluent and river water would increase by less than 0.20 mg/L. This increase is not considered to be significant.

Suspended solids were measured in the river upstream and downstream from the discharge point of the effluent. The data indicate (Table 23) that no increase was evident in the river.

4.3.4.4 Bacteriological Quality

Fecal coliform values in the effluent have been as high as 2 400 000 MPN/100 mL. Most values greater than 240 000 MPN/100 mL (75th percentile value) generally occurred between December and March, a time of year when ultraviolet radiation would have its least impact.

Assuming the maximum effluent discharge rate, the maximum fecal coliform concentration, a 10-year 7-day average low flow in the river, and complete mixing of the effluent and river water, the fecal coliform values potentially could increase by about 1 200 MPN/100 mL without Kemano Completion, or by about 2 400 MPN/100 mL with the Kemano Completion proposal. Using projected effluent discharge rates for 1995, these increases in the concentrations in the river would be raised to about 1 600 MPN/100 mL and 3 290 MPN/ 100 mL, respectively.

Limited monitoring of the water quality of the river upstream and downstream from the discharge occurred in 1982. These data are in Table 23. They indicate that fecal coliforms did not increase beyond the initial dilution zone, although some increases were measured within the zone, about 20 m downstream from the discharge.

4.3.4.5 Nutrients

Limited data have been collected on nutrients in the effluent. The maximum recorded total dissolved phosphorus value in the effluent was 4.72 mg/L (Table 22). This could potentially cause an increase of 2.3 μg/L without Kemano Completion or 4.7 μg/L with the Kemano Completion proposal, assuming complete mixing of the effluent and river water at the maximum effluent discharge rate and the 10-year 7-day average low flow. By 1995, these values could increase to 3.2 μg/L and 6.6 μg/L, respectively.

However, since these anticipated increases would occur in months when aquatic macrophyte growth is not a problem in the river, they are not considered to be significant. Values during summer months would be about half or less than the maximum values predicted, due to increased river releases at Cheslatta Falls.

Orthophosphorus and total dissolved phosphorus values were measured upstream and downstream from the discharge on 4 occasions in 1982 (Table 23). Increases beyond the initial dilution zone of 0.003 mg/L to 0.181 mg/L (ortho) and from 0.010 mg/L to 0.184 mg/L (total dissolved) were measured. These increases are several times the predicted maximum, possibly due to incomplete mixing.

Calculated un-ionized ammonia values in the effluent have been as high as 0.424 mg/L (Table 22). With complete mixing of the effluent and the Nechako River, un-ionized ammonia values could increase in the river by only 0.2 μg/L without Kemano Completion, or 0.4 μg/L with the Kemano Completion proposal at maximum permitted effluent flow rates and the 10-year, 7-day average low flow. However, dispersion of the effluent is not good in the river since the effluent is discharged through a pipe, not a diffuser, and the effluent tends to stay close to the south shore. This could possibly result in high un-ionized ammonia values in the river outside the initial dilution zone before adequate mixing occurs. However, even if the effluent is only mixing with 25% of the river flow with Kemano Completion, a resulting value of only 1.7 µg/L would result.

Ammonia (total) values can potentially increase by 0.011 mg/L in the river without Kemano Completion or 0.023 mg/L with the Kemano Completion proposal, assuming the maximum effluent concentration, the maximum permitted effluent discharge rate and the 10-year 7-day average low flow in the river and complete mixing. By 1995, these values could increase to 0.015 mg/L and 0.031 mg/L, respectively. These values would not be of concern in the river in terms of the presence of toxic ammonia concentrations if complete mixing occurs rapidly.

Total ammonia values increased for 1 of 4 coincident samples taken upstream and downstream from the discharge in 1982 beyond the initial dilution zone (Table 23). The value increased from 0.007 mg/L to 0.695 mg/L. This indicates that complete mixing of the effluent and the river had not taken place since the increase in ammonia was greater than that predicted above, but the downstream value was still well below criteria for aquatic life at the usual pH of the river (7.7).

4.3.5 ALUMINUM COMPANY OF CANADA

Alcan had proposed to construct and operate a smelter to the north of Vanderhoof, just west from highway 27. No information was available on effluent discharges or their effects, although major discharges to surface waters were not expected. This project has been postponed indefinitely.

4.3.6 DIFFUSE SOURCES

The effects of forestry and residential developments have not been examined in this assessment. However, each would have some impact on water quality.

The locations of cattle in the Nechako watershed from Fraser Lake to Vanderhoof are shown on Figure 3. The number of cattle was estimated from statistics of the Beef Assurance Program of the B.C. Ministry of Agriculture. The estimates for nutrient coefficients proposed by Bangay[31] were used to calculate potential nutrient contributions from cattle. The total yearly output of nitrogen and phosphorus would be as follows:

	kg/year	
	P	N
Cows	23 094	198 288
Yearlings	4 350	53 905
Calves	213	4 641
Total	27 657	256 834

The significance of these potential loadings is discussed in Section 4.4.3.

4.4 AMBIENT WATER QUALITY AND PROVISIONAL WATER QUALITY OBJECTIVES

Ambient water quality data were collected near Vanderhoof (Site 0920069) and Isle Pierre (Site 0920100) by the Inland Waters Directorate from 1972 to 1974 and 1966 to 1974, respectively. Limited data were collected by the Ministry of Environment near Vanderhoof (Site 0920069) in 1982 and 1983 and Isle Pierre (Site 0400040) from 1972 to 1975. These data are in Tables 24, 25 and 26. The locations of the water quality sites are on Figure 3. The water quality of Decker, Burns, Francois, and Fraser Lakes are not considered in this assessment.

Designated water uses for the Nechako River from the Nautley River to Isle Pierre are protection of aquatic life, wildlife, drinking water supplies (after filtration or equivalent), irrigation, livestock watering, and primary-contact recreation.

4.4.1 pH AND BUFFERING CAPACITY

The pH of the Nechako River would appear to vary little between Vanderhoof and Isle Pierre, with median values around 7.6. This is not expected to change should the Kemano Completion proceed, since the median pH of the Stuart River (Table 21) was 7.7. The proportion of the Stuart River water and all other tributaries to the Nechako would increase due to Kemano Completion. All pH values were within the range of working water quality criteria (6.5 to 9.0) for the protection of sensitive aquatic life[12] and drinking water supplies (6.5-8.5)[11]. These near neutral pH values should be maintained in order to reduce the amount of un-ionized ammonia being formed near the Vanderhoof sewage treatment facility discharge. A provisional water quality objective therefore is proposed for pH. The objective, applicable to discrete samples collected from outside inital dilution zones of effluents, is that the pH in any discrete sample should be within the range 6.5 to 8.5. By restricting the upper limit for pH to 8.5, the percentage of toxic ammonia in aqueous ammonia solution will be about one-third that which would be available at pH 9.0[22]. The objective will apply to the Nechako River from the Nautley River to Isle Pierre, exclusive of initial dilution zones of effluents described in Section 2.4.1.

The buffering capacity of the river to acids was acceptable with an average alkalinity value of about 40 mg/L at Isle Pierre (Tables 25 and 26). It is expected that the alkalinity near Vanderhoof would be about the same. Alkalinity values should not be changed downstream from the confluence of the Stuart River by the Kemano Completion project, since values in that river are of approximately the same magnitude (Table 21).

4.4.2 HARDNESS AND METALS

Based upon very limited data for Site 0920069 at Vanderhoof (Table 24), the hardness of the river increased from about 30 mg/L to about 40 mg/L at Isle Pierre (Table 25). This increase is likely attributable to the Stuart

River, which has slightly harder water (mean of 48.5 mg/L - Table 21) than the Nechako. The implementation of the Kemano Completion project will mean that the Stuart River will have a greater influence on the water quality of the Nechako River. However, such a small increase in hardness is not thought to be detrimental.

Metal values were generally low, often below detection limits and usually less than the working water quality criteria in Table 4. Exceptions were values for dissolved and total aluminum, with maximum values at Sites 0920069 and 0920100 which exceeded the criterion of 0.10 mg/L(13) for the protection of aquatic life. However, these high values were likely naturally occurring. Due to the lack of information on the proposed smelter (Section 4.3.5), it is not known if the already high aluminum values will be affected.

One high total iron value at Site 0920100 exceeded the working water quality criterion of 0.3 mg/L for the protection of aquatic life and public water supplies(10)(11). However, all other recorded values were below this criterion. One high molybdenum value of 0.03 mg/L at Vanderhoof exceeded some criteria for irrigation. A high lead value of 0.01 mg/L and a high manganese value (0.09 mg/L) were recorded at Isle Pierre.

The metal values would change little should the Kemano Completion project be implemented, since values in the Stuart River are also low (Table 21).

4.4.3 NUTRIENTS

Ammonia, nitrate/nitrite, and organic nitrogen values (n=2) in the Nechako River were low at Vanderhoof in 1982 and 1983 (Table 24), but were considerably higher at Isle Pierre up to 1975 (Table 25 and 26). A maximum ammonia value of 0.2 mg/L was recorded on four dates in 1967 (June 23, June 29, September 22, September 23) at Site 0920100. The values in June were associated with pH and temperature values of 7.3 and 17°C, respectively, while the September values were associated with 7.9 and 13.3°C, respectively. The September samples contained the larger amount of un-ionized ammonia, 1.88% compared to 0.62%, or 0.004 mg/L and 0.001 mg/L, for September and June respectively. These ammonia values are well below the B. C. criteria in Table 31.

It was calculated in Section 4.3.4.5 that total ammonia values in the river might increase by between 0.01 mg/L and 0.03 mg/L under certain conditions. These values and the probable increase in un-ionized ammonia values would not be of concern if complete mixing of the effluent and river water were assured. However, effluent dilution does not occur quickly. Thus, in order to protect the sensitive fishery in the Nechako River, a provisional water quality objective is proposed for total ammonia. The objective, which will apply from the Nautley River to Isle Pierre, exclusive of initial dilution zones of effluents described in Section 2.4.1, is that the average concentration of total ammonia should not exceed the value listed in Table 32, while the maximum value in any discrete sample should not exceed the value listed in Table 31. The average value is to be calculated for a minimum of five weekly samples collected in a 30-day period.

Nitrate nitrogen values at Vanderhoof (n=3) (Table 24) were at or near the detection limit of 0.02 mg/L, but were higher for one sample (0.7 mg/L) at Isle Pierre in January 1969. Organic nitrogen values at Vanderhoof (n=2) (Table 24) were about one-half those values recorded at Isle Pierre for the earlier data base.

Data in Tables 24 and 26 show that values of nitrite nitrogen were all <0.005 mg/L at Sites 0920069 and 0400040. This was also the case for Site 0400450, downstream from the outfall (Table 23). However, ammonia discharged in the effluent can be oxidized to nitrite, which can be toxic to aquatic life. Therefore, to protect aquatic life, a provisional objective is proposed for nitrite nitrogen. The objective is that the average value should not exceed 0.02 mg/L, and the maximum value should not exceed 0.06 mg/L. These objectives apply to the Nechako River, from the Nautley

River to Isle Pierre, except in initial dilution zones of effluents, described in Section 2.4.1. The average value is to be calculated from a minimum of five weekly samples collected in a 30-day period.

Diffuse sources can increase phosphorus, nitrogen, and subsequently biological productivity in the river. The greatest potential for these increases is after winter, when waste has accumulated. Assuming a six-month accumulation, the following maximum increases are possible, depending upon release periods and river flows. These assume 100% transmission to the river.

MAXIMUM POTENTIAL INCREASES (mg/L) IN PHOSPHORUS AND NITROGEN FROM DIFFUSE SOURCES

Release Period	19.1 m^3/s (Kemano Comp. Proposal)		38.2 m^3/s (without K.C.)	
	P	N	P	N
1 week	1.2	11.1	0.6	5.6
2 weeks	0.6	5.6	0.3	2.8
4 weeks	0.3	2.8	0.1	1.4

These potential increases, with or without Kemano Completion, are considerable. The relatively few measurements to date suggest that these levels may not be reached. A large part of these nutrients would be in organic and particulate form, and not immediately available to algae. As well, these nutrients would be released at spring runoff when the river is turbid.

Orthophosphorus values were generally at or near the detection limit of 0.003 mg/L, but higher values were recorded occasionally in the earlier data base for Isle Pierre (Tables 25 and 26). Total dissolved phosphorus values were considerably higher, with values near 0.01 mg/L (Tables 24 and 25). This could be considered a moderate level of dissolved phosphorus which is naturally occurring. Information in Section 4.3.4.5 indicates that should the Kemano Completion project proceed, the effluent from the Vanderhoof sewage treatment facility would increase these natural levels by <0.01 mg/L with complete mixing, even at 1995 projected effluent flow rates. This is not considered to be a problem.

Coincident measurements of orthophosphorus and inorganic nitrogen (nitrate and ammonia) were usually not recorded or one or more of the variables was at or below detection limits. However, two nitrogen/phosphorus ratios were calculated at Isle Pierre (Site 0400040) in 1974 (2.4:1 and 12:1), while one was calculated at Vanderhoof (Site 0920069) in 1983 (6.5:1). Ratios greater than 12:1 indicate that phosphorus is the limiting nutrient, while values less than 5:1 indicate that nitrogen is the limiting nutrient. The three calculated ratios indicate that either nutrient may be limiting.

4.4.4 AQUATIC PLANTS

Aquatic plant growth near Vanderhoof is quite extensive, with growths of Elodea canadensis protruding above the water surface and extending about 20 m from the shore. Also present in large numbers are Potamogeton sp. and Myriophyllum type sp.

Strands of filamentous green algae, up to 1 m in length, are very abundant on the rooted macrophytes. Floating green mats of algae, supported by air bubbles, are also common along the shore.

An investigation downstream from the Vanderhoof sewage treatment facility was conducted to determine if nutrients from the sewage were promoting heavier growths. No discernible difference in plant or algal growths could be found between upstream and downstream from the discharge, since heavy growths were found in both directions.

As discussed in Section 2.4.4, should the Kemano Completion project proceed, water clarity likely will improve. This will allow more light transmission and greater aquatic plant and algal productivity. Reduced water flows also will decrease the water depth, increasing the potential littoral area. Great increases in primary productivity manifested by aquatic plant growths (an extreme situation) could potentially impede migration of salmon, encourage coarse fish production, deoxygenate the water at night, or spoil the river for such recreational pursuits as boating and swimming.

Periphyton chlorophyll-a values have not been measured in the Nechako River. However, the Ministry of Environment has suggested a level of 50 mg/m^2 to protect recreational use of rivers[30]. To ensure that periphyton growth does not become a problem, a provisional objective is proposed for the Nechako River, from Fort Fraser to Isle Pierre, except in initial dilution zones of effluents, described in Section 2.4.1. The objective is as follows: the average of at least five periphyton chlorophyll-a values from natural substrate on any sampling occasion should not exceed 50 mg/m^2. Monitoring will be needed to confirm that this is a realistic objective for the Nechako River.

4.4.5 DISSOLVED OXYGEN AND OXYGEN-CONSUMING MATERIALS

Dissolved oxygen values were generally high, with all values being above 7.75 mg/L - the working water quality criterion that provides a high level of protection to salmonids[16]. Percent saturation values were generally about 90% (Tables 24,25,26). Since this section of the river is an important migratory route, and since high dissolved oxygen values should be maintained, it is proposed that a provisional water quality objective be established for dissolved oxygen in the Nechako River, from Isle Pierre upstream to the Nautley River, exclusive of initial dilution zones of effluents described in Section 2.4.1. This objective is that the dissolved oxygen concentration should not be less than 7.75 mg/L in any discrete sample in order to provide a high level of protection to the salmonid populations which utilize this reach of the river. In addition, a minimum of 11.2 mg/L should be present when fish eggs are in the "eye" to hatch stage, or 8.0 mg/L when fish eggs and/or larvae or alevin are present.

Values for BOD_5 were not measured. Calculations in Section 4.3.4.2 have indicated that BOD_5 values in the river will not be increased appreciably by the discharge from the Vanderhoof sewage treatment facility.

4.4.6 SOLIDS

Dissolved solids were not measured directly, but specific conductivity values were low (≈100 µS/cm), indicating fairly low dissolved solids values (Tables 24,25,26). Suspended solids were generally low, about ≦10 mg/L, although some higher values (50 mg/L) were recorded. Values greater than about 20 mg/L at Sites 0400040 or 0920100 were recorded in either April or May of several years, and were therefore likely associated with freshet.

Suspended solids values less than 25 mg/L are considered typical of water which provides a high level of protection to aquatic life[13]. Turbidity values followed the trends of suspended solids concentrations. Since flows resulting from the proposed Kemano Completion project would reduce turbidity, and since it has been calculated (Section 4.3.4.3) that increases due to the Vanderhoof sewage discharge are minimal, this high level of protection to aquatic life should continue. The high turbidity associated with the high summer cooling flows released through the Skins Lake Spillway are the major river sediment related problem. Further study of this issue is warranted.

Colour has been as high as 60 apparent colour units and 39 TAC units. The maximum acceptable level recommended for drinking water in British Columbia is 15 true colour units[11]. Some treatment would be required to provide drinking water on a continuous basis at a level ≦15 true colour units.

4.4.7 BACTERIOLOGICAL QUALITY

Limited data have been collected on the bacteriological quality of the river. Fecal coliform values ranged from <2 MPN/100 mL to 33 MPN/100 mL at Site 0400040 at Isle Pierre (Table 26) in 1973. One value recorded at Vanderhoof at Site 0920069 in 1983 was 5 MPN/100 mL. Such levels would require disinfection and possibly filtration of the raw water if it is to be used as a drinking water supply[11]. However, more samples need to be collected to decide whether filtration would be required.

Information in Section 4.3.4.4 has shown that fecal coliforms did not increase beyond the initial dilution zone upstream to downstream from the Vanderhoof sewage treatment facility. However, it has been calculated that with complete mixing of the effluent and river water, fecal coliform values at river flows typical of the Kemano Completion project could increase in the river by 2 400 MPN/100 mL now or by about 3 300 MPN/100 mL in 1995. Without Kemano Completion, these values would be 1 200 and 1 600 MPN/100 mL, respectively.

In order to ensure that the water will be suitable for drinking after only filtration or equivalent treatment and disinfection, on the Nechako River from the Nautley River to Isle Pierre, a provisional objective is proposed for fecal coliforms. It is proposed that outside the initial dilution zones of effluents, described in Section 2.4.1, the 90th percentile of at least 5 discrete samples collected weekly in a consecutive 30-day period should not exceed 100 MPN/100 mL. Turbidity fluctuations in the river at times when water is released from the Skins Lake Spillway likely preclude a lower bacteriological objective (i.e., treatment to remove turbidity is required at present).

It is anticipated that, at present, this objective can only be met in the summer during periods of high river flows and when the bacteria in the stabilization ponds are removed by ultraviolet radiation. It is therefore possible that the effluent will have to be disinfected for at least part of the year, and that a diffuser section may have to be added to the present outfall pipe. The use of aeration could also be investigated. This potentially could reduce coliforms to acceptable levels in winter and reduce BOD_5 year-round.

Should disinfection of the effluent proceed utilizing chlorine, dechlorination using sulphur dioxide likely will be required to prevent chlorine toxicity to the important salmonid populations. In order to protect these sensitive salmonid populations, the working water quality criterion for chlorine residual has been adopted from the United States

Environmental Protection Agency[12]. The proposed water quality objective is that the total chlorine residual in any discrete sample should not exceed 0.002 mg/L. This objective applies to the Nechako River from Isle Pierre upstream to the Nautley River confluence, except in the initial dilution zones of effluents, described in Section 2.4.1. Since the objective is less than the minimum detectable concentration, it would be necessary to estimate the receiving water concentration using effluent loadings and stream flows.

4.4.8 TEMPERATURE

The problems associated with increased water temperatures were reviewed briefly in Section 2.4.8. Water quality objectives were proposed for the Nechako River, as measured at Cheslatta Falls. Since the Stuart River adds significantly to the flow of the Nechako River, an increasingly important consideration should the Kemano Completion project proceed, it is not feasible to set objectives for water temperatures downstream from the Stuart River confluence.

In order that Nechako River temperatures be controlled to the maximum degree possible, the following provisional water quality objective for a temperature regime is proposed for the Nechako River 100 m upstream from the confluence with the Stuart River. The objective is that the maximum mean daily temperature, should not exceed 20°C in July or August, or 18°C at any other time. These values should be checked according to the procedure outlined in Section 2.4.8.

4.4.9 TOTAL GAS PRESSURE

Total gas pressure has been discussed extensively in Section 2.4.9. Values measured at Vanderhoof were generally low, at 103%[7]. These low values should be maintained. It is therefore proposed that the total gas pressure, from Fort Fraser to Isle Pierre, should not exceed 109%.

4.5 MONITORING PROGRAMS

Provisional water quality objectives have been proposed for the Nechako River just upstream from the Stuart River and for the entire reach from the Nautley River to Isle Pierre. Monitoring of water temperatures upstream from the Stuart River site should be undertaken at least once per week in July and August between mid-July and mid- August, following periods of warmer weather and coincident with temperature sampling outlined in Section 2.4.8 (if required).

It is recommended that monitoring for the remaining proposed water quality objectives should be carried out upstream and 100 m downstream from the Vanderhoof sewage treatment facility, at least once between mid-July and mid-August and once during the winter low flow period, preferably in February or March. Samples should be analyzed for pH, temperature, ammonia, nitrite, dissolved oxygen, total gas pressure, fecal coliforms, and chlorine residual (estimated). Locations of aquatic plant growths (as well as approximate density) should be noted in summer and measurements made of periphyton chlorophyll-a. Other characteristics which might be worth measuring include dissolved orthophosphorus and nitrate nitrogen. Improving the data base for fecal coliforms and ammonia downstream from the Vanderhoof sewage facility is the main monitoring priority.

4.6 CONCLUSIONS

The importance of the Stuart River in determining the water quality of the Nechako River has increased steadily since Kemano I was completed. Prior to 1973, the Stuart River (at low flows) was 68.5% of the upstream flow in the Nechako River. This increased to 74.9% for the period ending in 1982, and to 128.3% for the period 1980-1982. Characteristics which could be affected by this trend were examined in Section 3.6.

Four operations discharge effluents in this sub-basin, all upstream from the Stuart River confluence. Two landfills and one operation which discharges to a rock pit do not affect surface water quality. The fourth operation is the sewage treatment facility at Vanderhoof, which calculations show could have a considerable effect on fecal coliforms in the river. Calculated increases in the river of 1 200 MPN/100 mL could rise to 2 400 MPN/100 mL with implementation of the Kemano Completion proposal, at low river flows and maximum loadings. Additional treatment (e.g., disinfection) and improved effluent diffusion may be necessary to meet the proposed objective for fecal coliforms. All other characteristics in the effluent were calculated as potentially not affecting downstream water quality.

Designated water uses including use for drinking water, livestock watering, irrigation, primary-contact recreation, and the preservation and protection of sensitive aquatic life and wildlife have been proposed for this reach of the Nechako River. Water quality objectives for pH, dissolved oxygen, total ammonia nitrogen, nitrite nitrogen, fecal coliforms, chlorine residual, periphyton chlorophyll-*a*, total gas pressure, and temperature have been proposed to protect the designated uses.

The water quality of the Nechako River from the Nautley River to Isle Pierre was good. This was reflected in low nutrient, solids and metal values and high dissolved oxygen. However, some naturally occurring aluminum values exceeded the working water quality criterion for aquatic life, and aquatic plant growths near Vanderhoof were abundant. Increased water clarity resulting from the implementation of the Kemano Completion proposal could result in greater aquatic plant growth and primary productivity. In extreme situations, this could lead to migration routes that are impeded, coarse fish production, deoxygenation of the water at night, and the elimination of recreational pursuits.

5. NECHAKO RIVER FROM ISLE PIERRE TO FRASER RIVER

From Isle Pierre, the Nechako River flows south-easterly and then north-easterly to Prince George, where it meets the Fraser River (Figure 3).

5.1 HYDROLOGY

The Nechako River from Isle Pierre to Prince George receives only small increments in flow. The largest flow increment comes from the Chilako River, located to the south from the Nechako River, which enters the Nechako River just as it swings north-easterly towards Prince George.

Mean monthly flows in the Chilako River at Water Survey of Canada Station 08JC005 in the period 1960 to 1974 ranged from 3.63 m^3/s to 55.1 m^3/s. The gauge ceased operation in 1974. Freshet occurred between April and July. The 7-day average low flow (10-year return period) is 3.39 m^3/s.

The 10-year 7-day average low flows in the major rivers are: in the Stuart River, 26.4 m^3/s (Table 6); in the Nautley River, 4.9 m^3/s (Section 4.1); and in the Nechako River at Cheslatta Falls should the Kemano Completion project proceed, 14.2 m^3/s. Thus, the 10-year 7-day average low flow in the Nechako River at Isle Pierre would be about 45.5 m^3/s should the Kemano Completion project proceed (and about 64.6 m^3/s without Kemano Completion). The 7-day average low flow for the Chilako River is only 6% of the projected low river flow in the Nechako River at Isle Pierre.

The Fraser River is gauged just upstream from Prince George at Shelley (Water Survey of Canada station 08KB001), where the average monthly mean discharge (1950 to 1982) has ranged from 179 m^3/s to 2 230 m^3/s[2], with a 10-year, 7-day average low flow of about 110 m^3/s. Thus, the Nechako River would increase flows in the Fraser River at Prince George under low flow conditions to 159 m^3/s (by about 40%) with the Kemano Completion project in place and 178 m^3/s (by about 60%) without Kemano Completion.

5.2 WATER USES

Licensed water withdrawals on the Nechako River include the use of 141 850 m^3/year for irrigation, 2.65 m^3/s for waterworks, and 5.66 m^3/s for industry (Figure 3).

This section of the river is used as a migratory route for salmonid species which spawn upstream. Rainbow trout utilize the mouths of some tributary creeks in this sub-basin for spawning[6].

There are four licensed water withdrawals for irrigation (388 547 m^3/year) on the Chilako River. The river is also used by salmonids and likely as a drinking water supply.

This section of the Nechako River is also very popular for recreation. There are several areas that are popular for swimming. Canoeing, rafting, tubing, and boating are also common summer activities.

5.3 WASTE DISCHARGES

There are very few point-source waste discharges located adjacent to the Nechako and Chilako Rivers. There is one landfill operation located near the Chilako River and one on the Nechako River approximately half way to Prince George from Isle Pierre. Their locations are noted on Figure 3 by permit numbers issued pursuant to the Waste Management Act.

5.3.1 NORBRATEN BROTHERS LUMBER

This company disposes of solid domestic waste from a camp cookhouse to a refuse site located over 300 m from the Nechako River (north bank). Permit PR 2464 requires that the waste be covered weekly.

The small volume of waste and the distance of the refuse site to the river will not affect the Nechako River.

5.3.2 REGIONAL DISTRICT OF FRASER FORT GEORGE

The Lower Mud (Chilako) River Road refuse site, located about 16 km west from Prince George, receives municipal-type wastes from a population equivalent of 400. Permit PR 2533 allows the disposal of 700 m^3/yr (1.9 m^3/d), with a maximum burning frequency of 12 times per year. The Chilako River is about 1.5 km east from the site.

Due to the small volume of waste handled, and the distance to the Chilako River, no effect should be seen in the river.

5.3.3 DIFFUSE SOURCES

The effects of forestry and residential developments have not been examined in this assessment. However, each would have some impact on water quality.

An estimated 1000 cows and 500 calves are present in the Chilako watershed. On a yearly basis, these could generate 8 030 kg of phosphorus and 70 400 kg of nitrogen, based upon nutrient coefficients proposed by Bangay(31). The significance of these potential loadings is discussed in Section 5.4.1.

5.4 AMBIENT WATER QUALITY AND PROPOSED PROVISIONAL WATER QUALITY OBJECTIVES

5.4.1 CHILAKO RIVER

Land use in the Chilako River basin includes residential use, agriculture, and forestry. The residential development is mainly in the river valley, over the last 20 km reach of the river.

Agricultural production consists mainly of hay, vegetables and some beef cattle. There is a minimal amount of grazing in the river valley but extensive grazing in the upper areas of the watershed. It is known that cattle are allowed free access to the river, in some areas.

Minimal amounts of logging occur in the river valley, but more occurs in the upper watershed.

Farmland is located along the length of the river[23]. The river is used by chinook salmon. In the five-year period 1975 to 1979, an average of 150 chinook returned[23]. Designated water uses for the Chilako River are irrigation, livestock watering, the protection and preservation of sensitive aquatic life and wildlife, and drinking water (partial treatment plus disinfection).

The Chilako River was sampled from 1972 to 1975 at Site 0400039 about 25 km upstream from its confluence with the Nechako River (Figure 3). Data are summarized in Table 27, and will be compared to data collected in the same time period at site 0400040 on the Nechako River at Isle Pierre (Table 26).

5.4.1.1 pH and Alkalinity

The pH was slightly more alkaline (median 7.9 compared to 7.75) than in the Nechako River, and the mean buffering capacity to acids was approximately triple that in the Nechako River (118.9 mg/L alkalinity compared to 40.1 mg/L).

The pH of Chilako River water ranged from 7.1 to 8.2 (Table 27), within the range of working water quality criteria of 6.5 to 9.0 to protect aquatic life[12] and 6.5-8.5 to protect drinking water supplies[11]. A provisional water quality objective therefore is proposed for pH in order to reduce the amount of un-ionized ammonia which can be formed from cattle wastes. The objective, applicable to discrete samples collected along the total length of the Chilako River from outside the initial dilution zones of effluents, described in Section 7.4.1, is that the pH in any discrete sample should be within the range 6.5 to 8.5. By restricting the upper limit of pH to 8.5, the percentage of un-ionized ammonia available in aqueous ammonia solution will be about one-third that which will be available at pH 9.0[22].

5.4.1.2 Hardness and Metals

Water in the Chilako River was harder than that in the Nechako River (109.5 mg/L compared to 39.7 mg/L). The water would be considered moderately soft.

Dissolved and total metal values in the Chilako River (Table 27) were generally low, often below detection and working water quality criteria. Some higher total metal values were associated with high suspended solids values. Of special note was one detectable dissolved mercury value of 0.00025 mg/L. This was probably a natural occurrence as the drainage is located in the mercuriferous Pinchi Fault geological formation. Both total and dissolved iron and manganese exceeded drinking water criteria[11].

5.4.1.3 Nutrients

Orthophosphorus values were generally higher than in the Nechako River (mean value of 0.025 mg/L compared to 0.005 mg/L), as were ammonia, nitrate/nitrite, and organic nitrogen values.

Diffuse sources can increase phosphorus and nitrogen concentrations in the river. The greatest potential for these increases is after winter, when waste has accumulated. Assuming a six-month accumulation, the following increases are the maximum possible, depending upon release periods and river flows. These assume 100% transmission to the river.

MAXIMUM POTENTIAL INCREASES (mg/L) IN PHOSPHORUS AND NITROGEN FROM DIFFUSE SOURCES

Release Period	3.39 m^3/s (7-day avg. low)		3.63 m^3 (low mean monthly		55.1 m^3/s (max. mean monthly)	
	P	N	P	N	P	N
1 week	1.96	17.2	1.83	16.0	0.12	1.05
2 weeks	0.98	8.6	0.91	8.0	0.06	0.53
4 weeks	0.49	4.3	0.46	4.0	0.03	0.26

These data indicate considerable phosphorus and nitrogen increases can occur due to cattle wastes at lower flows.

The maximum recorded ammonia nitrogen value was 0.032 mg/L. At the maximum temperature of 19°C and pH of 8.2, a concentration of 0.002 mg/L un-ionized ammonia would be present. This total ammonia value is well below the B.C. criteria in Table 31. In order to protect aquatic life, a provisional objective is proposed for total ammonia. The objective, which will apply to the Chilako River except in initial dilution zones of effluents described in Section 2.4.1, is that the average concentration of total ammonia should not exceed the value listed in Table 32, while the maximum value should not exceed the value listed in Table 31. The average value is to be calculated from a minimum of five samples collected weekly in thirty days.

The maximum nitrite concentration was 0.007 mg/L, well below the criteria of 0.02 mg/L as an average and 0.06 mg/L as a maximum[14]. However, ammonia which originates from diffuse sources can be oxidized to nitrite, a nitrogen form potentially toxic to aquatic life. Provisional objectives of an average 0.02 mg/L and maximum of 0.06 mg/L nitrite are proposed. The objectives apply to the Chilako River, except in initial dilution zones described in Section 2.4.1. The average value is to be calculated from five samples collected weekly in thirty days.

The quantity of nutrients present, stream velocity and light availability are factors which affect algal growths. Periphyton chlorophyll-a values have not been measured in the Chilako River. However, the Ministry of Environment has suggested a level of 50 mg/m^2 to protect recreation and 100 mg/m^2 to protect aquatic life[30]. To ensure that periphyton growth does not become a problem, a provisional objective is proposed for the Chilako River, except in initial dilution zones of effluents, described in Section 2.4.1. The objective is that the average of at least five periphyton chlorophyll-a values from natural substrate on any sampling occasion should not exceed 100 mg/m^2. Monitoring will be needed to confirm that this is a realistic objective for the Chilako River.

5.4.1.4 Dissolved Oxygen

Dissolved oxygen values were high, with calculated percent saturation values exceeding 80% in both rivers. Concentrations were ≧7.8 mg/L (Table 27).

Since the river is an important migratory route which must have high dissolved oxygen concentrations maintained, a provisional water quality objective is proposed for dissolved oxygen in the Chilako River, except in initial dilution zones of effluents, described in Section 2.4.1. The objective is that the dissolved oxygen concentration should not be less than 7.75 mg/L in any discrete sample. In addition, a minimum of 11.2 mg/L should be present when eggs are in the "eye" to hatch stage, or 8.0 mg/L when fish eggs and/or larvae or alevin are present.

5.4.1.5 Solids

High suspended solids values were measured in the Chilako River in May of two years. However the mean value for the Nechako and the median value for the Chilako were each 10 mg/L.

5.4.1.6 Bacteriological Quality

Coliforms were measured only three times (Table 27); all values were less than 100 MPN/100 mL.

In order that the water be suitable for drinking after filtration or equivalent and disinfection, a provisional objective is proposed for fecal coliforms. It is proposed that outside the initial dilution zones of effluents, described in Section 2.4.1, the 90th percentile value of at least five samples collected weekly in a period no longer than thirty days should not exceed 100 MPN/100 mL. Natural turbidity fluctuations in the river preclude a lower bacteriological objective (i.e., treatment to remove turbidity is required at present). Turbidity in the river was high.

5.4.2 NECHAKO RIVER

Data were collected on the Nechako River at Prince George from 1974 to 1983 at Site 0920066, although most data were collected from 1974 to 1976.

Proposed designated water uses are irrigation, livestock watering, drinking water (with filtration or equivalent treatment) primary-contact recreation, and the preservation and protection of sensitive aquatic life and wildlife.

5.4.2.1 pH and Buffering Capacity

The pH of the river was measured twice in 1982, with both values being 7.8. Alkalinity values were not recorded, but they should be about 40 mg/L, unchanged from those measured at Isle Pierre.

The fact that there are no controllable waste discharges entering the Nechako River in this reach would normally preclude setting a water quality objective for pH. However, since Isle Pierre is a rather arbitrary cut-off (i.e., that is where data were collected), it is logical to extend the Section 4.4 objectives to Prince George. Therefore, a provisional objective is proposed that the pH in any discrete sample should be within the range 6.5 to 8.5.

5.4.2.2 Hardness and Metals

The Nechako River would be considered to have soft water, with hardness values of about 40 mg/L (Table 28). Limited data for metals (n=1 or 2) collected in 1982 and 1983 showed that values were often below detection and met water quality criteria for the protection of sensitive aquatic life[10]. An exception was the total lead value of 0.11 mg/L in 1982 which exceeded the water quality criterion of 0.005 mg/L for the protection of sensitve aquatic life in soft water[10] and 0.05 mg/L for drinking water[11]. Suspended solids values were only 2 mg/L and thus the lead was probably soluble rather than associated with particulate matter. This is a very high lead value, particularly in the absence of substantial particulate matter, and may be an error considering the low lead values measured at Isle Pierre in 1974-1975, and the lack of upstream sources of lead. Further monitoring should be done.

5.4.2.3 Nutrients

Limited data were collected for nutrients in 1983. Ammonia values could not be detected (<0.005 mg/L), while nitrate/nitrite and organic nitrogen values were low. The un-ionized ammonia concentrations could not be calculated, but would not be a concern due to the low total ammonia value.

Phosphorus values were low, with an orthophosphorus value below the detection limit of 0.003 mg/L.

As was explained in Section 5.4.2.1, proposed objectives for the Nechako River upstream From Isle Pierre should be extended to Prince

George. Therefore, the provisional objective for total ammonia listed in Table 32 as an average and listed in Table 31 as a maximum value is proposed. As well, the proposed objective for nitrite nitrogen should be continued. The average nitrite value should not exceed 0.02 mg/L, while the maximum value should not exceed 0.06 mg/L. The average periphyton chlorophyll-a from at least five samples using natural substrate should not exceed 50 mg/m^2.

5.4.2.4 Dissolved Oxygen and Oxygen-Consuming Materials

Dissolved oxygen values were all high and greater than 9 mg/L (Table 28). Percent saturation values generally exceeded 100%. Percent saturation values as high as the maximum of 164% are of concern since they can cause stress to fish. As was explained in Section 5.4.2.1, appropriate objectives proposed for the Fraser lake to Isle Pierre reach should be extended to Prince George. Therefore, in order to provide a high level of protection to salmonids, the dissolved oxygen concentration should not be less than 7.75 mg/L in any discrete sample, 8.0 mg/L when fish eggs and/or larvae or alevin are present, and 11.2 mg/L when eggs are in the "eye" to hatch stage.

5.4.2.5 Solids

Suspended solids values were recorded only twice, both being 2 mg/L. This is not unexpected, considering the values recorded at Isle Pierre (Table 26), although some higher values (50 mg/L) had been recorded at Isle Pierre. Values less than 25 mg/L are considered typical of water which provides a high level of protection to aquatic life(13). Since flows resulting from the Kemano Completion project likely would reduce turbidity, this high level of protection to sensitive aquatic life should continue.

5.4.2.6 Bacteriological Quality

Limited bacteriological data (n=10) were collected on the Nechako River at Prince George. These were sampled at a location where Prince George would have only a minimal influence on the river. Fecal coliform values have been as high as 1 500 MPN/ 100 mL, with a median value of 150 MPN/ 100 mL (Table 28). Insufficient samples were collected to determine the level of treatment required to allow the raw water to be used for a drinking water supply, but the data suggest that complete treatment plus disinfection may be needed. The City of Prince George use infiltration wells adjacent to the river to obtain its water. Treatment consists solely of chlorination, except at one well where iron and manganese are also removed. The maximum value of 1 500 MPN/100 mL was recorded on three occasions in August and September of 1976, and may have been related to the discharge from the Vanderhoof sewage treatment facility (see Section 4.4.7). Values at this level exceed recreation criteria of 200 MPN/100 mL (geometric mean) and 400 MPN/100 mL (90th percentile). Should the proposed water quality objective be met in the Nechako River between Vanderhoof and Isle Pierre, it is likely that values between Isle Pierre and Prince George will remain satisfactory for all water users. Therefore, extending the proposed bacteriological objective to Prince George, not more than 10% of at least five discrete samples collected weekly in a consecutive 30-day period should exceed 100 MPN/100 mL.

5.5 MONITORING PROGRAMS

Site 0920066 on the Nechako River at Prince George is an important monitoring site due to the influence of the Nechako River on Fraser River water quality at this point in the Fraser River system and the need for a good data base for this extensive drainage. Since May 1984, sampling has taken place every four weeks for total alkalinity, fecal coliforms, pH, total hardness, total and dissolved solids, turbidity, specific conductivity, temperature, orthophosphorus, total dissolved phosphorus, and total phosphorus, ammonia, nitrate/nitrite, Kjeldahl nitrogen, and a scan of total and dissolved metals. The site is now part of a Federal-Provincial trend monitoring network. It will be sampled every two weeks. In addition to the aforementioned analyses, other characteristics which will be measured include phenolphthalein alkalinity, potassium, sodium, chloride, fluoride, silica, sulphate, colour (TAC), and suspended solids. Sampling at this site will integrate everything that has happened upstream, will delete anomalies associated with low flows, and will encompass seasonal variability.

Impacts within the Nechako River basin from non-point sources are likely more important than from point sources. It would be prudent to examine one smaller drainage basin within it to better understand the impacts of logging, agriculture, and residential development on water quality. The Chilako River basin may provide a suitable basin for such a study due to the varied and concentrated land uses in the basin. Logging occurs mainly in the upper portion of the system, agriculture in the middle, and residential development in the lower portion of the basin. The basin is also close to Prince George and has excellent access.

Details of such a study can be determined elsewhere. However, sampling would be concentrated in the spring and summer period, with nutrients, algal growth, and suspended solids being the main focus of the study. Some of the Chilako River tributaries could be used to demonstrate the impact of concentrated single land use. It is likely that at least five separate monitoring sites would be required.

5.6 CONCLUSIONS

There are no important point source discharges in this reach affecting the water quality of the rivers.

The Chilako River was examined by comparing its water quality to that of the Nechako River. Generally, the Chilako River which carries only 6% of the flow in the Nechako, is more alkaline and has higher hardness and nutrient levels. High metal values have been associated with high suspended solids recorded during the freshet in May. Dissolved oxygen values were good. One detectable dissolved mercury value probably reflects natural mercury levels in the general geological area (i.e., in the Pinchi Fault). Designated water uses, including irrigation, livestock watering, drinking water, and the preservation and protection of sensitive aquatic life and wildlife have been proposed for the Chilako River.

The Nechako River has good water quality, represented by low nutrients, metals, and suspended solids and high dissolved oxygen values. A high measured lead value may have been an error. Some high fecal coliform values have been recorded which exceeded criteria for drinking water and recreation.

Designated water uses for the Nechako River between Isle Pierre and its confluence with the Fraser River include irrigation, livestock watering, drinking water, primary-contact recreation and the preservation and protection of sensitive aquatic life and wildlife.

6. WATER QUALITY EFFECTS FROM AIRBORNE CONTAMINANTS

An integral part of the proposed Kemano Completion project is a proposed aluminum smelter near Vanderhoof. In late 1983, the B.C. Ministry of Environment began a program to identify and subsequently to obtain background water quality data on lakes which might be impacted by airborne emissions from the proposed Alcan smelter near Vanderhoof. This program was subsequently dropped when Alcan announced the indefinite postponement of Kemano Completion.

The area surrounding the assumed smelter location was broken into four sectors, generally to the northeast, northwest, southeast and southwest.On a yearly basis, based upon wind speeds and directions measured at Prince George, it was projected that 57% of the winds would blow to the northeast, 22.4% to the southwest, 11.1% to the southeast, and 8% to the northwest. These percentages were used to determine "weighting" factors for sampling. These factors were 7:1 for the northeast, 3:1 for the southwest, 2:1 for the southeast and 1:1 for the northwest. Thus if 13 lakes were to be sampled, then 7 would be sampled in the northeast sector, 3 in the southwest sector, 2 in the southeast sector and 1 in the northwest sector. Lakes were to be within a 100 km radius from the assumed smelter location, if possible, and were to be as sensitive as possible to acidic input (i.e., alkalinity ≦10 mg/L).

Levels of certain characteristics such as pH, alkalinity, sulphate, fluoride, and calcium were to be documented to provide information on pre-operational conditions. The program was also to be conducted during the operational phase, possibly as a condition of a Waste Management permit. The main characteristics of concern associated with the emissions would be sulphur dioxide and hydrogen fluoride. Acid sensitive lakes with an alkalinity of less than 40 mg/L were chosen for long-term monitoring.

Although about 50 lakes were examined, only 12 lakes have met the required criteria. Raising the acceptable alkalinity to 50 mg/L would only enable the addition of 1 or 2 lakes. Most of the lakes in the area have high buffering capacity, with even the lowest alkalinities lying between 20-30 mg/L. The most important zone, the N.E. quadrant, does have at least 6 suitable lakes. Almost all of the fluoride values have been below 0.2 mg/L with most results being below the detectable limit of the test (0.10 mg/L).

By the end of October 1984, the network of stations for long-term monitoring was finalized. Most of the lakes in the network had been sampled 3-4 times. It will take about two years to build the smelter, so further sampling should probably wait until it is evident that the smelter will be built. For detection of an impact (i.e., a trend), two years of continuous time series of monthly or biweekly values immediately prior to emissions beginning from the smelter would be the most effective.

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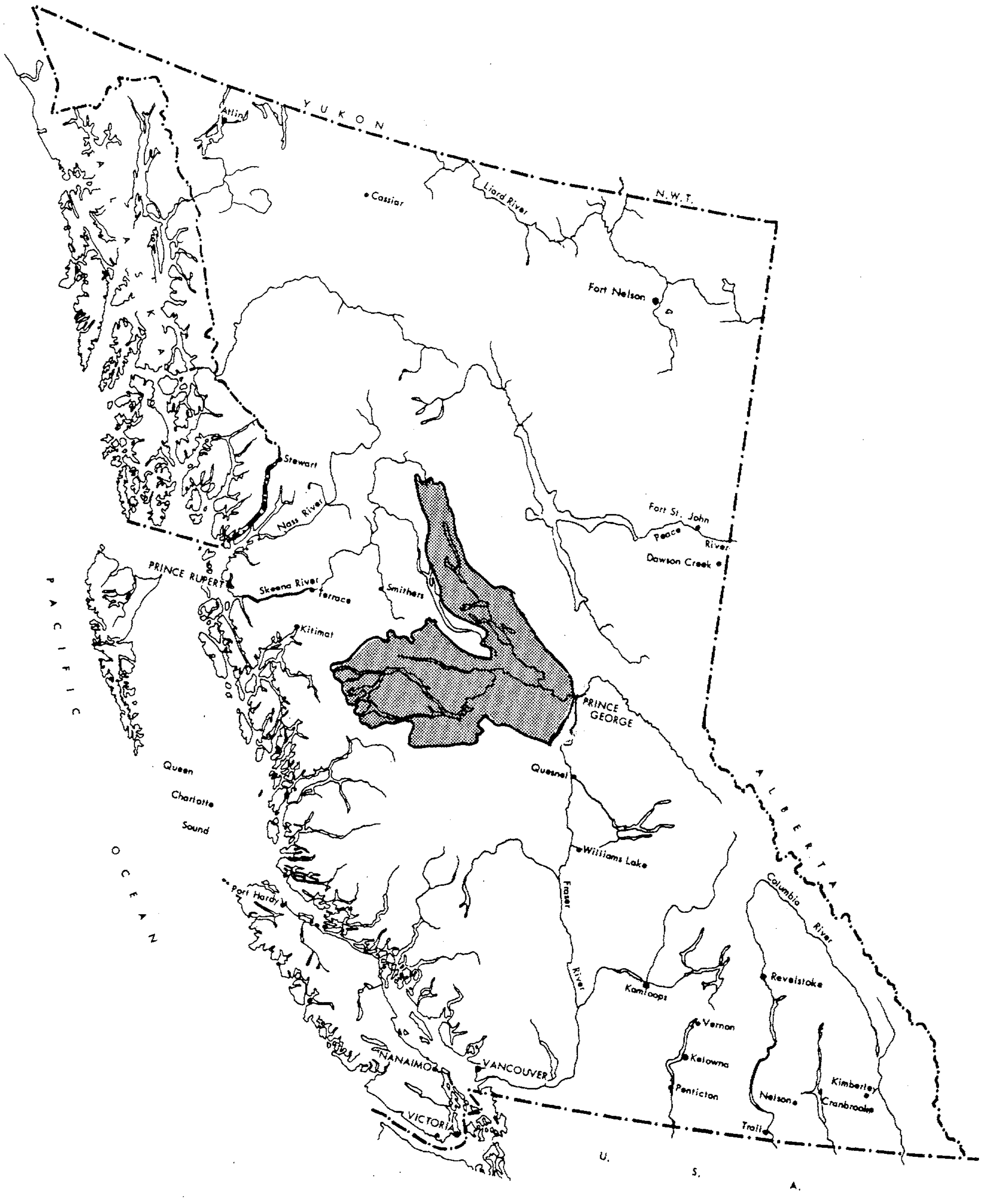


Figure 1 Nechako River Basin

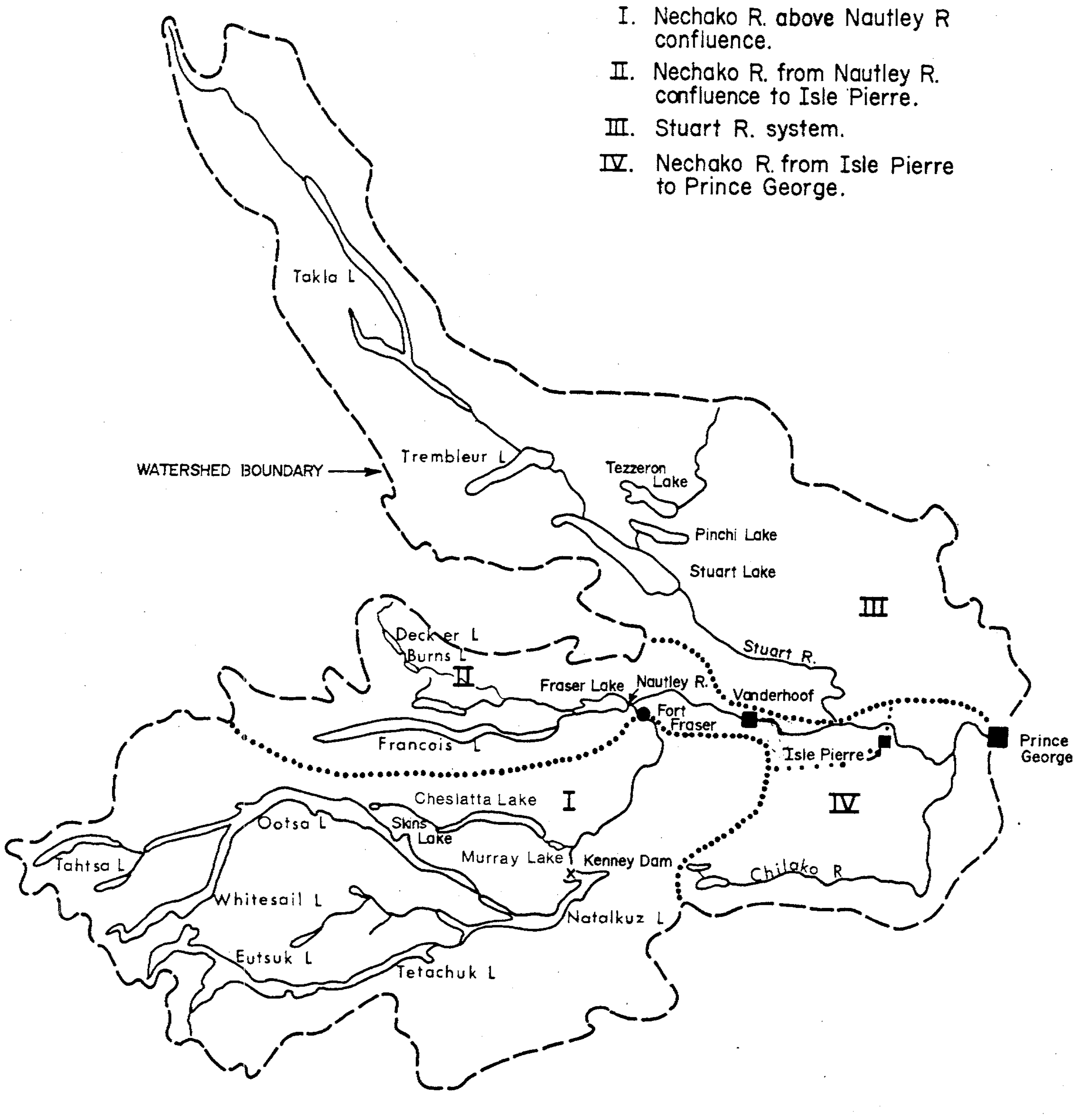


Figure 2. Sub-Basins of the Nechako River Watershed.

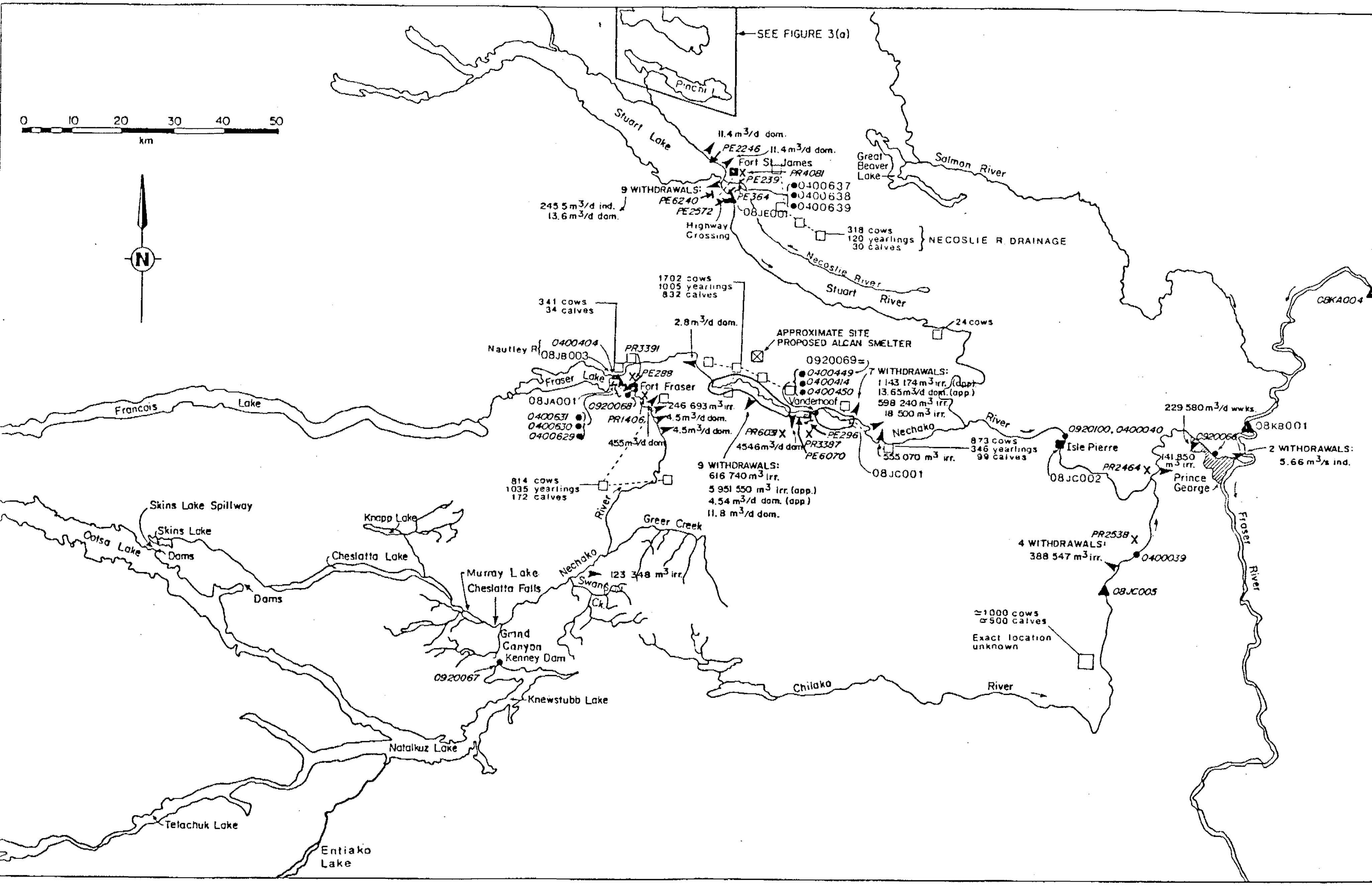


Figure 3. Locations of Waste Discharges, Ambient Water Quality Monitoring Sites, and Licensed Water Withdrawals.

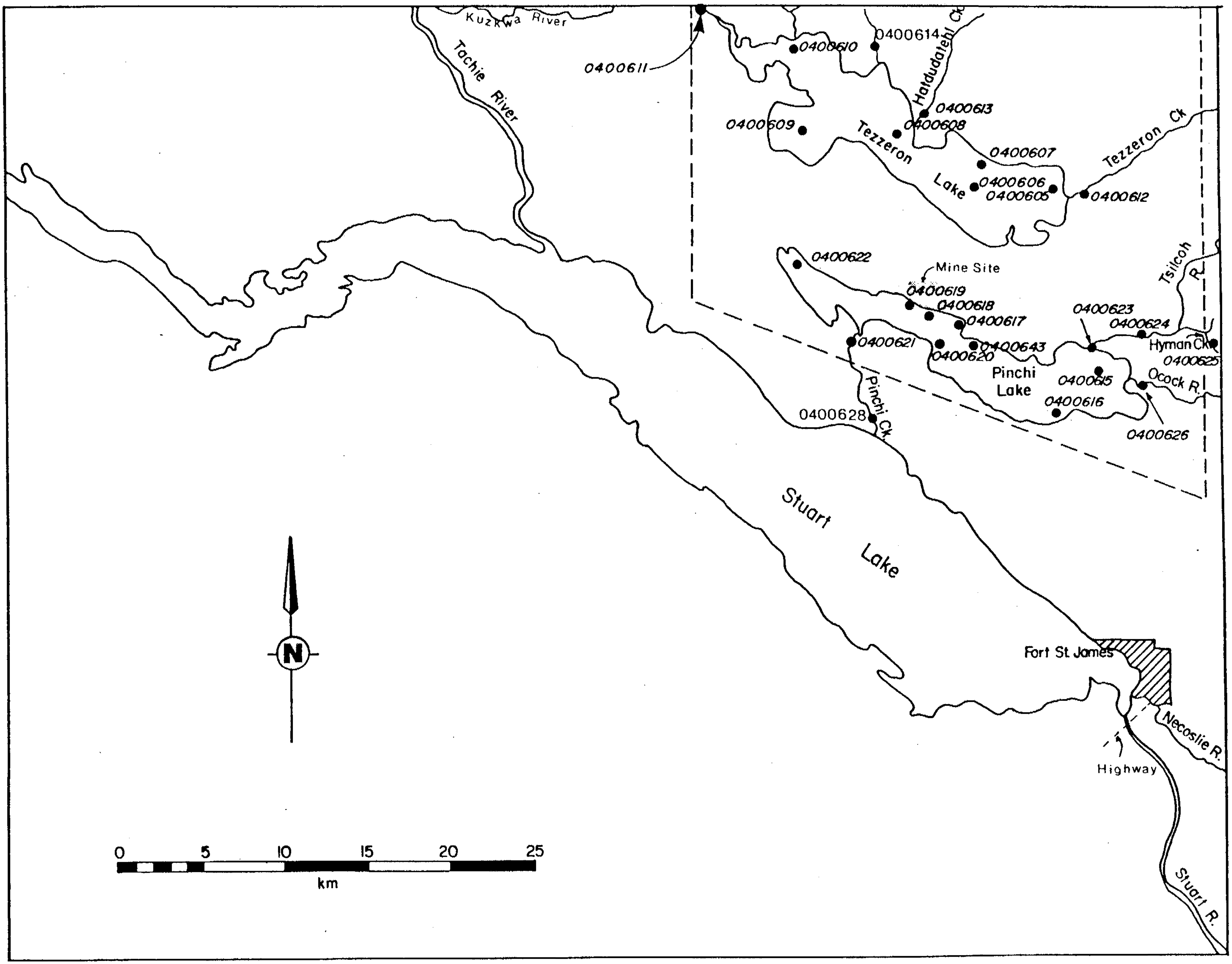
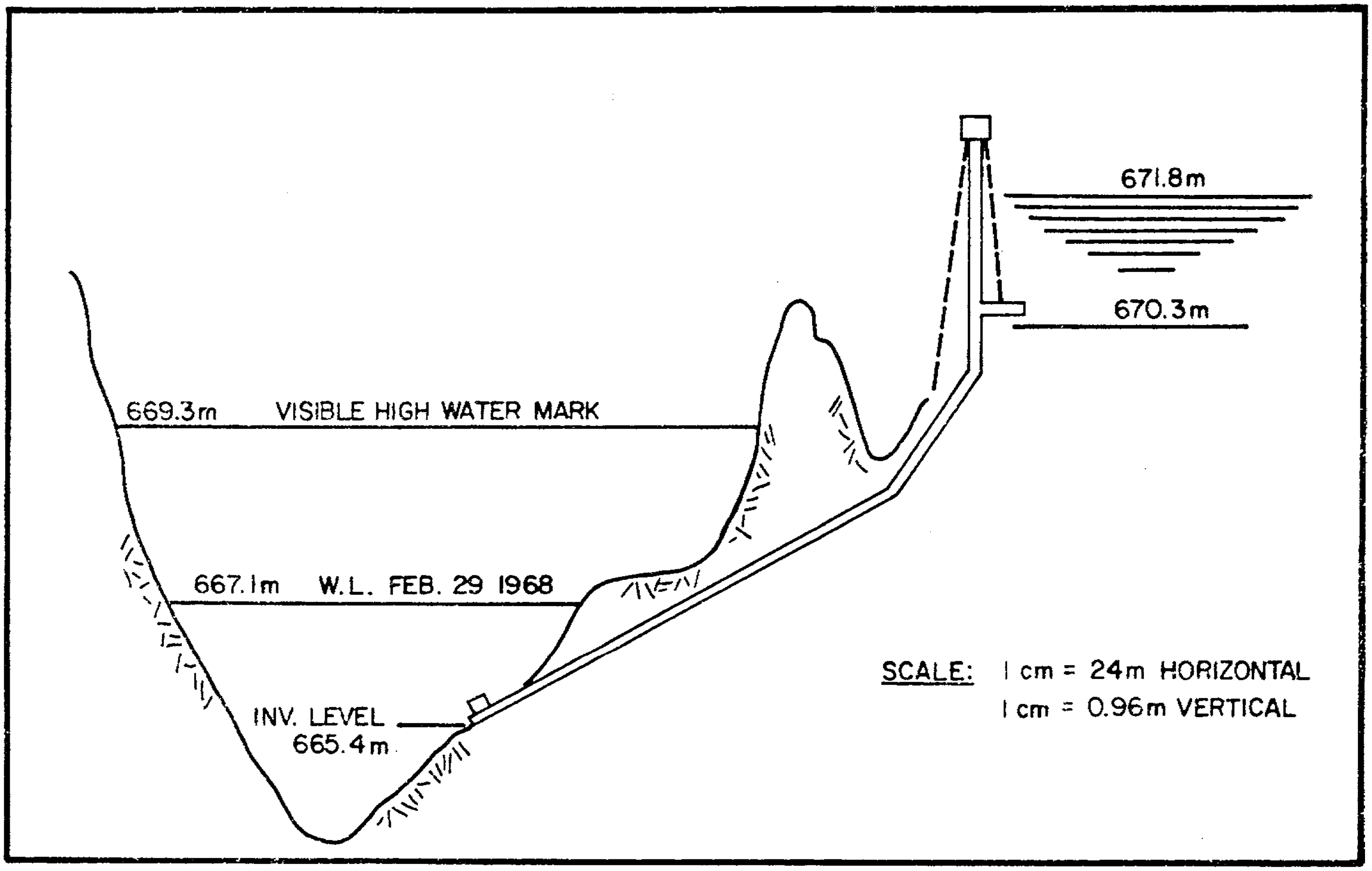


Figure 3(a). Locations of Ambient Water Quality Monitoring Sites near Pinchi and Tezzeron Lakes.



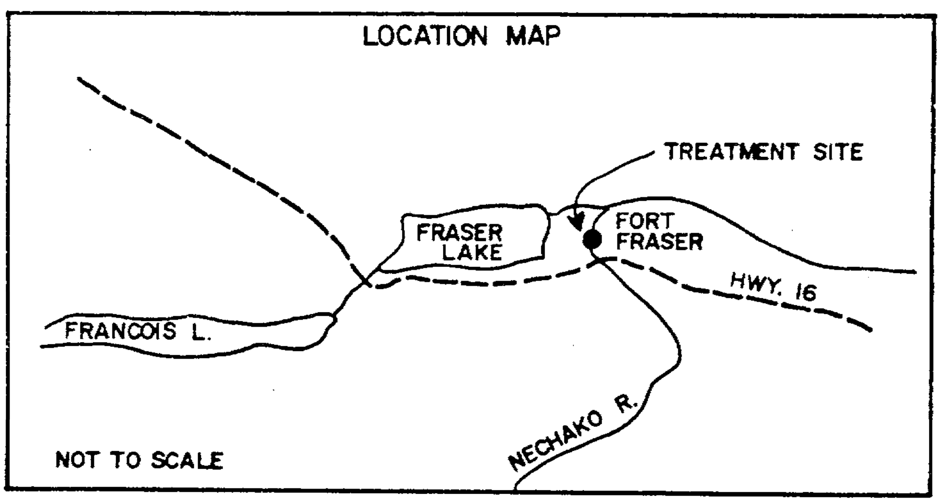
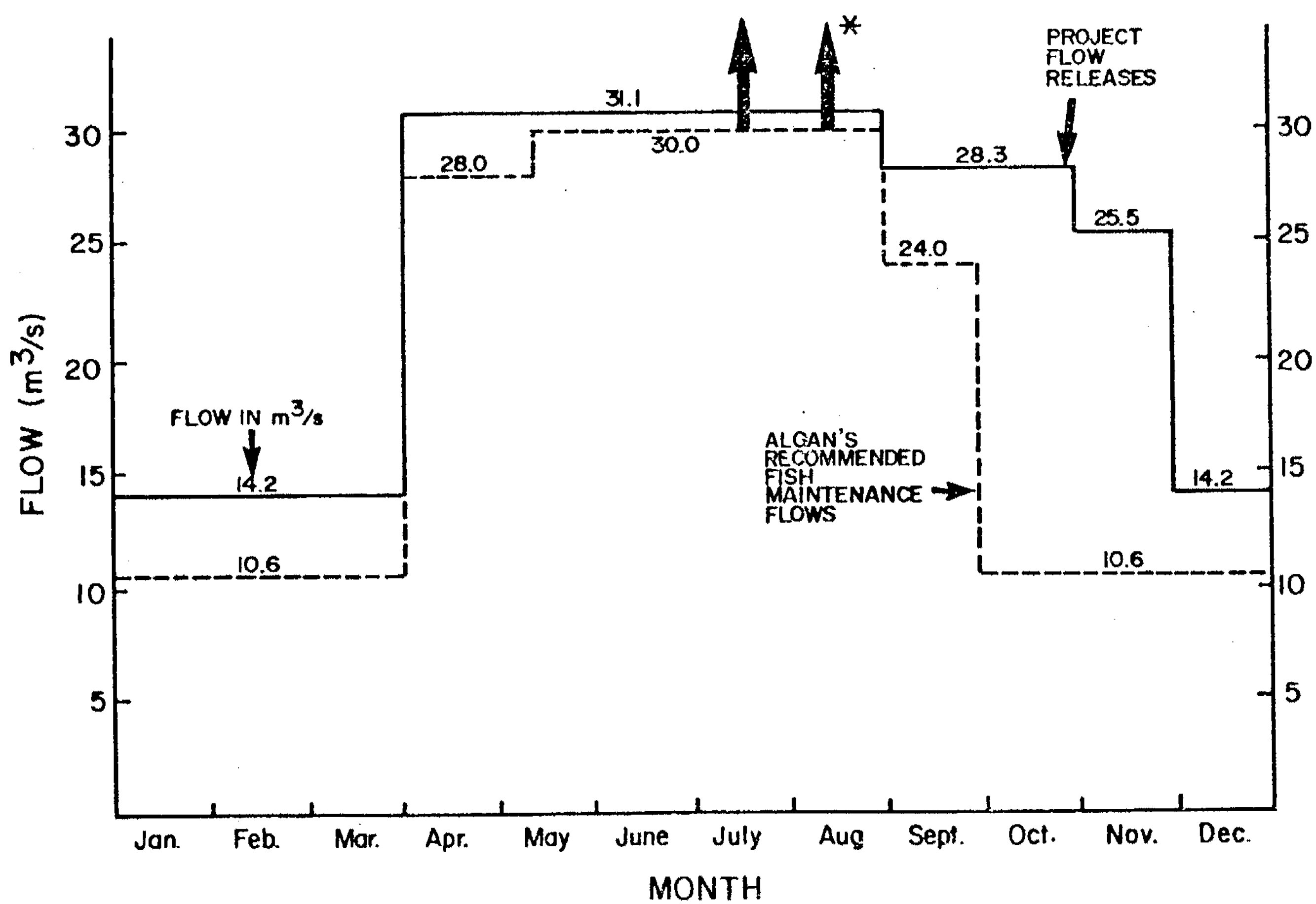


Figure 4. Profile of existing outfall main from the Bulkley-Nechako (Fort Fraser) Sewage Treatment Facility.

(after Envirocon Ltd., Volume 15B, Figure 7.1)



* additional cooling water releases, as required, in July and August (Section F)

Figure 5. Proposed flow regime for the Nechako River at Cheslatta Falls (by Alcan)

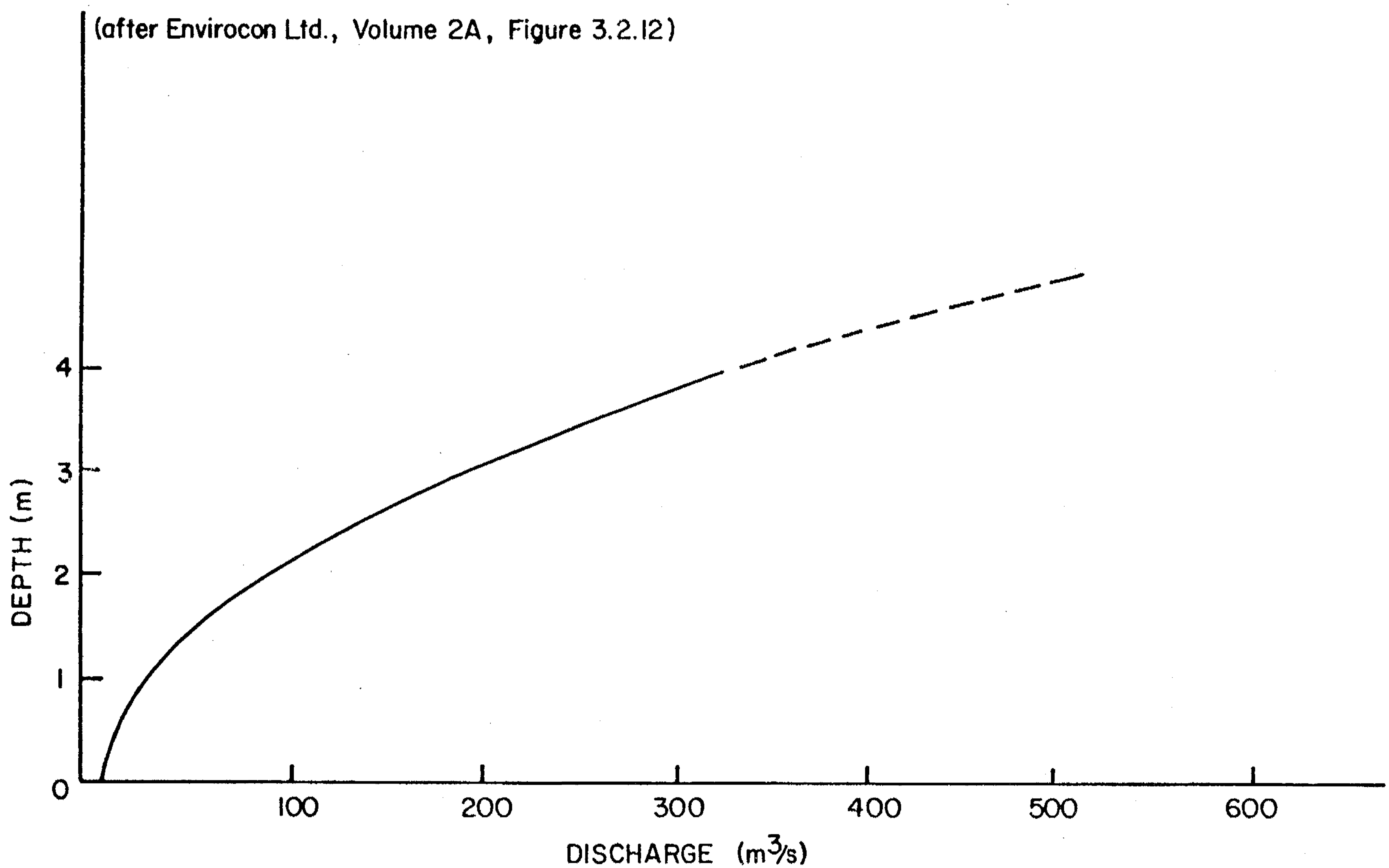


Figure 6. Stage–Discharge Curve for the Nechako River at Fort Fraser (at Archie Adam's farm).

TABLE 1
CALCULATED ANNUAL AVERAGE
7-DAY LOW FLOWS:NECHAKO RIVER
AT FORT FRASER (1978-1983)

YEAR	7-DAY LOW FLOWS (m^3/s)			
	NECHAKO RIVER AT VANDERHOOF 08JC001	NAUTLEY RIVER NEAR FT. FRASER 08JB003	NECHAKO RIVER JUST U/S FROM FT. FRASER* (BY DIFFERENCE)	NECHAKO RIVER D/S CHESLATTA FALLS 08JA017
1984	36.2 (Dec)	-	-	-
1983	31.0 (Dec)	5.97 (Mar)***	-	-
	34.1 (Mar)***	7.15 (Dec)	23.85 (Dec)**	30.3 (Dec)
1982	38.2 (Jan)	6.4 (Jan)	31.8	34.4 (Dec)
1981	37.0 (Oct)	6.6 (Dec)***	-	-
	38.2 (Dec)***	8.8 (Oct)	28.2 (Oct)**	28.9 (Oct)
	48.8 (Oct-Nov)	10.1 (Oct-Nov)	-	-
1980	15.3 (Feb)+	4.5 (Feb)	10.8+	-
	38.2 ****	-	-	-
1979	18.1 (Dec)+	3.4 (Dec)	14.7+	-
1978	40.4 (Nov)+	8.5 (Mar)***	-	-
	63.5 (Mar)***	11.4 (Nov)	29 + (Nov)**	-
MEAN	-	5.9	23.1	31.2

\+ Pre-injunction flow.

* Calculated by subtracting 7-day low flows of Nautley R. from 7-day low flows of Nechako R. at Vanderhoof.

** Lowest calculated 7-day low flow using 7-day low flow figures from the same months at both stations.

*** Not used in calculation of 7-day low flow at Fort Fraser.

**** 1980 post-injunction low flow.

TABLE 2
EFFLUENT DATA SUMMARY
REGIONAL DISTRICT OF BUCKLEY-NECHAKO (FORT FRASER)
SEWAGE TREATMENT FACILITY

Characteristic		Period of Record	No. of Values	Values* Maximum	Minimum	Mean
Coliforms	- fecal	1973-1984	27	1 600 000	< 200	92 000+
	- total	1972-1980	23	2 200 000	<2000	130 000+
Flow		1972-1983	17	250	42.55	122.3
Nitrogen	- ammonia (total)	1976-1983	9	36.2	0.082	13.1
	- ammonia(un-ionized)	1976-1983	9	0.712	0.01	0.192
	- nitrate/nitrite	1976-1983	6	0.1	<0.02	0.04
	- Kjeldahl	1976-1983	9	40	10	21.6
	- organic	1976-1983	9	17.42	<0.01	8.5
	- total	1976-1983	9	40	10	21.6
Oxygen	- BOD_5	1972-1983	45	138	<10	56
	- dissolved	1976	4	16.8	0.3	4.55+
pH		1972-1983	35	9.6	6.6	7.4+
Phosphorus	- ortho	1976-1983	9	6.85	0.504	3.37
	- total dissolved	1977-1983	5	6.92	3.08	4.98
	- total	1976-1983	9	7.52	1.92	4.76
Solids	- suspended	1972-1983	44	299	15.7	76
Temperature		1972-1979	8	18.5	1	12

\+ Median
* Values are as mg/L except : (1) coliforms as MPN/100 mL
(2) Flow as m^3/d
(3) pH
(4) Temperature as °C

Data Collected by Ministry of Environment and Parks

TABLE 3
AMBIENT WATER QUALITY DATA SUMMARY
NECHAKO RIVER DOWNSTREAM FROM NAUTLEY RIVER (Site 0400629)

Characteristic	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Alkalinity	1976-1982	3	27.7	27	27.5
Arsenic	1982-1983	3	<0.25	<0.25	<0.25
Carbon - inorganic	1976	1	6	-	-
- organic	1976	2	8	6	-
Coliforms - fecal	1976-1983	5	49	2	11+
- total	1976	1	350	-	-
Colour TAC	1976	1	18	-	-
Hardness - total as $CaCO_3$	1976-1983	5	28.5	24.7	27.2
- calcium as Ca	1982-1983	3	8.97	8.58	8.93
- magnesium as Mg	1982-1983	3	1.49	1.35	1.42
Metals (total):					
Aluminum	1982-1983	3	0.08	0.03	0.05
Cadmium	1982-1983	3	<0.01	<0.0005	<0.0005+
Chromium	1982-1983	3	<0.01	<0.01	<0.01
Copper	1982-1983	3	<0.01	<0.001	0.003+
Iron	1982-1983	3	0.33	0.09	0.17
Lead	1982-1983	3	<0.01	0.003	0.004+
Manganese	1982-1983	3	0.04	0.01	0.02
Molybdenum	1982-1983	3	0.01	<0.01	<0.01+
Nickel	1982-1983	3	<0.05	<0.01	<0.01+
Zinc	1982-1983	3	0.03	<0.01	<0.01+
Nitrogen:					
Ammonia	1976-1983	6	0.033	<0.005	<0.005+
Nitrite	1976-1983	6	<0.005	<0.005	<0.005
Nitrate/Nitrite	1976-1983	5	0.02	<0.02	<0.02+
Organic	1976-1983	6	0.32	0.11	0.17
Kjeldahl	1976-1983	6	0.35	0.11	0.18
Total	1976-1983	6	0.37	0.11	0.18
Oxygen:					
BOD_5	1976	2	<10	<10	-
Dissolved	1976	2	10	10	10
% Saturation	1976	2	92.6	87.2	89.9
pH	1976-1983	7	7.6	6.8	7.5+
Phosphorus:					
Total Dissolved	1982-1983	4	0.011	0.005	0.007
Ortho	1976-1983	6	0.003	<0.003	<0.003+
Total	1976-1983	6	0.071	0.007	0.029
Solids:					
Dissolved	1976-1983	7	60	41	46
Suspended	1976-1983	7	56	2	16
Total	1976-1983	7	116	44	62
Specific Conductivity	1976-1983	7	67	58	62
Temperature	1976	2	10.5	8	9.2
Turbidity	1976-1982	4	18	0.8	7.7

TABLE 3 (Continued)

\+ Median

* All values are as mg/L except:
(1) Coliforms as MPN/100 mL
(2) Colour
(3) pH
(4) Specific conductivity as µS/cm
(5) Temperature as °C
(6) Turbidity as NTU
(7) % Saturation as percent

Data Source: Ministry of Environment and Parks

TABLE 4

COMMON WATER QUALITY CHARACTERISTICS AND CRITERIA FOR SPECIFIC WATER USES

Characteristic	Most Restrictive Criteria	Associated Use	Reference
Alkalinity	>20 mg/L	aquatic life	12
	<25% change	aquatic life	13,18
Arsenic	0.05 mg/L	aquatic life & drinking	10,12,18
Chloride	250 mg/L	public water supplies/food processing	11
Coliform - fecal	0-100 MPN/100 mL	public water	11
		supplies/food	11
		processing	11
	200 MPN/100 mL	recreation	12
	400 MPN/100 mL	recreation	12
Colour	15-100 TCU	recreation	12
	15- 75 TCU	public water supplies/food processing	11,19
Dissolved Oxygen	7.75 mg/L	aquatic life (mixed freshwater)	16
Fluoride	1.0 mg/L	aquatic life	10
Hardness	80-100 mg/L	public water supplies/food processing	11
Metals:			
Aluminum	0.05-0.10 mg/L	aquatic life	13
Boron	0.75-3.0 mg/L	irrigation waters	12,13,18
Cadmium	0.0002-0.0004 mg/L	aquatic life, species dependent	10
Chromium	0.02-0.04 mg/L	aquatic life	10

TABLE 4 (Continued)

Characteristic	Most Restrictive Criteria	Associated Use	Reference
Copper	0.002 mg/L	aquatic life and wildlife	10
	max = $e^{(0.8545[\ln (\text{hardness})]-1.465)}$ avg = $e^{(0.9422[\ln (\text{hardness})]-1.464)}$	aquatic life	29
Iron	0.3 mg/L	aquatic life; public water supplies/food processing	10,11
Lead	0.005 mg/L	aquatic life	10
	max = $e^{(1.266[\ln (\text{hardness})]-4.661)}$ avg = $e^{(1.266[\ln (\text{hardness})]-1.416)}$	aquatic life	29
Manganese	0.05 mg/L	public water supplies/food processing	11
Mercury	0.0001 mg/L	protect consumers of fish	10
Molybdenum	0.01-0.05 mg/L	irrigation	13
Nickel	0.025 mg/L	aquatic life	10
Silver	0.0001 mg/L	aquatic life	10
Zinc	0.05-0.3 mg/L	aquatic life and wildlife, dependent upon hardness	10
Nitrogen:			
Ammonia	Tables 31 and 32	aquatic life	14
Nitrite	0.02 mg/L (average) 0.06 mg/L (maximum)	aquatic life	14

TABLE 4 (Continued)

Characteristic	Most Restrictive Criteria	Use	Reference
Pentachlorophenol	0.0004 mg/L	aquatic life	15
pH	6.5 - 9.0	aquatic life	12
Potassium	20 mg/L	livestock watering	21
Solids:			
Suspended	25 mg/L (high level protection) 80 mg/L (moderate protection) 400 mg/L (low protection)	aquatic life	13
Dissolved	500 mg/L	public water supplies/food processing	11
Sodium	20 mg/L	public water supplies/food processing	11
Specific Conductivity	750-7500 µS/cm	irrigation	11
Sulphate	150 mg/L (taste)	public water supplies/food processing	11
Temperature	15° C	public water supplies	11
	18 - 19° C	aquatic life (maximum weekly average for adult and juvenile salmonids)	12
Turbidity	5 NTU	public water supplies	11

TABLE 5

7-DAY LOW FLOWS AND PERCENTAGE OF FLOWS

YEAR	NECHAKO RIVER AT VANDERHOOF 08JC001	NAUTLEY RIVER NEAR FORT FRASER 08JB003		STUART RIVER NEAR FORT ST. JAMES 08JE001	
	Flow (m^3/s)	Flow (m^3/s)	%*	Flow (m^3/s)	%**
1983	31.0	6.0	25.0	No Data	-
1982	38.2	6.4	20.1	33.5	87.7
1981	37.0	6.6	23.4	41.8	113.0
1980	15.3	4.5	41.7	28.2	184.3
1979	18.1	3.4	23.1	39.4	217.7
1978	40.4	8.5	29.3	34.0	84.2
1977	62.0	11.2	-	47.3	76.3
1976	96.7	14.0	-	42.1	43.5
1975	52.4	No Data	-	41.4	79.0
1974	57.1	No Data	-	36.6	64.1
1973	47.4	9.6	-	45.0	94.9
Pre-1973	59.0	10.6	-	40.4	68.5
Mean	53.5	9.8	-	40.1	74.9
Mean 1980-1983	30.4	5.9	27.6	34.5	128.3

* % of 7-day low flow for same year of Nechako River at Fort Fraser (Table 1)

** % of 7-day low flow for same year of Nechako River at Vanderhoof (This Table)

TABLE 6
RECURRENCE INTERVALS FOR 7-DAY LOW FLOWS

Rank	NAUTLEY RIVER NEAR FORT FRASER 08JB003		STUART RIVER NEAR FORT ST. JAMES 08JE001	
	7-day low flow (m^3/s)	Recurrence Interval (yrs)	7-day low flow (m^3/s)	Recurrence Interval (yrs)
1	0.9	31	23.25	49
2	3.4	15.5	24.32	24.5
3	4.5	10.3	25.43	16.33
4	5.7	7.75	26.16	12.25
5	6.0	6.2	26.48	9.8
6	6.1	5.17	26.99	8.17
7	6.26	4.43	27.41	7
8	6.4	3.88	28.2	6.13
9	6.6	3.44	28.32	5.44
10	6.6	3.1	29.17	4.9
11	7.05	2.82	32.56	4.45
12	7.48	2.58	32.85	4.08
13	7.93	2.38	33.13	3.77
14	8.5	2.21	33.5	3.5
15	8.72	2.07	33.70	3.27
16	9.6	1.94	34.0	3.06
17	9.91	1.82	36.53	2.88
18	10.22	1.72	36.53	2.72
19	10.45	1.63	36.53	2.58
20	10.73	1.55	36.6	2.45
21	11.2	1.48	37.09	2.33
22	11.55	1.41	37.38	2.23
23	12.94	1.35	37.38	2.13
24	13.7	1.29	38.79	2.04
25	13.99	1.24	39.36	1.96
26	14	1.19	39.4	1.88
27	14.84	1.15	39.93	1.81
28	18.80	1.11	39.93	1.75
29	19.25	1.07	41.06	1.69
30	20.02	1.03	41.4	1.63
48	-	-	73.90	1.02

Rank indicates the order of 7-day low flows, from the smallest to the largest.

TABLE 7

EFFLUENT DATA SUMMARY

FORT ST. JAMES SEWAGE TREATMENT FACILITY

(PE 239)

Characteristic	Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean
Chlorine Residual	1978-1984	32	3	0	0.22 0.1** 0.27***
Coliform - Fecal	1972-1984	37	1 600 000	<20	240 000+
Flow	1979-1984	7	954.7	104.6	591.6
Nitrogen - ammonia	1976-1984	11	21.9	4.28	16.5
Phosphorus- ortho	1976-1984	10	4.3	0.13	2.94
- total diss.	1976-1984	10	4.36	2.64	3.53
Oxygen - BOD_5	1972-1984	66	185	12	58.9 76** 96***
Solids - suspended	1972-1984	40	284	4	36 38** 55***

+ Median
* Values are as mg/L except Flow as m^3/d
** 75th percentile
*** 90th percentile

Data Source: Ministry of Environment and Parks

TABLE 8
EFFECT OF DISCHARGE FROM
FORT ST. JAMES SEWAGE TREATMENT
FACILITY ON THE NECOSLIE RIVER

Characteristic	Date	0400637 UPSTREAM	0400638 INITIAL DILUTION ZONE	0400639 DOWNSTREAM 100 m
Coliform - fecal	76 06 15	33	7	49
	83 04 19	49	-	-
	83 12 14	-	-	920 000
	84 02 22	-	-	350 000
Nitrogen - ammonia	76 06 15	0.039	0.03	0.042
	83 04 19	0.019	-	0.244
	83 09 15	0.008	-	1.03
	83 12 14	-	-	18.1
	84 02 22	-	-	11
Oxygen - BOD_5	83 12 14	-	-	39
	84 02 22	-	-	39
pH	76 06 15	7.4	7.3	7.6
	83 04 19	7.7	-	7.5
	83 09 15	8.0	-	7.9
Phosphorus- ortho	76 06 15	0.023	0.018	0.013
	83 04 19	0.015	-	-
	83 09 15	<0.003	-	0.217
	83 12 14	-	-	3.32
	84 02 22	-	-	2.1
- total	76 06 15	0.181	0.063	0.051
	83 04 19	0.39	-	-
	83 09 15	0.046	-	0.362
	83 12 14	-	-	4.05
	84 02 22	-	-	2.48
Solids - suspended	76 06 15	37	12	12
	83 04 19	323	-	-

* All values are mg/L except:
(1) Coliform-fecal as MPN/100 mL
(2) pH

Data Source: Ministry of Environment and Parks

TABLE 9
EFFLUENT DATA SUMMARY
BCBC FORT ST. JAMES RANGER STATION

Characteristic	Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean
Chlorine Residual	1973-1984	33	3.5	0	0.8 0.4+
Coliform - Fecal	1976-1984	35	>2 400 000	<2	1 700+
	1981-1984	16	11 000	<20	410
Flow	1975-1984	58	8.5	<1.4	6.6
Nitrogen - ammonia	1978-1984	4	24.3	0.06	9.3
Oxygen - BOD_5	1973-1984	43	392	<10	27+
pH	1973-1984	37	9.3	4.6	7.5+
Solids - suspended	1973-1984	43	452	10	85 55+

\+ Median
* All values are mg/L except:
(1) Coliforms MPN/100 mL
(2) Flow as m^3/d

Data Source: Permittee and Ministry of Environment and Parks

TABLE 10
EFFLUENT DATA SUMMARY
T. GOODSON TRAILER PARK (PE 364)

Characteristic	Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean
Chlorine Residual	1973-1983	24	0.7	0	0.1
Coliform - Fecal	1973-1983	24	>2 400 000	80	28 500+
Flow (m^3/s)	1976-1978	2	0.00053	0.00015	0.00034
(m^3/d)	1979-1983	10	32.7	10.5	17.6
Nitrogen - ammonia	1976	1	3.8	-	-
Oxygen - BOD_5	1972-1983	27	154	<10	72
pH	1972-1983	24	8.1	6.7	7.25+
Solids - suspended	1972-1983	26	286	13	79 53+

+ Median value
* Values are as mg/L except:
  (1) pH
  (2) Flow (as noted)
  (3) Coliform - fecal as MPN/100 mL

Data Source: Ministry of Environment and Parks

TABLE 11
EFFECT OF DISCHARGE FROM
T. GOODSON TRAILER PARK
ON THE STUART RIVER

Characteristic	0400640 UPSTREAM	0400641 INITIAL DILUTION ZONE	0400642 DOWNSTREAM 100 m
Coliform - fecal	23	79	110
Nitrogen - ammonia	0.034	0.02	0.025
- organic	0.33	0.39	0.38
Oxygen - BOD_5	<10	<10	<10
pH	7.8	7.7	7.7
Phosphorus- ortho	0.004	0.003	<0.003
- total	0.029	0.038	0.025
Solids - suspended	9	14	10
- total	94	102	104
Turbidity	8.7	12	8.7

* All values are as mg/L except:
(1) Coliform - fecal as MPN/100 mL
(2) pH
(3) Turbidity as NTU

Data Collected in 1976
Data Source: Ministry of Environment and Parks

TABLE 12
EFFLUENT DATA SUMMARY
WILLICK LOGGING TRAILER PARK (PE 2572)

Characteristic	Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean
Chlorine Residual	1977-1981	3	0	0	0
Coliform - Fecal	1976-1984	23	5 400 000	2 000	160 000+
Flow (m^3/s)	1978	1	0.00012	-	-
(m^3/d)	1979-1983	8	28.6	9.1	16.7
Nitrogen - ammonia	1976	1	43.2	-	-
Oxygen - BOD_5	1975-1984	27	482	15	91
pH	1975-1984	24	9.1	7.1	7.4+
Solids - suspended	1975-1983	24	190	5	63

+ Median
* Values are as mg/L except:
  (1) pH
  (2) Flow (as noted)
  (3) Coliform-fecal as MPN/100 mL

Data Source: Ministry of Environment and Parks

TABLE 13
EFFECT OF DISCHARGE FROM
R. WILLICK TRAILER PARK ON STUART RIVER

Characteristic	0400634 UPSTREAM	0400635 INITIAL DILUTION ZONE	0400636 DOWNSTREAM 100 m
Coliform - fecal	<2	7	2
Nitrogen - ammonia	0.015	0.02	0.017
- organic	1.99	0.24	0.39
Oxygen - BOD_5	<10	<10	<10
pH	7.8	7.7	7.7
Phosphorus - ortho	<0.003	<0.003	<0.003
- total	0.019	0.013	0.013
Solids - suspended	8	2	1
- total	84	74	76
Turbidity	7.8	1.8	1.4

* All values are as mg/L except:
(1) Coliform - fecal as MPN/100 mL
(2) pH
(3) Turbidity as NTU

Data Collected: June 15, 1976
Data Source: Ministry of Environment and Parks

TABLE 14
EFFECT OF FORT ST. JAMES
REFUSE SITE ON THE NECOSLIE RIVER

Characteristic	Date	0400644 Upstream	0400645 Opposite Site	0400646 Downstream 100 m	0400647 Swamp on Tributary
Colour	76 11 02	16	16	16	70
	77 09 20	-	26	23	-
Iron	76 06 23	1.7	1.7	2	1
	76 07 29	1.3	1.3	1.4	-
	76 11 02	0.8	0.7	0.8	3.9
	77 09 20	-	1.7	1.5	0.6
	78 04 18	-	7	-	3.4
	78 06 15	-	3.9	-	0.9
	83 04 19	-	16.8	-	-
	83 09 15	-	0.61	-	-
Manganese	76 06 23	0.08	0.09	0.08	0.07
	76 07 29	0.13	0.14	0.11	-
	77 09 20	-	1.18	0.3	-
	78 06 15	-	-	-	0.02
	83 04 19	-	0.5	-	-
	83 09 15	-	0.56	-	-
Nitrogen - ammonia	76 06 23	0.035	0.025	0.033	0.07
	76 07 29	0.034	0.029	0.024	0.077
	76 11 02	0.035	0.052	0.046	0.033
	77 09 20	-	0.105	0.035	0.023
	78 04 18	-	0.046	-	-
	78 06 15	-	0.022	-	-
	83 04 19	-	0.02	-	-
	83 09 15	-	0.007	-	-
pH	76 06 23	7.6	7.6	7.7	7.8
	76 07 29	8.1	8.1	8.2	7.1
	76 11 02	8.1	8.1	7.9	7.0
	77 09 20	-	7.9	8.0	8.1
	78 04 18	-	7.5	-	-
	78 06 15	-	8.3	-	-
	83 04 19	-	7.5	-	-
	83 09 15	-	7.6	-	-
Phosphorus					
- total diss.	76 06 23	0.019	0.018	0.015	0.114
- ortho	76 07 29	0.007	0.007	0.006	-
	76 11 02	<0.003	<0.003	<0.003	0.039
	77 09 20	-	<0.003	<0.003	-
	78 04 18	-	0.021	-	0.046
	78 06 15	-	0.014	-	0.006
	83 09 15	-	0.003	-	-
- total	76 06 23	0.066	0.068	0.059	0.178
	76 07 29	0.042	0.043	0.056	-
	76 11 02	0.018	0.042	0.023	0.465
	77 09 20	-	0.059	0.041	-
	78 04 18	-	0.135	-	0.31
	78 06 15	-	0.059	-	-
	83 09 15	-	0.047	-	-

TABLE 14 (Continued)

Characteristic	Date	0400644 Upstream	0400645 Opposite Site	0400646 Downstream 100 m	0400647 Swamp on Tributary
Solids - suspended	76 06 23	16	14	20	8
	76 07 29	15	14	28	89
	76 11 02	9	36	6	19
	77 09 20	-	23	22	2
	78 04 18	-	109	-	-
	78 06 15	-	40	-	-
Specific Conductivity	76 06 23	134	134	135	199
	76 07 29	215	216	213	450
	76 11 02	520	500	530	439
	77 09 20	-	395	330	470
	78 04 18	-	157	-	-
	78 06 15	-	204	-	-
	83 04 19	-	88	-	-
	83 09 15	-	1 190	-	-
Turbidity	76 06 23	16	14	18	1.8
	76 07 29	13	12	19	14
	76 11 02	7.4	13	6.6	-
	77 09 20	-	21	20	-

* Values are as mg/L except:
(1) Colour
(2) pH
(3) Specific Conductivity as µS/cm
(4) Turbidity as NTU

Data Source: Ministry of Environment and Parks

TABLE 15

AMBIENT WATER QUALITY DATA SUMMARY

TRIBUTARIES OF TEZZERON LAKE

Characteristic	Site 0400611 Kuzkwa River near Lake Outlet					Site 0400612 Tezzeron Creek near Lake				
	Period of Record	No. of Values	Values*			Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean			Maximum	Minimum	Mean
Alkalinity	1976	2	56	53.6	54.8	1976	1	70	-	-
Arsenic	1976	1	<0.005	-	-	-	-	-	-	
Carbon: - Organic	1976	2	9	8	8.5	1976	1	6	-	-
- Inorganic	1976	2	14	13	13.5	1976	1	18	-	-
Colour TAC	1976	2	18	13	15.5	1976	1	12	-	-
Hardness - calcium	1976	3	55.8	13.9	28.6	1976	2	49.6	17.9	33.7
- magnesium	1976	3	17	4.1	8.5	1976	2	15.1	5	10.1
- total	1976	3	209	51.6	58.6+	1976	2	186	65.3	125.7
Metals: (total)										
- Cadmium	1976-1977	3	<0.0005	<0.0005	<0.0005	1976-1977	3	<0.0005	<0.0005	<0.0005
- Chromium	1976-1977	3	<0.005	<0.005	<0.005	1976-1977	2	<0.005	<0.005	<0.005
- Copper	1976-1977	3	0.003	<0.001	0.002+	1976-1977	2	0.002	0.002	0.002
- Iron	1976-1977	3	7.3	0.1	0.2+	1976-1977	3	2.7	0.5	0.7+
- Lead	1976-1977	3	0.099	<0.001	0.002+	1976-1977	3	0.019	<0.001	<0.001+
- Manganese	1976-1977	3	<0.02	<0.02	<0.02	1976-1977	2	0.04	0.04	0.04
- Mercury	1976-1977	3	<0.00005	<0.00005	<0.00005	1976-1977	2	<0.00005	<0.00005	<0.00005
- Molybdenum	1976-1977	3	0.0008	<0.0005	<0.0005+	1976-1977	2	0.0015	0.0012	0.0013
- Nickel	1976-1977	3	<0.01	<0.01	<0.01	1976-1977	2	<0.01	<0.01	<0.01
- Zinc	1976-1977	3	0.007	<0.005	<0.005+	1976-1977	2	0.006	<0.005	-
Nitrogen: - Ammonia	1976	3	0.255	0.013	0.02+	1976	2	0.273	0.013	0.143
- Nitrate/nitrite	1976	3	0.07	<0.02	<0.02+	1976	2	0.06	<0.02	-
- Organic	1976	3	0.55	0.21	0.22+	1976	2	0.3	0.15	0.22
Oxygen - dissolved	1976	1	10.7	-	-	-	-	-	-	
pH	1976	3	7.9	7.5	7.7+	1976	2	8	7.2	7.6
Phosphorus:										
-ortho	1976	3	0.003	<0.003	<0.003+	1976	2	0.006	0.004	0.005
-total dissolved	1976	1	0.01	-	-	1976	1	0.008	-	-
-total	1976	3	0.176	0.008	0.012+	1976	2	0.139	0.016	0.078
Solids: - Suspended	1976	3	50	2	2+	1976	2	37	3	20
- Total	1976	2	308	92	-	1976	1	288	-	-
Specific Conductivity	1976	3	430	114	115+	1976	2	400	146	273
Temperature	1976	1	13.5	-	-	-	-	-	-	-
Turbidity	1976	2	1.1	0.7	0.9	1976	1	2.1	-	-

* All values are as mg/L except:
- (1) Coliform-fecal as MPN/100 mL
- (2) Colour
- (3) Oxygen % saturation as percent
- (4) pH
- (5) Specific Conductivity as µS/cm
- (6) Temperature as °C
- (7) Turbidity in NTU

\+ Median Value

Data Source: Ministry of Environment and Parks

TABLE 15 (Continued)

Characteristic	Site 0400613 Hatdudatehl Cr. at Lake				
	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Alkalinity	1976	2	92.5	53	72.8
Arsenic	1976	1	<0.005	-	-
Carbon: - Organic	1976	2	9	7	8
- Inorganic	1976	2	25	14	19.5
Colour TAC	1976	2	28	15	21.5
Hardness - calcium	1976	3	39.2	17.5	27.5
- magnesium	1976	3	11.3	2.9	6.4
- total	1976	3	144	55.6	95.1
Metals: (total)					
- Cadmium	1976	3	<0.0005	<0.0005	<0.0005
- Chromium	1976-1977	3	<0.005	<0.005	<0.005
- Copper	1976-1977	3	0.01	<0.001	0.003+
- Iron	1976-1977	4	9.4	0.4	0.6+
- Lead	1976-1977	4	0.15	<0.001	<0.001+
- Manganese	1976-1977	3	0.05	0.03	0.04+
- Mercury	1976-1977	3	<0.00005	<0.00005	<0.00005
- Molybdenum	1976-1977	3	0.0006	<0.0005	0.0006
- Nickel	1976-1977	3	<0.01	<0.01	<0.01
- Zinc	1976-1977	3	0.007	<0.005	<0.005
Nitrogen: - Ammonia	1976	3	0.208	0.012	0.013+
-nitrate/nitrite	1976	3	0.09	<0.02	<0.02+
- Organic	1976	3	1.79	0.23	0.23+
- Kjeldahl	1976	3	2	0.24	0.24+
pH	1976	3	8.1	7	7.5+
Phosphorus					
-ortho	1976	3	0.005	<0.003	0.004+
-total dissolved	1976	1	0.01	-	-
-total	1976	3	0.345	0.014	0.018+
Solids: - Suspended	1976	3	85	3	6+
- Total	1976	2	294	96	195
Specific Conductivity	1976	3	324	110	204
Turbidity	1976	2	2.6	2.1	2.4

* All values are as mg/L except: + Median Value

(1) Coliform-fecal as MPN/100 mL
(2) Colour
(3) Oxygen % saturation as percent
(4) pH
(5) Specific Conductivity as μS/cm
(6) Temperature as °C
(7) Turbidity in NTU

Data Source: Ministry of Environment and Parks

TABLE 16
AMBIENT WATER QUALITY DATA SUMMARY
TEZZERON LAKE

Characteristic	Site 0400605					Site 0400606				
	Period of Record	No. of Values	Values*			Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean			Maximum	Minimum	Mean
Alkalinity	1976	10	58.5	47.1	51.5	1976	12	53.8	50.2	51.5
Arsenic	1976	2	0.006	<0.005	-	1976	2	<0.005	<0.005	<0.005
Carbon: - Organic	1976	10	11	8	9.5	1976	12	12	7	9.4
- Inorganic	1976	10	14	11	12.3	1976	12	13	11	12.1
Coliform- fecal	1976	3	13	7	13+	1976	3	33	17	23+
Colour TAC	1976	8	26	10	19.6	1976	10	25	10	20.1
Hardness - calcium	1976	10	15	12	13.6	1976	12	13.9	12.1	13.5
- magnesium	1976	10	4.4	3.5	3.9	1976	12	4.2	3.6	4.1
- total	1976	10	55.6	44.8	50	1976	12	51.7	45	49.5
Metals: (total)										
- Cadmium	1976	10	<0.0005	<0.0005	<0.0005	1976	24	<0.0005	<0.0005	<0.0005
- Chromium	1976	10	0.009	<0.005	0.005	1976	24	<0.005	<0.005	<0.005
- Copper	1976	10	0.004	<0.001	0.002	1976	24	0.009	<0.001	0.002**
- Iron	1976	10	0.6	0.1	0.19	1976	24	0.3	<0.01	0.13
- Lead	1976	10	0.002	<0.001	0.001	1976	24	0.007	<0.001	0.001
- Manganese	1976	10	0.03	<0.02	0.021	1976	24	0.04	<0.02	<0.02+
- Mercury	1976	10	<0.00005	<0.00005	<0.00005	1976	22	0.0001	<0.00005	<0.00005+
- Molybdenum	1976	8	0.0011	0.0006	0.0007	1976	21	0.0011	<0.0005	0.0007
- Nickel	1976	10	<0.01	<0.01	<0.01	1976	24	<0.01	<0.01	<0.01
- Zinc	1976	10	0.014	<0.005	0.006	1976	24	0.04	<0.005	<0.005**
Nitrogen: - Ammonia	1976	10	0.021	0.011	0.016	1976	12	0.025	0.01	0.018
-nitrate/nitrite	1976	6	<0.02	<0.02	<0.02	1976	7	<0.02	<0.02	<0.02
- Organic	1976	10	0.36	0.2	0.28	1976	12	0.43	0.19	0.27
- Kjeldahl	1976	10	0.38	0.22	0.3	1976	12	0.44	0.21	0.30
Oxygen - dissolved	1976	8	10.6	7.8	9.1	1976	8	11	7.2	8.9
-% saturation	1976	8	105.1	83.2	93	1976	8	105.5	65.9	85.6
pH	1976	10	8.1	7.6	7.85+	1976	12	8	7.4	7.7+
Phosphorus										
-ortho	1976	10	<0.003	<0.003	<0.003	1976	12	0.015	<0.003	<0.003++
-total dissolved	1976	2	0.006	0.005	0.005	1976	2	0.006	0.006	0.006
-total	1976	10	0.03	0.011	0.015	1976	12	0.026	0.008	0.014
Solids: - Suspended	1976	10	21	1	5.5	1976	12	3	1	2
- Total	1976	7	108	84	91	1976	10	90	84	87
Specific Conductivity	1976	10	124	95	106	1976	12	115	101	106
Temperature	1976	8	17.5	10	14.9	1976	10	19	8	13
Turbidity	1976	10	5.1	0.8	1.3+	1976	12	1.4	0.6	0.9

\+ Median
++ Median for all values. Higher values were collected in deeper water (>20 m), presumably near sediments.
* All values are as mg/L except:
(1) Coliform-fecal as MPN/100 mL
(2) Colour
(3) Oxygen % saturation as percent
(4) pH
(5) Specific Conductivity as μS/cm
(6) Temperature as °C
(7) Turbidity in NTU
** Median Value. Maximum value recorded for surface sample from July 28, 1976 (12:20 P.M.)

Data Source: Ministry of Environment and Parks

TABLE 16 (Continued)

Characteristic	Site 0400607					Site 0400608				
	Period of Record	No. of Values	Values*			Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean			Maximum	Minimum	Mean
Alkalinity	1976	9	52.5	42	50.3	1976	10	55	53	54.1
Arsenic	1976	2	<0.005	<0.005	<0.005	1976	2	<0.005	<0.005	<0.005
Carbon: - Organic	1976	9	11	8	9.7	1976	10	11	7	9
- Inorganic	1976	9	13	10	11.7	1976	10	14	11	12.7
Coliform- fecal	1976	2	26	8	17	-	-	-	-	-
Colour	1976	7	37	11	21.4	1976	8	68	12	23.2
Hardness - calcium	1976	9	14.1	11.4	13.3	1976	11	61.2	13.2	18.6
- magnesium	1976	9	4	3.3	3.8	1976	11	13.5	3.7	4.9
- total	1976	9	51.4	42	48.7	1976	11	208	48.6	66.5
Metals: (total)										
- Cadmium	1976	9	<0.0005	<0.0005	<0.0005	1976	10	<0.0005	<0.0005	<0.0005
- Chromium	1976	9	0.005	<0.005	<0.005+	1976	10	<0.005	<0.005	<0.005
- Copper	1976	9	0.004	<0.001	0.002	1976	11	0.004	<0.001	0.002
- Iron	1976	9	0.4	0.1	0.18	1976	11	0.5	<0.1	0.17
- Lead	1976	9	0.007	<0.001	0.003	1976	11	0.004	<0.001	<0.001+
- Manganese	1976	9	0.02	<0.02	<0.02+	1976	10	0.02	<0.02	<0.02+
- Mercury	1976	9	<0.00005	<0.00005	<0.00005	1975	11	<0.00005	<0.00005	<0.00005
- Molybdenum	1976	8	0.001	<0.0005	0.0007	1976	9	1.1	0.0005	0.0007+
- Nickel	1976	9	<0.01	<0.01	<0.01	1976	10	<0.01	<0.01	<0.01
- Zinc	1976	9	0.011	<0.005	0.006	1976	11	0.013	<0.005	0.006
Nitrogen: - Ammonia	1976	9	0.02	0.011	0.015	1976	10	0.024	0.011	0.016
-nitrate/nitrite	1976	5	<0.02	<0.02	<0.02	1976	8	<0.02	<0.02	<0.02
- Organic	1976	9	0.39	0.22	0.30	1976	10	0.45	0.14	0.27
- Kjeldahl	1976	9	0.4	0.23	0.31	1976	10	0.47	0.16	0.28
Oxygen - dissolved	1976	5	10.1	8.1	9.3	1976	8	11	8.6	9.4
- % saturation	1976	5	104.6	84.7	94.1	1976	8	95.6	74.7	87.2
pH	1976	9	8	7.6	7.8+	1976	11	8.1	7.4	7.9+
Phosphorus										
-ortho	1976	9	<0.003	<0.003	<0.003	1976	10	0.003	<0.003	<0.003+
-total dissolved	1976	2	0.005	0.005	0.005	1976	2	0.006	0.004	0.005
-total	1976	9	0.016	0.01	0.013	1976	10	0.016	0.009	0.011
Solids: - Suspended	1976	9	5	1	2+	1976	11	13	1	2+
- Total	1976	7	92	74	87	1976	9	472	84	130
Specific Conductivity	1976	9	114	83	104	1976	11	703	108	165
Temperature	1976	7	19	10	15.6	1976	8	16.5	9	12.9
Turbidity	1976	9	2.2	0.7	1.2	1976	10	2.6	0.5	0.9

* All values are as mg/L except:
(1) Coliform-fecal as MPN/100 mL
(2) Colour
(3) Oxygen % saturation as percent
(4) pH
(5) Specific Conductivity as µS/cm
(6) Temperature as °C
(7) Turbidity in NTU

\+ Median Value

Data Source: Ministry of Environment and Parks

TABLE 16 (Continued)

Characteristic	Site 0400609					Site 0400610				
	Period of Record	No. of Values	Values*			Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean			Maximum	Minimum	Mean
Alkalinity	1976	10	58	50.5	54.2	1976	2	54	54	54
Arsenic	1976	2	<0.005	<0.005	<0.005	-	-	-	-	-
Carbon: - Organic	1976	10	13	7	9.4	1976	2	11	9	10
- Inorganic	1976	10	14	10	12.6	1976	2	13	12	12.5
Colour TAC	1976	8	17	13	16.1	1976	2	13	12	12.5
Hardness - calcium	1976	11	55.8	12.5	18.1	1976	3	61.8	13.9	29.9
- magnesium	1976	11	12.1	3.7	4.8	1976	3	19.1	4.1	9.1
- total	1976	11	189	46.4	65	1976	3	233	51.6	112.1
Metals: (total)										
- Cadmium	1976	10	0.0028	<0.0005	<0.0005+	1976	2	<0.0005	<0.0005	<0.0005
- Chromium	1976	10	0.007	<0.005	<0.005+	1976	2	<0.005	<0.005	<0.005
- Copper	1976	11	0.005	<0.001	0.002	1976	2	0.004	0.002	0.003
- Iron	1976	11	2.4	<0.1	0.1+	1976	3	0.7	0.1	0.1+
- Lead	1976	11	0.005	<0.001	<0.001+	1976	3	0.007	<0.001	<0.001+
- Manganese	1976	10	0.7	<0.02	<0.02+	1976	2	<0.02	<0.02	<0.02
- Mercury	1976	11	<0.00005	<0.00005	<0.00005	1976	2	<0.00005	<0.00005	<0.00005
- Molybdenum	1976	9	0.6	<0.0005	0.0007+	1976	2	0.0011	0.0006	0.0008
- Nickel	1976	10	<0.01	<0.01	<0.01	1976	2	<0.01	<0.01	<0.01
- Zinc	1976	11	0.009	<0.005	0.005	1976	2	<0.005	<0.005	<0.005
Nitrogen: - Ammonia	1976	10	0.024	0.012	0.016	1976	3	0.341	0.014	0.015+
-nitrate/nitrite	1976	8	0.02	<0.02	<0.02+	1976	3	0.05	<0.02	0.03
- Organic	1976	10	0.34	0.14	0.22	1976	3	2.66	0.23	0.24+
- Kjeldahl	1976	10	0.35	0.16	0.24	1976	3	3	0.24	0.25+
Oxygen - dissolved	1976	8	10.8	8.5	9.3	-	-	-	-	-
- % saturation	1976	8	104.8	77.7	89.7	-	-	-	-	-
pH	1976	11	8.3	7.6	8+	1976	3	8	7.5	7.9+
Phosphorus										
-ortho	1976	10	0.011	<0.003	<0.003+	1976	3	0.011	<0.003	<0.003+
-total dissolved	1976	2	0.006	0.005	0.006	1976	2	0.006	0.005	0.006
-total	1976	10	0.08	0.008	0.017	1976	3	0.093	0.009	0.037
Solids: - Suspended	1976	11	31	<1	5	1976	3	6	2	3
- Total	1976	9	372	84	123	1976	1	290	-	-
Specific Conductivity	1976	11	582	108	111+	1976	3	454	114	227
Temperature	1976	8	15.5	7.5	12.3	-	-	-	-	-
Turbidity	1976	10	9.3	0.5	1.5	1976	2	0.6	0.6	0.6

* All values are as mg/L except:
(1) Coliform-fecal as MPN/100 mL
(2) Colour
(3) Oxygen % saturation as percent
(4) pH
(5) Specific Conductivity as µS/cm
(6) Temperature as °C
(7) Turbidity in NTU
Data Source: Ministry of Environment and Parks

\+ Median Value

TABLE 17
AMBIENT WATTER QUALITY DATA SUMMARY
TRIBUTARIES OF PINCHI LAKE

Characteristic	Site 0400623 Tsilcoh Cr. at Lake					Site 0400624 Tsilcoh Cr. at Pinchi Lake Rd.				
	Period of Record	No. of Values	Values*			Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean			Maximum	Minimum	Mean
Alkalinity	1976	4	117	47.7	88.6	1976-1977	11	138	49.1	120.4
Arsenic	1976	1	0.006	-	-	-	-	-	-	-
Carbon: - Organic	1976	4	23	8	17	1976-1977	11	23	5	9.7
- Inorganic	1976	4	29	12	22	1976-1977	11	36	12	30.2
Colour TAC	1976	4	90	29	55.5	1976-1977	10	92	19	36.2
Hardness - calcium	1976	4	28	11.6	21.1	1976-1977	11	32.3	12	28.2
- magnesium	1976	4	11.1	5	8.55	1976-1977	11	12.4	5.1	10.9
- total	1976	4	116	49.1	87.4	1976-1977	11	132	51	115
Metals: (total)										
- Cadmium	1976	4	<0.0005	<0.0005	<0.0005	1976-1977	10	<0.0005	<0.0005	<0.0005
- Chromium	1976	4	0.017	<0.005	<0.005+	1976-1977	10	<0.005	<0.005	<0.005
- Copper	1976	4	0.006	<0.001	0.003	1976-1977	10	0.002	<0.001	<0.001
- Iron	1976	4	1	0.7	0.78	1976-1977	10	0.8	0.6	0.69
- Lead	1976	4	0.003	<0.001	0.001+	1976-1977	10	<0.001	<0.001	<0.001
- Manganese	1976	4	0.09	0.05	0.07	1976-1977	10	0.09	0.07	0.08
- Mercury	1976	4	<0.00005	<0.00005	<0.00005	1976-1977	11	<0.00005	<0.00005	<0.00005
- Molybdenum	1976	3	0.0013	<0.0005	0.001	1976-1977	9	0.0022	0.0009	0.0013
- Nickel	1976	4	<0.01	<0.01	<0.01	1976-1977	10	0.01	<0.01	<0.01
- Zinc	1976	4	0.01	<0.005	<0.005+	1976-1977	9	0.021	<0.005	0.007
Nitrogen: - Ammonia	1976	4	0.03	0.021	0.025	1976-1977	11	0.037	0.016	0.022
-nitrate/nitrite	1976	4	0.02	<0.02	<0.02	1976-1977	9	<0.02	<0.02	<0.02
- Organic	1976	4	0.6	0.25	0.42	1976-1977	11	0.65	0.17	0.29
- Kjeldahl	1976	4	0.62	0.27	0.45	1976-1977	11	0.67	0.19	0.31
pH	1976	4	8.2	7.6	7.8+	1976-1977	11	8.3	7.6	8.1+
Phosphorus										
-ortho	1976	4	0.019	0.008	0.015	1976-1977	11	0.019	0.01	0.013
-total dissolved	1976	1	0.023	-	-	1976-1977	7	0.022	0.019	0.021
-total	1976	4	0.044	0.032	0.039	1976-1977	11	0.04	0.025	0.037
Solids: - Suspended	1976	4	11	3	6	1976-1977	11	10	3	6
- Total	1976	3	172	100	135	1976-1977	10	178	104	162
Specific Conductivity	1976	4	221	95	171	1976-1977	11	265	98	232
Temperature	1976	2	16	13.5	14.7	-	-	-	-	-
Turbidity	1976	4	5	2.8	3.6	1976-1977	11	6.6	2.2	4.9

* All values are as mg/L except:
(1) Colour
(2) pH
(3) Specific Conductivity as µS/cm
(4) Temperature as °C
(5) Turbidity in NTU

\+ Median Value

Data Source: Ministry of Environment and Parks

TABLE 17 (Continued)

Characteristic	Site 0400625 Hyman Cr at Pinchi L. Rd.					Site 0400621 Pinchi Cr at Outlet of Pinchi Lake				
	Period of Record	No. of Values	Values*			Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean			Maximum	Minimum	Mean
Alkalinity	1976-1977	10	121	66.8	102.6	1976-1977	9	80.3	75.5	77.3
Arsenic	-	-	-	-	-	1976	1	<0.005	-	-
Carbon: - Organic	1976-1977	11	44	15	33.8	1976-1977	8	15	9	11.4
- Inorganic	1976-1977	11	32	19	27.6	1976-1977	8	21	17	18.9
Colour TAC	1976-1977	9	167	91	116	1976-1977	9	22	20	21.2
Hardness - calcium	1976-1977	10	22.3	13.5	19.5	1976-1977	9	16.3	15.3	16
- magnesium	1976-1977	10	15	8.9	12.8	1976-1977	9	10.2	8.8	9.7
- total	1976-1977	10	117	71.6	101.4	1976-1977	9	82.4	74.4	79.8
Metals: (total)										
- Cadmium	1976-1977	10	<0.0005	<0.0005	<0.0005	1976-1977	9	<0.0005	<0.0005	<0.0005
- Chromium	1976-1977	10	0.007	<0.005	<0.005+	1976-1977	9	<0.005	<0.005	<0.005
- Copper	1976-1977	9	0.006	<0.001	<0.001+	1976-1977	9	0.004	<0.001	0.002
- Iron	1976-1977	10	1.3	1	1.11	1976-1977	9	0.3	<0.1	0.14
- Lead	1976-1977	10	0.006	<0.001	<0.001+	1976-1977	9	0.008	<0.001	0.001+
- Manganese	1976-1977	10	0.94	0.13	0.67	1976-1977	9	<0.02	<0.02	<0.02
- Mercury	1976-1977	10	<0.00005	<0.00005	<0.00005	1976-1977	9	<0.00005	<0.00005	<0.00005
- Molybdenum	1976-1977	9	0.0007	<0.0005	0.0005	1976-1977	9	0.001	<0.0005	0.0008
- Nickel	1976-1977	10	<0.01	<0.01	<0.01	1976-1977	9	<0.01	<0.01	<0.01
- Zinc	1976-1977	10	0.011	<0.005	<0.005+	1976-1977	9	0.012	<0.005	<0.005+
Nitrogen: - Ammonia	1976-1977	10	0.063	0.029	0.05	1976-1977	9	0.035	0.015	0.024
-nitrate/nitrite	1976-1977	8	<0.02	<0.02	<0.02	1976-1977	9	0.06	<0.02	0.02+
- Organic	1976-1977	10	1.16	0.81	0.94	1976-1977	9	0.53	0.37	0.44
- Kjeldahl	1976-1977	10	1.2	0.87	0.99	1976-1977	9	0.55	0.39	0.47
pH	1976-1977	10	7.8	7.3	7.6+	1976-1977	9	8.2	7.8	8+
Phosphorus										
-ortho	1976-1977	10	0.053	0.015	0.044	1976-1977	9	0.006	<0.003	0.003
-total dissolved	1976-1977	6	0.079	0.05	0.067	1976-1977	7	0.01	0.008	0.008
-total	1976-1977	10	0.123	0.042	0.10	1976-1977	9	0.026	0.013	0.019
Solids: - Suspended	1976-1977	10	11	3	9	1976-1977	9	5	3	4
- Total	1976-1977	9	206	150	190	1976-1977	8	120	114	116
Specific Conductivity	1976-1977	10	223	127	191	1976-1977	9	160	152	157
Temperature	-	-	-	-	-	1976-1977	2	16	15	-
Turbidity	1976-1977	10	6.3	1.8	4.8	1976-1977	9	2.7	1.1	1.5

* All values are as mg/L except:
(1) Colour
(2) pH
(3) Specific Conductivity as µS/cm
(4) Temperature as °C
(5) Turbidity in NTU

\+ Median Value

Data Source: Ministry of Environment and Parks

TABLE 17 (Continued)

Characteristic	Site 0400627 Ocock Cr. at Germansen Rd.					Site 0400626 Ocock Cr at Lake				
	Period of Record	No. of Values	Values*			Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean			Maximum	Minimum	Mean
Alkalinity	1976-1977	11	140	69.6	97.6	1976	4	142	73.6	100.9
Carbon: - Organic	1976-1977	9	28	13	16.9	1976	4	25	13	17.8
- Inorganic	1976-1977	9	34	18	24.6	1976	4	34	19	25.3
Colour TAC	1976-1977	10	72	33	45.1	1976	4	65	18	44.8
Hardness - calcium	1976-1977	11	22.8	15	17.9	1976	4	18.3	14.4	16.3
- magnesium	1976-1977	11	20.5	7.6	11.9	1976	4	23.4	8.9	14.5
- total	1976-1977	11	141	69.1	93.3	1976	4	142	73.3	100.4
Metals: (total)										
- Cadmium	1976-1977	8	<0.0005	<0.0005	<0.0005	1976	3	<0.0005	<0.0005	<0.0005
- Chromium	1976-1977	8	0.007	<0.005	<0.005+	1976	2	0.01	<0.005	-
- Copper	1976-1977	8	0.003	<0.001	<0.001+	1976	3	0.004	<0.001	0.003
- Iron	1976-1977	8	1.5	0.3	0.9	1976	3	0.9	0.5	0.7
- Lead	1976-1977	8	0.003	<0.001	<0.001+	1976	3	0.003	<0.001	<0.001+
- Manganese	1976-1977	8	0.11	0.09	0.10	1976	3	0.1	0.04	0.07
- Mercury	1976-1977	10	0.00005	<0.00005	<0.00005+	1976	4	<0.00005	<0.00005	<0.00005
- Molybdenum	1976-1977	7	0.0011	<0.0005	0.0008	1976	2	0.0009	<0.0005	-
- Nickel	1976-1977	8	<0.01	<0.01	<0.01	1976	3	0.01	<0.01	<0.01+
- Zinc	1976-1977	8	0.012	<0.005	0.006	1976	3	0.005	<0.005	<0.005+
Nitrogen: - Ammonia	1976-1977	11	0.047	<0.005	0.035	1976	4	0.037	0.021	0.03
-nitrate/nitrite	1976-1977	10	0.03	<0.02	0.023	1976	4	0.06	<0.02	0.03
- Organic	1976-1977	11	0.77	0.45	0.55	1976	4	0.6	0.43	0.52
- Kjeldahl	1976-1977	11	0.8	0.49	0.59	1976	4	0.64	0.45	0.55
Oxygen - dissolved	-	-	-	-	-	1976	1	8.7	-	-
pH	1976-1977	11	8.2	7.6	7.8+	1976	4	8.2	7.8	7.85
Phosphorus										
-ortho	1976-1977	11	0.8	0.51	0.6	1976	4	0.015	0.009	0.012
-total dissolved	1976-1977	11	0.018	0.008	0.013	1976	1	0.014	-	-
-total	1976-1977	11	0.058	0.035	0.048	1976	4	0.044	0.023	0.037
Solids: - Suspended	1976-1977	11	15	3	10	1976	4	16	4	9
- Total	1976-1977	10	206	104	141	1976	3	220	118	155
Specific Conductivity	1976-1977	11	255	134	185	1976	4	255	138	187
Temperature	-	-	-	-	-	1976	3	16	13	14.3
Turbidity	1976-1977	11	12	1.7	7	1976	4	6.2	4	5.4

* All values are as mg/L except:
(1) Colour
(2) pH
(3) Specific Conductivity as μS/cm
(4) Temperature as °C
(5) Turbidity in NTU

\+ Median Value

Data Source: Ministry of Environment and Parks

TABLE 18
AMBIENT WATER QUALITY DATA SUMMARY
PINCHI LAKE

Characteristic	Site 0400643					Site 0400622				
	Period of Record	No. of Values	Values*			Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean			Maximum	Minimum	Mean
Alkalinity	1976	6	77.5	75.6	76.4	1976	5	78.7	76	76.7
Arsenic						1976	1	<0.005	-	-
Carbon: - Organic	1976	6	15	11	12.8	1976	5	15	10	12.2
- Inorganic	1976	6	19	17	18.2	1976	5	21	18	19
Colour TAC	1976	6	23	19	21.3	1976	5	25	20	22.6
Hardness - calcium	1976	6	15.8	14.8	15.4	1976	5	16	15.4	15.6
- magnesium	1976	6	9.4	8.2	8.9	1976	5	9.4	8.9	9.2
- total	1976	6	78.1	70.7	74.9	1976	5	78.6	75.3	76.8
Metals: (total)										
- Cadmium	1976	6	<0.0005	<0.0005	<0.0005	1976	5	<0.0005	<0.0005	<0.0005
- Chromium	1976	6	<0.005	<0.005	<0.005	1976	5	<0.005	<0.005	<0.005
- Copper	1976	6	0.006	<0.001	0.003	1976	5	0.006	0.001	0.003
- Iron	1976	6	0.1	<0.1	<0.1+	1976	5	0.3	<0.1	0.16
- Lead	1976	6	0.003	<0.001	<0.001+	1976	5	0.026	<0.001	0.002+
- Manganese	1976	6	<0.02	<0.02	<0.02	1976	5	0.02	<0.02	<0.02+
- Mercury	1976	6	<0.00005	<0.00005	<0.00005	1976	5	<0.00005	<0.00005	<0.00005
- Molybdenum	1976	4	0.001	0.0008	0.0009	1976	5	0.0008	0.0005	0.0006
- Nickel	1976	6	<0.01	<0.01	<0.01	1976	5	<0.01	<0.01	<0.01
- Zinc	1976	6	0.005	<0.005	<0.005+	1976	5	0.011	<0.005	0.006
Nitrogen: - Ammonia	1976	6	0.029	0.016	0.020	1976	5	0.026	0.013	0.020
-nitrate/nitrite	1976	4	0.07	0.02	0.05	1976	3	0.08	0.08	0.08
- Organic	1976	6	0.37	0.28	0.32	1976	5	0.39	0.29	0.34
- Kjeldahl	1976	6	0.39	0.3	0.34	1976	5	0.41	0.3	0.36
Oxygen- disssolved	1976	2	9	8.7	8.9	1976	2	9	7.1	-
- % saturation	-	-	-	-	-	1976	2	94.1	68.1	-
pH	1976	5	8.2	7.7	7.8+	1976	6	8.2	7.8	7.85+
Phosphorus										
-ortho	1976	5	0.01	<0.003	0.008	1976	6	0.007	<0.003	0.005
-total dissolved	1976	2	0.013	0.012	-	1976	2	0.008	0.008	0.008
-total	1976	5	0.025	0.014	0.021	1976	6	0.02	0.012	0.016
Solids: - Suspended	1976	5	3	2	3	1976	6	6	2	3
- Total	1976	3	120	118	-	1976	4	122	116	119
Specific Conductivity	1976	5	156	152	153	1976	6	154	151	152
Temperature	1976	3	16	6.5	11.5	1976	4	15	10	12.6
Turbidity	1976	4	1.4	1	1.2	1976	6	2.1	0.6	1.1

* All values are as mg/L except:
(1) Colour
(2) Oxygen % saturation as percent
(3) pH
(4) Specific Conductivity as μS/cm
(5) Temperature
(6) Turbidity as NTU

\+ Median Value

Data Source: Ministry of Environment and Parks

TABLE 18 (Continued)

Characteristic	Site 0400615					Site 0400616				
	Period of Record	No. of Values	Values*			Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean			Maximum	Minimum	Mean
Alkalinity	1976	2	76.1	76	76.1	1976	2	75.8	75.1	75.5
Carbon: - Organic	1976	2	11	11	11	1976	2	11	11	11
- Inorganic	1976	2	19	19	19	1976	2	19	19	19
Colour TAC	1976	2	19	18	18.5	1976	2	20	20	20
Hardness - calcium	1976	3	49.7	15.2	26.8	1976	3	31.9	15.3	20.9
- magnesium	1976	3	16.3	9.4	11.7	1976	3	10	9.4	9.6
- total	1976	3	191	76.6	115.1	1976	3	121	76.9	91.8
Metals: (total)										
- Cadmium	1976	2	<0.0005	<0.0005	<0.0005	1976	2	<0.0005	<0.0005	<0.0005
- Chromium	-	-	-	-	-	1976	2	<0.005	<0.005	<0.005
- Copper	1976	2	0.001	0.001	0.001	1976	2	0.002	0.001	0.002
- Iron	1976	3	3.4	<0.1	0.1+	1976	3	0.5	<0.1	<0.1+
- Lead	1976	3	0.023	<0.001	<0.001+	1976	3	<0.001	<0.001	<0.001
- Manganese	1976	2	<0.02	<0.02	<0.02	1976	2	<0.02	<0.02	<0.02
- Mercury	1976	2	<0.00005	<0.00005	<0.00005	1976	2	<0.00005	<0.00005	<0.00005
- Molybdenum	1976	2	0.0011	0.0009	0.00010	1976	2	0.0013	0.0013	0.0013
- Nickel	1976	2	<0.01	<0.01	<0.01	1976	2	<0.01	<0.01	<0.01
- Zinc	1976	2	<0.005	<0.005	<0.005	1976	2	<0.005	<0.005	<C.005
Nitrogen: - Ammonia	1976	3	0.048	0.016	0.027	1976	3	0.121	0.017	0.052
-nitrate/nitrite	1976	3	0.08	0.05	0.07	1976	3	0.16	0.08	0.13
- Organic	1976	3	0.91	0.27	0.51	1976	3	0.3	0.07	0.22
- Kjeldahl	1976	3	0.96	0.29	0.54	1976	3	0.41	0.09	0.27
Oxygen - dissolved	1976	1	7.8	-	-	-	-	-	-	-
pH	1976	3	7.8	7.3	7.8+	1976	3	7.8	7.4	7.4+
Phosphorus										
-ortho	1976	3	0.006	0.005	0.006	1976	2	0.024	0.007	0.015
-total dissolved	1976	2	0.012	0.009	0.010	1976	2	0.029	0.01	0.02
-total	1976	3	0.176	0.013	0.024+	1976	2	0.03	0.016	0.023
Solids: - Suspended	1975	3	54	2	8+	1976	3	18	1	1+
- Total	1976	1	304	-	-	1976	1	184	-	-
Specific Conductivity	1976	3	416	154	241	1976	3	258	153	188
Temperature	1975	1	15	-	-	-	-	-	-	-
Turbidity	1976	2	2.2	0.7	1.5	1976	2	0.9	0.7	0.8

* All values are as mg/L except:
(1) Colour
(2) pH
(3) Specific Conductivity as µS/cm
(4) Temperature as °C
(5) Turbidity in NTU

+Median Value

Data Source: Ministry of Environment and Parks

TABLE 18 (Continued)

Characteristic	Site 0400617 Period of Record	No. of Values	Values* Maximum	Minimum	Mean	Site 0400618 Period of Record	No of Values	Values* Maximum	Minimum	Mean
Alkalinity	1976	8	79.1	75.5	76.5	1976	8	79.7	75.4	76.5
Arsenic	1976	1	<0.005	-	-	1976	1	<0.005	-	-
Carbon: - Organic	1976	8	15	10	12.1	1976	8	15	10	12
- Inorganic	1976	8	20	17	18.9	1976	8	20	17	18.9
Colour TAC	1976	8	25	19	21.9	1976	8	27	19	22.4
Hardness - calcium	1976	8	16.3	14.3	15.4	1976	8	16.3	14.4	15.4
- magnesium	1976	8	9.4	8.9	9.2	1976	8	9.4	8.4	9.1
- total	1976	8	79	71.5	75.9	1976	8	79.4	70.5	75.6
Metals: (total)										
- Cadmium	1976	7	<0.0005	<0.0005	<0.0005	1976	7	<0.0005	<0.0005	<0.0005
- Chromium	1976	7	<0.005	<0.005	<0.005	1976	7	0.006	<0.005	<0.005+
- Copper	1976	7	0.003	<0.001	0.002	1976	7	0.004	<0.001	0.002
- Iron	1976	7	0.9	<0.1	0.1+	1976	7	0.4	<0.1	0.1+
- Lead	1976	7	0.012	<0.001	<0.001+	1976	7	0.004	<0.001	<0.001+
- Manganese	1976	7	0.03	<0.02	<0.02+	1976	7	0.02	<0.02	<0.02+
- Mercury	1976	8	<0.00005	<0.00005	<0.00005	1976	8	0.00005	<0.00005	<0.00005+
- Molybdenum	1976	5	0.0009	0.0008	0.0008	1976	5	0.0008	0.0005	0.0006
- Nickel	1976	7	<0.01	<0.01	<0.01	1976	7	<0.01	<0.01	<0.01
- Zinc	1976	7	0.006	<0.005	<0.005+	1976	7	0.008	<0.005	0.005
Nitrogen: - Ammonia	1976	8	0.021	0.016	0.018	1976	8	0.028	0.016	0.020
-nitrate/nitrite	1976	8	0.09	<0.02	<0.02+	1976	8	0.09	<0.02	0.05
- Organic	1975	8	0.45	0.28	0.37	1976	8	0.4	0.26	0.33
- Kjeldahl	1976	8	0.47	0.3	0.39	1976	8	0.42	0.28	0.35
Oxygen - dissolved	1976	2	9	9	9	1976	2	8.7	8.1	8.4
- % saturation	1976	2	91.2	90.2	90.7	1976	2	87.2	79.4	81.8
pH	1976	8	8.2	7.8	8.1+	1976	8	8.1	7.9	8+
Phosphorus										
-ortho	1976	8	0.006	<0.003	0.004	1976	8	0.011	<0.003	0.005
-total dissolved	1976	2	0.011	0.009	0.010	1976	2	0.011	0.01	0.01
-total	1976	8	0.3	0.011	0.018	1976	8	0.023	0.013	0.017
Solids: - Suspended	1976	8	13	2	4	1976	8	4	2	3
- Total	1976	5	126	112	120	1976	6	118	116	117
Specific Conductivity	1976	8	155	151	153	1976	8	157	151	153
Temperature	1976	6	17	11	13.5	1976	4	14	7	11.5
Turbidity	1976	8	4.3	0.8	1.8	1976	8	2.4	0.8	1.5

* All values are as mg/L except:
(1) Colour
(2) Oxygen % saturation as percent
(3) pH
(4) Specific Conductivity as µS/cm
(5) Temperature as °C
(6) Turbidity in NTU

\+ Median Value

Data Source: Ministry of Environment and Parks

TABLE 18 (Continued)

Characteristic	Site 0400619					Site 0400620				
	Period of Record	No. of Values	Values*			Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean			Maximum	Minimum	Mean
Alkalinity	1976-1977	20	80.5	75.5	77.3	1976	8	81.4	75.5	77.5
Arsenic	1976	1	<0.005	-	-	1976	1	<0.005	-	-
Carbon: - Organic	1976-1977	18	15	10	11.7	1976	8	15	9	11.9
- Inorganic	1976-1977	18	20	17	18.9	1976	8	21	17	18.9
Colour TAC	1976-1977	20	25	18	21.6	1976	8	23	20	21.1
Hardness - calcium	1976-1977	20	16.4	14.3	15.9	1976	8	16.5	15.2	15.7
- magnesium	1976-1977	20	10.5	8.2	9.5	1976	8	9.4	8.4	9.1
- total	1976-1977	20	83.9	69.5	78.7	1976	8	79.9	73.5	76.5
Metals: (total)										
- Cadmium	1976-1977	19	<0.0005	<0.0005	<0.0005	1976	7	<0.0005	<0.0005	<0.0005
- Chromium	1976-1977	19	<0.005	<0.005	<0.005	1976	7	<0.005	<0.005	<0.005
- Copper	1976-1977	19	0.004	<0.001	0.001+	1976	7	0.005	<0.001	0.003
- Iron	1976-1977	19	0.7	<0.1	0.1+	1976	7	1.3	<0.1	0.3
- Lead	1976-1977	19	0.004	<0.001	<0.001+	1976	7	0.003	<0.001	0.002
- Manganese	1976-1977	19	0.03	<0.02	<0.02+	1976	7	0.04	<0.02	<0.02+
- Mercury	1976-1977	18	0.0033	<0.00005	<0.00005+	1976	8	0.00007	<0.00005	<0.00005
- Molybdenum	1976-1977	17	0.0011	0.0006	0.0009	1976	5	0.0011	0.0006	0.0008
- Nickel	1976-1977	19	0.01	<0.01	<0.01+	1976	7	<0.01	<0.01	<0.01
- Zinc	1976-1977	19	0.017	<0.005	<0.005+	1976	7	0.01	<0.005	<0.005+
Nitrogen: - Ammonia	1976-1977	20	0.037	0.015	0.023	1976	8	0.022	0.013	0.017
-nitrate/nitrite	1976-1977	20	0.1	<0.02	0.07	1976	7	0.07	<0.02	<0.02+
- Organic	1976-1977	20	0.51	0.26	0.36	1976	8	0.62	0.3	0.39
- Kjeldahl	1976-1977	20	0.53	0.28	0.39	1976	8	0.64	0.31	0.41
Oxygen - dissolved	1976	2	8.9	7.9	-	1976	2	9.7	7.6	8.6
- % saturation	1976	2	89.2	75.7	-	1976	2	99.4	77.9	83.1
pH	1976-1977	20	8.1	7.8	8+	1976	8	8.3	7.8	7.95+
Phosphorus										
-ortho	1976-1977	20	0.013	<0.003	0.003	1976	8	0.007	<0.003	0.003+
-total dissolved	1976-1977	14	0.017	0.009	0.015	1976	2	0.011	0.009	0.010
-total	1976-1977	20	0.037	0.01	0.02	1976	8	0.064	0.012	0.022
Solids: - Suspended	1976-1977	20	13	2	3	1976	8	34	2	7
- Total	1976-1977	18	124	114	121	1976	6	152	114	123
Specific Conductivity	-	-	-	-	-	1976	8	156	151	154
Temperature	1976	4	14	7	11.3	1976	4	16	14	15
Turbidity	1976-1977	20	4.3	0.8	1.5	1976	8	18	1.1	3.8

* All values are as mg/L except:
(1) Colour
(2) Oxygen % saturation as percent
(3) pH
(4) Specific Conductivity as µS/cm
(5) Temperature as °C
(6) Turbidity in NTU

\+ Median Value

Data Source: Ministry of Environment and Parks

TABLE 19
AMBIENT WATER QUALITY DATA SUMMARY
TRIBUTARIES TO STUART LAKE

Characteristic	Site 0400628 Pinchi Cr. at Tachie Road				
	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Alkalinity	1976-1977	8	79.5	75.4	78.7
Carbon: - Organic	1976-1977	8	12	12	12
- Inorganic	1976-1977	8	19	18	18
Colour TAC	1976-1977	7	29	22	27
Hardness - calcium	1976-1977	8	15.8	14.6	15.3
- magnesium	1976-1977	8	9.2	8.5	9
- total	1976-1977	8	76.3	71.4	75.3
Metals: (total)					
- Cadmium	1976-1977	4	<0.0005	<0.0005	<0.0005
- Chromium	1976-1977	4	0.005	<0.005	<0.005+
- Copper	1976-1977	4	0.004	<0.001	0.002
- Iron	1976-1977	4	0.3	0.1	0.3
- Lead	1976-1977	4	0.003	<0.001	0.002
- Manganese	1976-1977	4	0.03	0.02	0.02
- Mercury	1976-1977	8	0.0004	<0.00005	0.0001
- Molybdenum	1976-1977	3	0.0008	0.0006	0.0007
- Nickel	1976-1977	4	<0.01	<0.01	<0.01
- Zinc	1976-1977	4	<0.005	<0.005	<0.005
Nitrogen: - Ammonia	1976-1977	8	0.053	0.015	0.044
-nitrate/nitrite	1976-1977	7	0.04	<0.02	0.03
- Organic	1976-1977	8	0.44	0.28	0.35
- Kjeldahl	1976-1977	8	0.48	0.33	0.4
pH	1976-1977	8	8.2	7.9	8.2+
Phosphorus					
-ortho	1976-1977	8	0.005	<0.003	0.004
-total dissolved	1976-1977	6	0.012	0.009	0.011
-total	1976-1977	8	0.022	0.016	0.019
Solids: - Suspended	1976-1977	8	9	5	6
- Total	1976-1977	8	122	110	116
Specific Conductivity	1976-1977	8	159	154	157
Turbidity	1976-1977	8	3.7	2.2	3.3

* All values are as mg/L except: + Median Value
(1) Colour
(2) pH
(3) Specific Conductivity as µS/cm
(4) Turbidity in NTU

Data Source: Ministry of Environment and Parks

TABLE 20
AMBIENT WATER QUALITY DATA SUMMARY
NECOSLIE RIVER

Characteristic	Site 0400800 Necoslie River Control					Site 0400801 Necoslie River at Highway Bridge				
	Period of Record	No. of Values	Values*			Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean			Maximum	Minimum	Mean
Alkalinity	-	-	-	-	-	1980	1	124	-	-
Arsenic	1983	3	<0.25	<0.25	<0.25	1983	1	<0.25	-	-
Carbon: - Organic	1983	3	30	11	19	1983	3	30	12	18.3
Coliform - fecal	1978-1984	7	130	7	59+	1978-1984	16	>24 000	2	3 762+
Colour TAC	1983	2	30	30	30	1980-1983	3	60	24	36
Hardness - calcium	1983	3	37.4	12.8	29.2	1980-1983	2	41.1	30.5	35.8
- magnesium	1983	3	12.7	7.19	10.8	1980-1983	2	15.6	12.7	14.1
- total	1983	3	106	39.2	66.1	1980	1	126	-	-
Metals: (total)										
- Aluminum	1983	3	10.4**	0.9	4.28	1983	1	0.73	-	-
- Cadmium	1983	3	<0.01	<0.0005	-	1983	1	<0.01	-	-
- Chromium	1983	3	0.03	<0.01	0.017	1983	1	<0.01	-	-
- Copper	1978-1983	7	0.02	0.004	0.011	1978-1983	4	0.014	0.006	0.010
- Iron	1978-1983	6	15	2.18	6.8	1978-1983	4	12	1.99	6.67
- Lead	1978-1983	7	<0.1	<0.001	0.016+	1978-1983	4	<0.1	0.001	0.026
- Manganese	1983	3	0.53	0.09	0.35	1983	1	0.17	-	-
- Molybdenum	1983	3	<0.01	<0.01	<0.01	1983	1	0.01	-	-
- Nickel	1983	3	<0.05	<0.05	<0.05	1983	1	<0.05	-	-
- Zinc	1978-1983	6	0.06	0.006	0.023	1978-1983	4	0.05	<0.005	0.020
Nitrogen: - Ammonia	1978-1983	6	0.037	<0.005	0.020	1978-1983	7	1.04	0.034	0.284
-nitrate/nitrite	1978-1983	6	0.05	<0.02	<0.02+	1978-1983	7	0.07	<0.02	0.036
- Organic	1978-1983	6	1.17	0.54	0.71	1978-1983	7	1.2	0.53	0.79
- Kjeldahl	1978-1983	6	1.18	0.57	0.73	1978-1983	7	1.8	0.59	1.04
pH	1978-1983	6	8.1	7.5	7.65+	1978-1983	7	8	7.5	7.7+
Phosphorus										
-ortho	1978-1983	5	0.018	<0.003	0.009	1978-1983	7	0.171	0.014	0.059
-total dissolved	1978-1983	6	0.051	0.012	0.026	1978-1983	7	0.188	0.033	0.078
-total	1978-1983	6	0.362	0.043	0.148	1978-1983	7	0.422	0.099	0.221
Solids: - Suspended	1978-1983	4	319	27	168	1978-1983	4	344	58	183
- Total	1978	3	400	124	229	1978-1980	4	308	148	223
Specific Conductivity	1978-1973	6	280	82	170	1978-1983	7	370	90	205
Turbidity	1983	1	170	-	-	1980	1	64	-	-

* All values are as mg/L except:
(1) Coliform-fecal as MPN/100 mL
(2) Colour
(3) pH
(4) Specific Conductivity as µS/cm
(5) Turbidity in NTU

Data Source: Ministry of Environment and Parks

** Value of 10.4 mg/L Al was associated with suspended solids concentration of 294 mg/L and a specific conductivity of only 82 µS/cm. This indicates the metal was associated with suspended material in the water column, and was not dissolved.

\+ Median Value

TABLE 21
AMBIENT WATER QUALITY DATA SUMMARY
STUART RIVER

Characteristic	Site 0920101 Stuart River at Fort St. James				
	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Alkalinity	1966-1974	87	87.9	32.4	44.8
Arsenic	1973-1974	3	0.006	<0.005	<0.005+
Carbon: - Organic	1973-1974	9	11	5	7.5
Colour - apparent	1966-1974	86	120	5	17.1
Hardness - calcium	1966-1974	87	26.8	3.1	14.1
- total	1966-1974	85	93.5	39.5	48.5
Metals: (total)					
- Cadmium	1973-1974	4	<0.001	<0.001	<0.001
- Chromium	1973	1	0.0003	-	-
- Copper	1969-1974	9	<0.01	0.001	0.004+
- Iron	1969-1974	6	3	0.023	0.54
- Lead	1969-1974	8	<0.01	<0.001	0.001+
- Manganese	1966-1974	23	0.2	<0.01	0.018
- Mercury	1973-1974	4	<0.00005	<0.00005	<0.00005
- Molybdenum	1973-1974	4	<0.05	<0.0002	0.0006+
- Nickel	1973-1974	4	0.001	<0.001	-
- Zinc	1967-1974	10	0.01	<0.001	0.006
Nitrogen: - Ammonia	1966-1974	18	0.2	0.003	0.106
-nitrate/nitrite	1966-1974	79	0.452	<0.001	0.037
- Kjeldahl	1973-1974	4	<0.5	0.178	-
Oxygen - dissolved	1973-1974	3	12	10	11
pH	1966-1974	87	8.3	7.1	7.7
Phosphorus					
-ortho	1967-1972	19	0.03	<0.002	0.005
-total dissolved**	1966-1973	15	0.186	<0.001	0.019
-total**	1967-1974	16	0.021	<0.002	0.009
Solids: - Suspended	1969-1973	5	104	<1	50
Specific Conductivity	1966-1974	87	175	75.3	99.6
Temperature	1967-1970	40	19.4	0.6	7.4
Turbidity	1966-1974	86	125	<0.1	5.5

* All values are as mg/L except:

(1) Colour
(2) pH
(3) Specific Conductivity as µS/cm
(4) Temperature as °C
(5) Turbidity as NTU

+ Median Value

Data Source: Ministry of Environment and Parks

** All values for total dissolved and total phosphorus were recorded for different dates, leading to the ranges of values for the former being greater than for the latter.

TABLE 21 (Continued)

Characteristic	Site 0400487 Stuart River Campground					Site 0400488 Stuart River at Hwy 27				
	Period of Record	No. of Values	Values* Maximum	Minimum	Mean	Period of Record	No of Values	Values* Maximum	Minimum	Mean
Coliform- fecal	1983-1984	2	170	110	140	1983-1984	5	9200	110	-
Colour TAC	1983-1984	2	6	6	6	1983-1984	3	24	7	13.7
Nitrogen: - Ammonia	1983-1984	2	0.009	0.008	0.009	1983-1984	4	0.215	0.014	0.088
-nitrate/nitrite	1983-1984	2	0.03	0.02	0.03	1983-1984	4	0.05	<0.02	0.03
- Organic	1983-1984	2	0.17	0.17	0.17	1983-1984	4	1.19	0.23	0.51
- Kjeldahl	1983-1984	2	0.18	0.18	0.18	1983-1984	4	1.22	0.28	0.59
pH	1983-1984	2	7.8	7	7.4	1983-1984	4	7.9	7.5	7.7+
Phosphorus										
-ortho	1983-1984	2	<0.003	<0.003	<0.003	1983-1984	4	0.042	0.004	0.02
-total dissolved	1983-1984	2	0.006	0.006	0.006	1983-1984	4	0.047	0.008	0.028
-total	1983-1984	2	0.013	0.009	0.011	1983-1984	4	0.354	0.032	0.121
Solids: - Suspended	1984	1	3	-		1983-1984	2	259	6	133
Specific Conductivity	1983-1984	2	101	98	100	1983-1984	4	171	93	130.5

* All values are as mg/L except:
(1) Colour
(2) pH
(3) Specific Conductivity as µS/cm

\+ Median Value

Data Source: Ministry of Environment and Parks

STUART RIVER
FECAL COLIFORMS
1980 - 1984

	Site 0400488 Stuart R. East Side at Hwy 27 Bridge	Stuart R. West side at Hwy 27 Bridge	0400487 Stuart R. 2 km D/S Hwy 27 Bridge, East Side
No. of Values	13	3	6
Maximum	9 200	2	170
Minimum	8	<2	<2
Median	1 450	<2	75

TABLE 22
EFFLUENT DATA SUMMARY
VILLAGE OF VANDERHOOF SEWAGE TREATMENT FACILITY
(PE 296)

Characteristic	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Coliform - fecal	1972-1983	28	2 400 000	800	49 500+
Flow	1972-1983	203	1 596	802	1 009
Nitrogen: - Ammonia	1976-1983	9	22.5	1.06	7.89
- un-ionized NH_3++	1976-1982	5	0.424	0.088	0.227
- Organic	1976-1983	9	11.32	2.2	6.25
- Kjeldahl	1976-1983	9	26	8	14.13
Oxygen - BOD_5	1972-1983	66	155	9	43.6**
Phosphorus					
-ortho	1976-1983	8	4.7	1.06	2.47
-total dissolved	1982-1983	5	4.72	1.82	3.2
-total	1976-1983	9	5	1.96	3.27
Solids: - Suspended	1974-1983	66	134	11	45**

Data Source: Ministry of Environment and Parks
and Permittee

+ Median. 90th percentile value 722 000 MPN/100 mL
++ Calculated

* Values are as mg/L except:
(1) Coliform - fecal as MPN/100 mL
(2) Flow as m^3/d

** 90th percentile values: 94 mg/L suspended solids
: 72 mg/L BOD_5

TABLE 23
IMPACT OF VANDERHOOF SEWAGE TREATMENT FACILITY ON NECHAKO RIVER WATER QUALITY

Characteristic	Date	0400449 or 0920069 upstream	0400414 Initial Dilution Zone 20 m downstream	0400450 Downstream 100 m
Coliform - fecal (MPN/100 mL)	82 07 21	33	46	23
	82 08 18	2	2	<2
	82 09 29	49	1 600	14
	83 02 24	5	-	>24 000
Nitrogen - ammonia	82 07 21	-	<0.005	<0.005
	82 08 18	<0.005	<0.005	<0.005
	82 09 29	<0.005	0.027	<0.005
	82 12 09	0.007	-	0.695
	83 02 24	0.006	-	0.063
- organic	82 07 21	-	0.13	0.27
	82 08 18	0.16	0.14	0.16
	82 09 29	0.16	0.19	0.16
pH	82 07 21	-	6.9	6.9
	82 08 18	7.7	7.7	6.8
	82 09 29	7.6	7.5	7.5
Phosphorus - ortho	82 07 21	-	<0.003	<0.003
	82 08 18	<0.003	<0.003	<0.003
	82 09 29	<0.003	0.015	<0.003
	82 12 09	0.003	-	0.181
	82 02 24	0.004	-	0.016
- total dissolved	82 07 21	-	0.007	0.007
	82 08 18	0.007	0.007	0.006
	82 09 29	0.006	0.021	0.006
	82 12 09	0.010	-	0.184
	83 02 24	0.009	-	0.020
- total	82 07 21	-	0.024	0.021
	82 08 18	0.016	0.016	0.016
	82 09 29	0.01	0.027	0.009
	82 12 09	0.013	-	0.219
	83 02 24	0.014	-	0.026
Solids - suspended	74 07 18	8	6	8
	82 07 21	-	8	10
	82 08 18	6	6	6
	82 09 26	2	4	4
	82 12 09	2	-	3
	83 02 24	1	-	2

Note: All nitrite nitrogen values < 0.005 mg/L

TABLE 24
AMBIENT WATER QUALITY DATA SUMMARY
NECHAKO RIVER AT VANDERHOOF

Characteristic	Site 0920069				
	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Arsenic	1982-1983	2	<0.25	<0.25	<0.25
Coliform- fecal	1983	1	5	-	-
Hardness - calcium	1982-1983	2	12.1	9.85	11
- magnesium	1982-1983	2	2.81	2.24	2.57
- total	1982-1983	2	33.1	26.9	30
Metals: (total)					
- Aluminum	1982-1983	2	0.13	0.11	0.12
- Cadmium	1982-1983	2	<0.01	<0.0005	-
- Chromium	1982-1983	2	<0.01	<0.01	<0.01
- Copper	1982-1983	2	<0.01	0.003	-
- Iron	1982-1983	2	0.18	0.08	0.13
- Lead	1982-1983	2	<0.1	0.004	-
- Manganese	1982-1983	2	0.02	0.02	0.02
- Mercury	1983	1	<0.00005	-	-
- Molybdenum	1982-1983	2	0.03	<0.01	-
- Nickel	1982-1983	2	<0.05	<0.01	-
- Zinc	1982-1983	2	<0.01	<0.01	-
Nitrogen: - Ammonia	1982-1983	2	0.007	0.006	0.007
-nitrite	1982-1983	2	<0.005	<0.005	<0.005
-nitrate/nitrite	1972-1983	3	0.02	<0.02	0.02
- Organic	1982-1983	2	0.13	0.12	0.13
- Kjeldahl	1982-1983	2	0.14	0.13	0.14
Oxygen - dissolved	1974	2	10.2	10	10.1
- % saturation	1974	2	114	102	108
pH	1982	2	7.7	7.6	-
Phosphorus					
-ortho	1982-1983	2	0.004	0.003	0.004
-total dissolved	1982-1983	2	0.01	0.009	0.01
-total	1982-1983	2	0.014	0.013	0.014
Solids: - Suspended	1982-1983	2	2	1	2
Specific Conductivity	1972-1983	3	78	75	77
Temperature	1974	2	17	13	15
Turbidity	1972	1	1.7	-	-

* All values are as mg/L except:
(1) Coliform-fecal as MPN/100 mL
(2) Oxygen % saturation as percent
(3) pH
(4) Specific Conductivity as µS/cm
(5) Temperature as °C
(6) Turbidity in NTU

Data Source: Ministry of Environment and Parks and Inland Waters Directorate

TABLE 25
AMBIENT WATER QUALITY DATA SUMMARY
NECHAKO RIVER AT ISLE PIERRE

Characteristic	Site 0920100				
	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Alkalinity	1966-1974	144	47.2	27	39.9
Arsenic	1973-1974	5	0.005	<0.005	0.005+
Carbon: - Organic	1971-1974	13	13	5.8	8.2
Colour Apparent	1966-1974	145	60	1	13.9
Hardness - calcium	1966-1974	144	15.8	9.9	12.3
- magnesium	1966-1974	36	4.4	1	2.8
- total	1966-1974	142	50.9	35.2	41.6
Metals: (total)					
- Aluminum(diss)	1966-1969	6	0.11	<0.01	0.04
- Cadmium	1973-1974	7	0.001	<0.001	<0.001+
- Chromium	1973	1	0.0002	0.0002	0.0002
- Copper	1967-1974	15	<0.01	0.001	0.002+
- Iron	1973-1974	8	1.1	0.06	0.28
- Lead	1969-1974	17	0.01	<0.001	0.006
- Manganese	1966-1968	29	0.05	<0.01	0.013
- Mercury	1971-1974	5	<0.00005	<0.00005	0.00005
- Molybdenum	1973-1974	7	<0.05	0.0002	0.0004+
- Nickel	1973-1974	7	0.004	<0.001	0.001
- Zinc	1967-1974	20	0.01	ND	0.004
Nitrogen: - Ammonia	1966-1974	29	0.2	0	0.1
-nitrate/nitrite	1966-1974	133	0.7	<0.001	0.03
- Kjeldahl	1973-1974	6	<0.5	0.2	0.33
Oxygen - dissolved	1973-1974	6	12	10	11.3
- % saturation	1973-1974	3	95.9	87.1	90
pH	1966-1974	144	8.3	6.9	7.6+
Phosphorus					
-ortho	1967-1972	18	0.01	<0.002	0.003
-dissolved	1966-1972	14	0.023	<0.001	0.007
-total	1967-1974	29	0.06	<0.002	0.009
Solids: - Suspended	1973-1974	9	36	4	17
Specific Conductivity	1966-1974	145	104	8	88
Temperature	1966-1974	104	21.1	0	8.1
Turbidity	1966-1974	83	40	0.2	4.3

* All values are as mg/L except:
(1) Colour
(2) Oxygen % saturation as percent
(3) pH
(4) Specific Conductivity as μS/cm
(5) Temperature as °C
(6) Turbidity in NTU

\+ Median Value
ND = Not Detectable

Data Source: Ministry of Environment and Parks and Inland Waters Directorate

TABLE 26
AMBIENT WATER QUALITY DATA SUMMARY
NECHAKO RIVER NEAR ISLE PIERRE

Characteristic	Site 0400040				
	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Alkalinity	1972-1975	19	47.6	35.2	40.1
Carbon: - Organic	1972-1975	20	11	<1	5.7
- Inorganic	1974-1975	13	14	8	9.8
Coliform - fecal	1973	3	33	<2	2+
Colour TAC	1974-1975	13	39	<1	12
Hardness - calcium	1972-1975	20	13.2	9.5	11
- magnesium	1972-1975	18	3.6	2.3	2.9
- total	1972-1975	20	49	34.4	39.7
Metals: (Dissolved)					
- Cadmium	1974-1975	6	0.0005	<0.0005	<0.0005+
- Chromium	1974-1975	13	<0.005	<0.005	<0.005
- Copper	1974-1975	14	0.003	<0.001	<0.001+
- Iron	1974-1975	14	0.2	<0.04	<0.1+
- Lead	1974-1975	14	0.004	<0.001	<0.001+
- Manganese	1972-1975	14	0.09	<0.01	0.02
- Mercury	1972-1975	12	0.00009	<0.00005	<0.00005
- Nickel	1974-1975	6	<0.01	<0.01	<0.01
- Zinc	1972-1975	14	0.03	<0.005	<0.005+
Nitrogen: - Ammonia	1974-1975	11	0.025	0.007	0.014
-nitrite	1972-1975	17	<0.005	<0.005	<0.005
-nitrate/nitrite	1972-1975	20	0.08	<0.02	0.023
- Organic	1974-1975	13	0.38	0.12	0.24
- Kjeldahl	1972-1975	18	0.37	0.13	0.27
Oxygen - dissolved	1972-1975	14	13	7.8	10.3
- % saturation	1972-1975	12	106.4	79.9	94.7
pH	1972-1975	18	7.9	7.5	7.75+
Phosphorus					
-ortho	1974-1975	13	0.017	<0.003	0.005
- total	1972-1975	20	0.091	0.007	0.019
Solids: - Suspended	1972-1975	20	51	<1	10
- Total	1975	7	116	58	69
Specific Conductivity	1972-1975	14	230	74	123
Temperature	1972-1975	19	19	0	9.7
Turbidity	1972-1975	19	22	1	4.2

* All values are as mg/L except:

(1) Coliform-fecal as MPN/100 mL
(2) Colour
(3) Oxygen % saturation as percent
(4) pH
(5) Specific Conductivity as μS/cm
(6) Temperature as °C
(7) Turbidity in NTU

\+ Median Value

Data Source: Ministry of Environment and Parks

TABLE 27
AMBIENT WATER QUALITY DATA SUMMARY
CHILAKO RIVER

Characteristic	Site 0400039				
	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Alkalinity	1972-1975	13	167	51.5	118.9
Carbon: - Organic	1972-1975	14	29	3	14.1
- Inorganic	1974-1975	7	43	12	30
Coliform -fecal	1973	3	79	5	13+
Colour True	1972-1975	14	120	10	47.1
Hardness - calcium	1972-1975	14	32.7	11.2	22.8
- magnesium	1972-1975	12	19	6.2	13.6
- total	1972-1975	13	156	55	109.5
Metals:					
- Cadmium (dissolved)	1974-1975	5	<0.0005	<0.0005	<0.0005
(total)	1975	2	<0.0005	<0.0005	<0.0005
- Chromium(total)	1975	2	0.027	0.005	0.016
(dissolved)	1972-1975	13	<0.005	<0.005	<0.005
- Copper (total)	1975	2	0.013	0.003	0.008
(dissolved)	1972-1975	13	0.004	<0.001	0.002
- Iron (total)	1975	2	13.6	0.7	7.2
(dissolved)	1972-1975	13	0.6	0.04	0.24
- Lead (total)	1975	2	0.002	<0.001	-
(dissolved)	1972-1975	13	<0.003	<0.001	<0.001+
- Manganese (total)	1975	1	0.36	-	-
(dissolved)	1972-1975	13	0.17	0.01	0.08
- Mercury (total)	1975	1	<0.00005	-	-
(dissolved)	1972-1975	12	0.00025	<0.00005	<0.00005+
- Nickel (total)	1975	1	<0.01	-	-
(dissolved)	1974-1975	5	<0.01	<0.01	<0.01
- Zinc (total)	1975	2	0.04	<0.005	-
(dissolved)	1972-1975	2	0.03	<0.005	0.006
Nitrogen: - Ammonia	1974-1975	7	0.032	0.008	0.02
- nitrite	1972-1975	11	0.007	<0.005	<0.005+
-nitrate/nitrite	1972-1975	14	0.09	<0.02	0.03
- Organic	1974-1975	7	1	0.16	0.46
- Kjeldahl	1972-1975	12	0.87	0.17	0.41
Oxygen - dissolved	1972-1975	10	13.4	7.8	10.7
- % saturation	1972-1975	10	102.6	79.8	94.8
pH	1972-1975	15	8.2	7.1	7.9+
Phosphorus					
-ortho	1974-1975	7	0.03	0.02	0.025
- total	1972-1975	14	0.42	0.036	0.11
Solids: - Suspended	1972-1975	13	339	3	49, 10+
- Total	1974-1975	2	464	454	459
Specific Conductivity	1972-1975	11	330	110	220
Temperature	1972-1975	13	19	0	9.2
Turbidity	1972-1975	13	124	2.4	20.2

* All values are as mg/L except:
(1) Coliform-fecal as MPN/100 mL
(2) Colour
(3) Oxygen % saturation as percent
(4) pH
(5) Specific Conductivity as μS/cm
(6) Temperature as °C
(7) Turbidity in NTU

Data Source: Ministry of Environment and Parks

\+ Median Value

TABLE 28
AMBIENT WATER QUALITY DATA SUMMARY
NECHAKO RIVER AT PRINCE GEORGE

Characteristic	Site 0920066				
	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Arsenic	1982-1983	2	<0.25	<0.25	<0.25
Coliform - fecal	1976-1983	10	1 500	40	150+
Hardness - calcium	1982-1983	2	15.7	14.7	15.2
- magnesium	1982-1983	2	3.95	3.81	3.88
- total	1982-1983	2	43.2	40.6	41.9
Metals: (total)					
- Aluminum	1982-1983	2	0.06	<0.02	-
- Cadmium	1982-1983	2	<0.0005	<0.0005	<0.0005
- Chromium	1982-1983	2	<0.01	<0.01	<0.01
- Copper	1982-1983	2	0.002	<0.001	-
- Iron	1982-1983	2	0.13	0.07	0.10
- Lead	1982-1983	2	0.11	0.003	0.06
- Manganese	1982-1983	2	0.01	<0.01	-
- Mercury	1983	1	<0.00005	-	-
- Molybdenum	1982-1983	2	0.02	<0.01	-
- Nickel	1982-1983	2	<0.01	<0.01	<0.01
- Zinc	1982-1983	2	<0.01	<0.01	<0.01
Nitrogen: - Ammonia	1983	1	<0.005	-	-
-nitrate/nitrite	1983	1	0.02	-	-
- Organic	1983	1	0.14	-	-
- Kjeldahl	1983	1	0.14	-	-
Oxygen - dissolved	1974-1976	23	18.4	9	11.2
- % saturation	1974-1976	17	164.4	86.3	110.3
pH	1982	2	7.8	7.8	7.8
Phosphorus					
-ortho	1983	1	<0.003	-	-
-total dissolved	1983	1	0.007	-	-
-total	1983	1	0.013	-	-
Solids: - Suspended	1982	2	2	2	2
Specific Conductivity	1982	2	124	119	122
Temperature	1974-1982	24	17	7	13.3
Turbidity	1982	1	1.8	-	-

* All values are as mg/L except: + Median Value
(1) Coliform-fecal as MPN/100 mL
(2) Colour
(3) Oxygen % saturation as percent
(4) pH
(5) Specific Conductivity as µS/cm
(6) Temperature as °C
(7) Turbidity in NTU

Data Source: Ministry of Environment and Parks and Inland Waters Directorate

TABLE 29
PROPOSED LAKE SAMPLING PROGRAM
STUART LAKE

STRATEGY	A	B	C	D
Frequency (times/yr)	1/yr	2/yr	3/yr	4/yr
Time of Year	Spring Overturn	Spring Overturn Late September	Spring Overturn Early July Early September	Spring Overturn Early July Early September Under Ice Cover (February or March)
Duration	Acceptable after first four years of lake sampling	Continuous*	Acceptable for first two years that lake is sampled if sample can't be collected under ice	First two years that lake is sampled
Characteristics: Laboratory Tests	same as "B"	pH, ammonia nitrogen, nitrate/nitrite, Kjeldahl nitrogen, total phosphorus, total dissolved phosphorus, orthophosphorus	same as "D"	COD, pH, ammonia nitrogen, nitrate/nitrite, Kjeldahl nitrogen, total phosphorus, orthophosphorus, total dissolved phosphorus, chlorophyll <u>a</u>, phytoplankton (surface unconcentrated - no nets), zooplankton (vertical haul), aluminum, mercury, cadmium, chromium, iron, manganese, copper, lead, zinc
Field Tests	Temperature and dissolved oxygen profiles Secchi Disk pH (can be eliminated in strategies "A" and "B")			
Sampling Locations	Minimum of one site near the lake centre Minimum of three samples at each site, one from the surface, one at mid-depth and one from near the bottom, preferably 3 or 4 particularly when lake is stratified.			

NOTE: The program outlined is general in nature. If specific problems are raised (drinking water suitability, etc.) it may be necessary to add properties such as coliforms, pesticides, or other metals, as needed. Sampling frequencies should only be reduced after a careful examination of the data.

* In a 5-year strategy, "D" would be undertaken the first two years, "B" would be undertaken in years 3 & 4, and it would be acceptable to reduce sampling to "A" during and subsequent to year 5. It is possible that "C" might replace "D" during one of the first two years; however, this is not desirable if it can be avoided.

TABLE 30
FISH SPECIES ANALYZED AT VARIOUS SELECTED LOCATIONS IN THE STUART AND FRASER RIVER SYSTEMS

SPECIES	STUART LAKE [26]	TEZZERON LAKE [26]	PINCHI LAKE [25]	PINCHI LAKE [26]	FRASER R. (QUESNEL)[28]	FRASER R. (MCBRIDE)[28]
Peamouth Chub	√	√	√	√		
Mountain Whitefish	√	√	√	√		
Rainbow Trout	√	√	√			
Northern Squawfish	√	√				
Largescale Sucker			√		√	√
Longnose Sucker	√					
White Sucker		√				
Dolly Varden	√				√	√
Kokanee			√			
Lake Trout		√	√			
Lake Whitefish			√			
Sockeye Salmon					√	

TABLE 31

MAXIMUM CONCENTRATION OF TOTAL AMMONIA NITROGEN FOR PROTECTION OF AQUATIC LIFE (mg/L-N)

pH	Temp. 0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
6.5	27.7	28.3	27.9	27.5	27.2	26.8	26.5	26.2	26.0	25.7	25.5
6.6	27.9	27.5	27.2	26.8	26.4	26.1	25.8	25.5	25.2	25.0	24.7
6.7	26.9	26.5	26.2	25.9	25.5	25.2	24.9	24.6	24.4	24.1	23.9
6.8	25.8	25.5	25.1	24.8	24.5	24.2	23.9	23.6	23.4	23.1	22.9
6.9	24.6	24.2	23.9	23.6	23.3	23.0	22.7	22.5	22.2	22.0	21.8
7.0	23.2	22.8	22.5	22.2	21.9	21.6	21.4	21.1	20.9	20.7	20.5
7.1	21.6	21.3	20.9	20.7	20.4	20.2	19.9	19.7	19.5	19.3	19.1
7.2	19.9	19.6	19.3	19.0	18.8	18.6	18.3	18.1	17.9	17.8	17.6
7.3	18.1	17.8	17.5	17.3	17.1	16.9	16.7	16.5	16.3	16.2	16.0
7.4	16.2	16.0	15.7	15.5	15.3	15.2	15.0	14.8	14.7	14.5	14.4
7.5	14.4	14.1	14.0	13.8	13.6	13.4	13.3	13.1	13.0	12.9	12.7
7.6	12.6	12.4	12.2	12.0	11.9	11.7	11.6	11.5	11.4	11.3	11.2
7.7	10.8	10.7	10.5	10.4	10.3	10.1	10.0	9.92	9.83	9.73	9.65
7.8	9.26	9.12	8.98	8.88	8.77	8.67	8.57	8.48	8.40	8.32	8.25
7.9	7.82	7.71	7.60	7.51	7.42	7.33	7.25	7.17	7.10	7.04	6.98
8.0	6.55	6.46	6.37	6.29	6.22	6.14	6.08	6.02	5.96	5.91	5.86
8.1	5.21	5.14	5.07	5.01	4.95	4.90	4.84	4.80	4.75	4.71	4.67
8.2	4.15	4.09	4.04	3.99	3.95	3.90	3.86	3.83	3.80	3.76	3.74
8.3	3.31	3.27	3.22	3.19	3.15	3.12	3.09	3.06	3.03	3.01	2.99
8.4	2.64	2.61	2.57	2.54	2.52	2.49	2.47	2.45	2.43	2.41	2.40
8.5	2.11	2.08	2.06	2.03	2.01	1.99	1.98	1.96	1.95	1.94	1.93
8.6	1.69	1.67	1.65	1.63	1.61	1.60	1.59	1.58	1.57	1.56	1.55
8.7	1.35	1.33	1.32	1.31	1.30	1.29	1.28	1.27	1.26	1.26	1.25
8.8	1.08	1.07	1.06	1.05	1.04	1.04	1.03	1.03	1.02	1.02	1.02
8.9	0.871	0.863	0.856	0.849	0.844	0.839	0.836	0.833	0.832	0.831	0.831
9.0	0.703	0.697	0.692	0.688	0.685	0.682	0.681	0.681	0.680	0.681	0.682

pH	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0
6.5	25.2	25.0	24.8	24.6	24.5	24.3	24.2	24.0	23.9	23.8
6.6	24.5	24.3	24.1	23.9	23.8	24.6	23.5	23.3	23.3	23.2
6.7	23.7	23.5	23.3	23.1	23.0	22.8	22.7	22.6	22.5	22.4
6.8	22.7	22.5	22.3	22.2	22.0	21.9	21.8	21.7	21.6	21.5
6.9	21.6	21.4	21.3	21.1	21.0	20.8	20.7	20.6	20.5	20.4
7.0	20.3	20.2	20.0	19.9	19.7	19.6	19.5	19.4	19.3	19.2
7.1	18.9	18.8	18.7	18.5	18.4	18.3	18.2	18.1	18.0	17.9
7.2	17.4	17.3	17.2	17.1	16.9	16.8	16.8	16.7	16.6	16.5
7.3	15.9	15.7	15.6	15.5	15.4	15.3	15.2	15.2	15.1	15.1
7.4	14.2	14.1	14.0	13.9	13.9	13.8	13.7	13.6	13.6	13.5
7.5	12.6	12.5	12.4	12.4	12.3	12.2	12.2	12.1	12.1	12.0
7.6	11.1	11.0	10.9	10.8	10.8	10.7	10.7	10.6	10.6	10.5
7.7	9.57	9.50	9.43	9.37	9.31	9.26	9.22	9.81	9.15	9.12
7.8	8.18	8.12	8.07	8.02	7.97	7.93	7.90	7.87	7.84	7.82
7.9	6.92	6.88	6.83	6.79	6.75	6.72	6.69	6.67	6.65	6.64
8.0	5.81	5.78	5.74	5.71	5.68	5.66	5.64	5.62	5.61	5.60
8.1	4.64	4.61	4.59	4.56	4.54	4.53	4.51	4.50	4.49	4.49
8.2	3.71	3.69	3.67	3.65	3.64	3.63	3.62	3.61	3.61	3.61
8.3	2.97	2.96	2.94	2.93	2.92	2.92	2.91	2.91	2.91	2.91
8.4	2.38	2.37	2.36	2.36	2.35	2.35	2.35	2.35	2.35	2.36
8.5	1.92	1.91	1.91	1.90	1.90	1.90	1.90	1.90	1.91	1.92
8.6	1.55	1.54	1.54	1.54	1.54	1.54	1.55	1.55	1.56	1.57
8.7	1.25	1.25	1.25	1.25	1.25	1.26	1.26	1.27	1.28	1.29
8.8	1.02	1.02	1.02	1.02	1.03	1.03	1.04	1.05	1.06	1.07
8.9	0.832	0.834	0.838	0.842	0.847	0.853	0.861	0.870	0.880	0.891
9.0	0.684	0.688	0.692	0.698	0.704	0.711	0.720	0.729	0.740	0.752

TABLE 32

AVERAGE 30-DAY CONCENTRATION OF TOTAL AMMONIA NITROGEN FOR PROTECTION OF AQUATIC LIFE (mg/L-N)

pH	Temp. 0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
6.5	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
6.6	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
6.7	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
6.8	2.08	2.05	2.02	1.99	1.96	1.94	1.92	1.90	1.88	1.86	1.84
6.9	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
7.0	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
7.1	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
7.2	2.08	2.05	2.02	1.99	1.96	1.95	1.92	1.90	1.88	1.86	1.85
7.3	2.08	2.05	2.02	1.99	1.97	1.95	1.92	1.90	1.88	1.86	1.85
7.4	2.08	2.05	2.02	2.00	1.97	1.95	1.92	1.90	1.88	1.87	1.85
7.5	2.08	2.05	2.02	2.00	1.97	1.95	1.93	1.91	1.88	1.87	1.85
7.6	2.09	2.05	2.03	2.00	1.97	1.95	1.93	1.91	1.89	1.87	1.85
7.7	2.09	2.05	2.03	2.00	1.98	1.95	1.93	1.91	1.89	1.87	1.86
7.8	1.78	1.75	1.73	1.71	1.69	1.67	1.65	1.63	1.62	1.60	1.59
7.9	1.50	1.48	1.46	1.44	1.43	1.41	1.39	1.38	1.36	1.35	1.34
8.0	1.26	1.24	1.23	1.21	1.20	1.18	1.17	1.16	1.15	1.14	1.13
8.1	1.00	0.989	0.976	0.963	0.952	0.942	0.932	0.922	0.914	0.906	0.899
8.2	0.799	0.788	0.777	0.768	0.759	0.751	0.743	0.736	0.730	0.724	0.718
8.3	0.636	0.628	0.620	0.613	0.606	0.599	0.594	0.588	0.583	0.579	0.575
8.4	0.508	0.501	0.495	0.489	0.484	0.479	0.475	0.471	0.467	0.464	0.461
8.5	0.405	0.400	0.396	0.381	0.387	0.384	0.380	0.377	0.375	0.372	0.370
8.6	0.324	0.320	0.317	0.313	0.310	0.308	0.305	0.303	0.301	0.300	0.298
8.7	0.260	0.257	0.254	0.251	0.249	0.247	0.246	0.244	0.243	0.242	0.241
8.8	0.208	0.206	0.204	0.202	0.201	0.200	0.198	0.197	0.197	0.196	0.196
8.9	0.168	0.166	0.165	0.163	0.162	0.161	0.161	0.160	0.160	0.160	0.160
9.0	0.135	0.134	0.133	0.132	0.132	0.131	0.131	0.131	0.131	0.131	0.131

pH	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0
6.5	1.82	1.81	1.80	1.78	1.77	1.64	1.52	1.41	1.31	1.22
6.6	1.82	1.81	1.80	1.78	1.77	1.64	1.52	1.41	1.31	1.22
6.7	1.83	1.81	1.80	1.78	1.77	1.64	1.52	1.41	1.31	1.22
6.8	1.83	1.81	1.80	1.78	1.77	1.64	1.52	1.42	1.32	1.22
6.9	1.82	1.81	1.80	1.78	1.77	1.64	1.53	1.42	1.32	1.22
7.0	1.83	1.81	1.80	1.79	1.77	1.64	1.53	1.42	1.32	1.22
7.1	1.83	1.81	1.80	1.79	1.77	1.65	1.53	1.42	1.32	1.23
7.2	1.83	1.81	1.80	1.79	1.78	1.65	1.53	1.42	1.32	1.23
7.3	1.83	1.82	1.80	1.79	1.78	1.65	1.53	1.42	1.32	1.23
7.4	1.83	1.82	1.80	1.79	1.78	1.65	1.53	1.42	1.32	1.23
7.5	1.83	1.82	1.81	1.80	1.78	1.66	1.54	1.43	1.33	1.23
7.6	1.84	1.82	1.81	1.80	1.79	1.66	1.54	1.43	1.33	1.24
7.7	1.84	1.83	1.81	1.80	1.79	1.66	1.54	1.44	1.34	1.24
7.8	1.57	1.56	1.55	1.54	1.53	1.42	1.32	1.23	1.14	1.07
7.9	1.33	1.32	1.31	1.31	1.30	1.21	1.12	1.04	0.970	0.904
8.0	1.12	1.11	1.10	1.10	1.09	1.02	0.944	0.878	0.818	0.762
8.1	0.893	0.887	0.882	0.878	0.874	0.812	0.756	0.704	0.655	0.611
8.2	0.714	0.709	0.706	0.703	0.700	0.651	0.606	0.565	0.527	0.491
8.3	0.571	0.568	0.566	0.564	0.562	0.523	0.487	0.455	0.424	0.396
8.4	0.458	0.456	0.455	0.453	0.452	0.421	0.393	0.367	0.343	0.321
8.5	0.369	0.367	0.366	0.366	0.365	0.341	0.318	0.298	0.278	0.261
8.6	0.297	0.297	0.296	0.296	0.296	0.277	0.259	0.242	0.227	0.213
8.7	0.241	0.240	0.240	0.241	0.241	0.226	0.212	0.198	0.186	0.175
8.8	0.196	0.196	0.196	0.197	0.198	0.185	0.174	0.164	0.154	0.145
8.9	0.160	0.161	0.161	0.162	0.163	0.153	0.144	0.136	0.128	0.121
9.0	0.132	0.132	0.133	0.134	0.135	0.128	0.121	0.114	0.108	0.102

- the average of the measured values must be less than the average of the corresponding individual values in Table 32.
- each measured value is compared to the corresponding individual values in Table 32. No more than one in five of the measured values can be greater than one-and-a-half times the corresponding criteria values in Table 32.